WHITE PAPERS

ENHANCING THE USE OF ALTERNATE FUELS AND RAW MATERIALS (CO-PROCESSING) IN CEMENT MANUFACTURE: WHITE PAPERS ON SELECTED TOPICS

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GPCB

GUJARAT POLLUTION CONTROL BOARD
PARYAVARAN BHAVAN
Sector 10-A, **Gandhinagar** 382 010
Phone : (079) 23226295
Fax : (079) 23232156
Website : www.gpcb.gov.in

FOREWORD

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The Indian cement industry has made significant progress over the years contributing to India's infrastructure growth and development. This has been accompanied with increased demand for coal, large amount of which is being imported, as domestic coal production is not able to cope up with the rising demand. Co-processing of alternate fuels and raw materials (AFRs) offers a very attractive solution that not only holds the promise of reducing industry's dependence on coal and to reduce green house gas emissions, but also an effective means of addressing some of the pressing local environmental issues being faced by India.

In India, the current thermal substitution rate is less than 1%, which is far below the global benchmark. This is diagnosed to be due to a number of policy and regulatory bottlenecks along with technical and financial issues, which in many cases are interlinked. The policy makers need to make concerted effort to support the industry to achieve this, along with providing an enabling regulatory environment that facilitates this transition.

In order to deliberate on the Policy and Regulatory issues and to identify ways of addressing them effectively, a Forum of Regulators was created comprising of senior representatives from select State Pollution Control Boards. While I had the privilege to Chair this Forum, we also had the advantage of getting the advice from Dr. B. Sengupta, Ex-Member Secretary, Central Pollution Control Board, who having considerable experience on the subject, acted as a Convener for this Forum. In order to get a balanced viewpoint, the Forum also had invited Members representing the industry and other stake holders. The Forum came out with a series of five White Papers detailing amendments to the existing policies and framing of guidelines, which if implemented, can create a conductive environment for enhanced AFR usage in cement Industry. This document is a compilation of the White papers prepared by the Forum.

It is encouraging that the Central Pollution Control Board (CPCB) has acknowledged this initiative and have decided to take it up at a bigger scale by creating a National Task Force on Co-processing. I am sure that under the guidance of CPCB, this initiative will gather the necessary momentum and lead to mainstreaming the use of alternate fuels and raw materials in cement industry.

(HARDIK SHAH)
Member Secretary, Gujarat Pollution Control Board &
Chairman, Forum of Regulators

Clean Gujarat Green Gujarat

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Message

I am very pleased that the compendium on 'Enhancing Use of Alternate Fuels and Raw Materials: White Papers on Select Recommendations', is coming to fruition thanks to the good work of various individuals and organizations. Indian policy makers and the cement industry have put in a great deal of effort over the past few decades in moving towards cleaner production methods. These same stakeholders have embraced the initiative for promoting 'Alternate Fuel and Raw Material for Co-processing' with enthusiasm and interest. The efforts of the Forum of Regulators and, in particular, the pro-active participation of Member Secretary, Gujarat Pollution Control Board, is noteworthy. The policy and regulatory reforms identified by the Members of the Forum through a series of five White Papers as documented in the compendium can provide the necessary impetus and act as a starting point for transformation in the use of alternate fuels and raw material in the cement industry.

It is heartening to note that the Central Pollution Control Board (CPCB) has acknowledged the effort of the 'Forum of Regulators' and is willing to take its recommendations forward by creating a National Task Force on Co-Processing. In today's context, when availability of coal is declining and there is a global pressure to mitigate CO2 emission, the recognition given by CPCB to the findings of the 'Forum of Regulators' is important and timely.

We at the Institute for Industrial Productivity are grateful for the encouragement provided by CPCB and pledge our continued support and cooperation in this effort. I am confident that together we will be able to make the future of the Indian cement industry environment friendly and energy secure.

Jigar V. Shah
Executive Director
Institute for Industrial Productivity

Selected Abbreviations and Acronyms

AFR	Alternate Fuels and Raw Materials
BAT	Best Available Techniques
BEP	Best Environmental Practice
BIS	Bureau of Indian Standards
CPCB	Central Pollution Control Board
CKD	Cement Kiln Dust
CEM	Continuous Emission Monitoring Equipment
CSR	Corporate Social Responsibility
EPA	Environment Protection Act, 1986
ESP	Electro Static Precipitator
HW	Hazardous Waste
I-TEQ	International Toxic Equivalent
JNNURM	Jawaharlal Nehru National Urban Renewal Mission
MINAS	Minimum National Standards
MOEF	Ministry of Environment and Forests
MNRE	Ministry of New and Renewable Energy
MSW	Municipal Solid Waste
MTPY/MTY	Million Tonnes Per Year
NTPC	National Thermal Power Corporation
PCDD	Poly Chlorinated Dibenzo-P-Dioxin
PCDF	Poly Chlorinated Dibenzo-Furan
PPP	Public Private Partnership
PM	Particulate Matter
PPE	Personal Protective Equipment
POP	Persistent Organic Pollutant
PPC	Portland Pozzolana Cement
PSC	Portland Slag Cement
QA	Quality Assurance
QC	Quality Control
RDF	Refuse Derived Fuel
SPCB	State Pollution Control Board
TSDF	Treatment, Storage and Disposal Facility
TSR	Thermal Substitution Rate
TISS	Tata Institute of Social Sciences
VOC	Volatile Organic Compounds
WAP	Waste Analysis Plan

Introduction

India is the world's largest producer of cement after China. Its production capacity, currently around 350 MTA, is likely to double over the next decade leading to a huge rise in the demand for coal. Some of this demand in the cement industry is currently met by imports but the problem of coal supply is expected to grow. Co-processing of waste in cement kilns provides an opportunity to address this issue. Studies suggest that the potential for reducing the use of fossil fuels and mitigating GHG emissions by using waste as a fuel in cement kilns is very high. The cost of mitigation is reasonable and the potential for replication enormous. Other associated co-benefits include an effective and efficient means of managing urban and industrial waste, both of which are increasingly becoming major concerns. It would appear therefore, that using alternate fuels and raw materials would be very useful in the Indian context.

However, despite these obvious benefits, the use of alternate fuels and raw materials by the Indian cement industry is limited. The current thermal substitution rate (TSR) of fossil fuels by alternate fuels in India ranges between just 0.5 to 1 percent, which is far below the double digit rates achieved in developed countries: in some developed countries, this figure is as high as 60%. The key challenge in raising the alternate fuel usage is not just related to technical limitations, but about creating an enabling policy and regulatory environment to catalyze investment in this area.

It was against this backdrop that the Institute for Industrial Productivity (IIP) launched the initiative: Increasing the TSR in the Indian cement industry by promoting the use of alternate fuels and raw materials. In order to discuss regulatory and policy issues surrounding this initiative and to overcome some of the barriers faced, a Forum of Regulators was created with senior representatives from the State Pollution Control Boards of states with a large cement production.

The Forum met regularly to deliberate on these policy and regulatory issues; their discussions/ recommendations were condensed and documented in the form of five White Papers. These White Papers contain the inputs from members of the state pollution control boards, technical experts, industry representatives, and also refer to international best practices, journals and research documents. The five White Papers prepared by the Forum cover:

- Amendment of the Hazardous Waste Management Rules, 1989, under the Environment Protection Act, 1986, to include co-processing in cement plants as a disposal option.
- Preparation of technical guidelines for setting up environmentally sound pre-processing facilities to prepare homogenous waste mixes suitable for co-processing in cement kilns.
- Developing emission standards for co-processing alternate fuel and raw (AFR) material in cement kilns including hazardous wastes.
- Increasing the use of fly ash generated by coal-based power plants and refuse-derived fuels (RDF) in cement plants.
- Developing guidelines for the transport and storage of hazardous waste.

The present document is a compilation of these White Papers. Once implemented, these recommendations will encourage the use of alternate fuels and raw material in the cement industry.

WHITE PAPER–I

AMENDING HAZARDOUS WASTE MANAGEMENT RULES, 2008, UNDER THE ENVIRONMENT PROTECTION ACT, 1986, TO INCLUDE CO-PROCESSING IN CEMENT PLANTS AS A DISPOSAL OPTION

White Paper–I

White Paper on amending Hazardous Waste Rules, 2008, Under the Environment Protection Act, 1986, to Include Co-Processing in Cement Plants as a Disposal Option

1. Summary

The objective of the paper is to propose amendments to the Hazardous Waste Rules, 2008, to include co-processing as a disposal option on a par with incineration and secured landfilling. The present practice, as outlined in Section 11, Chapter III of the Rules for Authorizing Co-processing of Hazardous Waste (HW), is discussed bringing out ambiguities. The paper defines co-processing and its advantages over secured landfilling and incineration. It also analyzes the following: the gap between installed incinerator capacity and incinerable waste generated (all-India); quantity of waste generated all over the country with potential for use in energy/resource recovery and co-processing; experience gained by cement plants in co-processing; and, the technical preparedness for adopting co-processing as an environmentally sound method of energy /resource recovery.

This is followed by a description of the proposed amendment and the legal implication to the co-processor/operator of the disposal facility.

2. Objective of the Paper

The objective of the paper is to present to the MoEF the need for the amendment, the proposed amendment and implications thereof.

The Ministry of Environment and Forests (MoEF) has laid down, in the Hazardous Wastes (Management, Handling and Transboundary Movement) Rules, 2008 (H W Rules) under Chapter III Section 11: "The utilization of hazardous waste as supplementary resource or for energy recovery or after processing, shall be carried out by the units only after obtaining approval from the Central Pollution Control Board."

The Central Pollution Control Board (CPCB), has framed a protocol for cement kilns in this regard which includes four trial burns; compliance with emission standards (as for hazardous waste incinerators); and clinker quality as per the norms of the Bureau of Indian Standards. The concerned State Pollution Control Boards (SPCB) issue authorizations to the kilns under the HW rules after the CPCB's approval. The CPCB has also laid down guidelines for applicant kilns for installing and operating storage facilities for HW.

An ambiguity in the rule cited above appears because the definite article 'the' is used with 'unit'. It is not clear whether this pertains to the unit generating and using the HW internally to produce energy or a resource, or does the term also include an outside party such as a cement manufacturing unit? It is therefore necessary to revisit the HW Rules and propose that the MoEF consider amending them so as to recognize using HW in cement kilns as a disposal method akin to physico - chemical biological treatment, incineration and disposal in a secured landfill (refer to the definitions under the HW Rules, 2008) with all consequential legal obligations on the part of the co-processor.

3. Why the Proposed Amendment?

3.1 What is co-processing?

Co-processing refers to utilization of suitable waste material in manufacturing processes for the purpose of energy and/or resource recovery and resultant reduction in the use of conventional fuels and/or raw materials through substitution (1, 2011). The waste materials used for co-processing are referred to as alternate fuels and raw materials (AFR). Cement manufacturing is the most attractive process for co-processing because of high flame temperatures (2000 °C, material temperature 1400 °C, residence time (4 to 5 seconds), oxygen rich reaction zone and high degree of turbulence available all of which and required for the near complete destruction of organic compounds in wastes.

3.2 Incinerable HW generation in major states

The quantity of incinerable hazardous waste generated by seven major states as assessed by the CPCB is presented in Table 1 below. The shortage in installed capacity of incinerators is noteworthy.

Table 1: Quantity of incinerable hazardous waste generated in tonnes per year, by seven major Indian states (installed capacity of incinerators in parentheses)

Andhra Pradesh	70,000 (25,000)
Gujarat	108,622 (36,600)
Madhya Pradesh	5,036 (NIL)
Maharashtra	152,791 (38,500)
Rajasthan	23,025 (5,500)
Tamil Nadu	11,145 (NIL)
West Bengal	12,583 (17,800)

The CPCB has identified cement plants in seventeen states with potential for co-processing HW (Table 2).

3.3 Advantages of co-processing

Conventionally and as per the HW Rules, 2008, wastes are either incinerated or disposed of in secured landfills after necessary treatment. Incineration is expensive and energy-intensive; the resultant ash requires disposal in secured landfills which puts to waste large tracts of land; there is also the possibility of water pollution.

Co-processing waste will preclude the possibility of these consequences and reduce greenhouse gas emissions.

3.4 Types of alternate fuels and raw materials used in co-processing

Some alternative fuels and raw materials that could be co-processed in cement plants and their calorific values are presented in Table 3.

Table 2: Cement plants in seventeen states with potential for co-processing hazardous waste

	Name of the State	Hazardous Wate, Incinerable Tonnes/Year	Cement plants potential for co-processing
1	Andhra Pradesh	70,000	Ultratech & Jaypee Group, Madras Cement, India Cements, Dalmia Cement, Penna Cement, My Home Cement, Rain Industries, Sagar Cement, Kesoram Cement, Orient Vasavadatta, ACC Wadi
2	Maharashtra	152791	ACC Cement, Ambuja Cement, Ultratech Cement
3	Tamil Nadu	11145	Grasim Cement, Chettinad Cement, Dalmia Cements
4	Gujarat	108622	Utratech & Jaypee Group, Sanghi & Saurashtra Cement
5	Chhattisgrah	6897	Grasim Cement, Lafarge Cement
6	Delhi	1740	Shree Cement, Mangalam Cement, Binani Cement & J K Lakshmi Cement
7	Goa	8271	-
8	Haryana	1429	Shree Cement, Mangalam Cement, Binani Cement, JK Lakshmi Cement
9	Himachal Pradesh	2248	Jaypee Cement, ACC Cement
10	Jharkhand	9813	ACC Cement
11	Karnataka	3713	JK Cement
12	Madhya Pradesh	5036	ACC, Birla Corporation, Ultratech, Jaypee and Prism Cement
13	Odisha	4052	ACC Cement and OCL Cement
14	Punjab	14831	Jaypee Cement, ACC Cement
15	Rajasthan	23025	Ambuja Cement, Ultratech Cement, ACC, JK Cement, Shree Cement, Mangalam Cement, Birla Corporation Cement
16	Uttar Pradesh	15697	Jaypee Cement
17	West Bengal	12583	ACC Cement and OCL Cement

Table 3: Alternative fuels and their calorific values in kcal/kg.

Refused Derived Fuel (RDF) From Municipal Solid Waste	2800-3800
Used tyres	6700-7700
Hazardous Waste	4000-9500
Industrial Plastic Waste	4070-6620
Biomass	2500-3800
Slaughterhouse Waste	700-1400
Poultry Litter	2700-3800
Dried Sewage Sludge	1700-1900

Source: *CPCB & Holtech*

Note: The corresponding calorific value of coal is 2700-5200 kcal per kg

3.4.1 Alternate Raw Materials

Fly ash is a well-known blending material, and about 115 million tonnes per year (MTA) are generated in India. Other wastes that could be used in co-processing for resource recovery are shown in Table 4 together with their estimated generation.

Table 4: Other wastes usable in co-processing for resource recovery (in million tonnes per annum)

	Unit MTA
Blast furnace slag from steel industry	4
Lime sludge (paper, carbide, sugar industry sludge)	4.5
Red mud from aluminum industry	3.75
Lead, zinc slag	0.5

Source: *Holtech*

3.5 Co-processing with HW as it exists

3.5.1. Co-processing in cement plants using the following types of HW has been permitted by the State Pollution Control Boards following procedures under Chapter III, Section 11 of the HW Rules, 2008.

1. Process organic residue from pharmaceutical industry
2. Process organic residue from pesticide industry
3. ETP bio-solid and spent carbon (soft drink industry)
4. Chemical sludge (automobile industry)
5. Phosphate sludge (automobile industry)
6. Chemical ETP sludge (automobile industry)
7. Grinding dust (rolling, bearing and steel industry)
8. ETP sludge (soft drink industry)
9. Spent catalyst from IOCL, Barauni Refinery
10. Poly residue (distillation residue) of M/s. SKF India Ltd.
11. Green mesh with resin (M/s. Suzlon Energy Ltd.)
12. Ply residue (M/s. SRF India Ltd.)
13. Solar evaporation pond sludge (M/s. Jubliant Organosys Ltd.), n-butanol salt (M/s. Jubliant Organosys Ltd.)
14. Grinding dust (M/s. SRF India Ltd.)
15. ETP sludge (textile industry)
16. Paint sludge from automobile industry.
17. Waste mix solids and solid mix liquid (GEPIL, Surat)
18. Waste liquid blend and waste solid blend (M/s. Colurtex Industries Ltd. (Unit 2))
19. Solid and liquid organic spent solvent
20. TDI tar waste from GNFC
21. Spent pot lining from aluminum industry

3.5.2 Technical Preparedness

The CPCB has already evolved an approval protocol for potential co-processors as per Section 11, Chapter III of the HW Rules. This is a prerequisite for obtaining authorization from the concerned SPCB under Section 5 of Chapter II. In para 3.5.1, and later in 3.5.3 experience gained has been incorporated.

The CPCB has specified emission standards, guidelines for storage, how HW is to be handled before co-processing and standards for the quality of clinker. However, some gaps remain and some of these are:

1. How to establish a pre-processing facility as part of a TSDF or standalone.
2. Determining how much of various types of HW can be co-processed such that the quality of clinker and flue gas emissions are acceptable.
3. Identifying pre-processing technology for each type of HW
4. Working out storage, handling and feeding systems for each type of waste
5. Studying, as an example, the techno-economic feasibility of co-processing for AFR generated in an industrial cluster/industrial area.
6. Examining the need for modifying emission standards prescribed for HW incinerators

(Annexure II); these standards are currently the same as those used in co-processing cement kilns.

7. Capacity building/training for monitoring and analysis at co-processing plants.

8. Inventorying HW generated and making all information accessible to co-processors, preprocessors. The SPCB should take on this task.

3.5.3. Details of trial runs for co-processing are presented in Table 5 below.

Table 5: Details of co-processing trial runs

Waste co-processed	Name of the cement plant	Period of trial run	% utilization (extent of substitution)
ETP sludge (BASF India Ltd., Mangalore)	M/s. Rajashree Cement, Gulbarga Cement, Karnataka (KA)	January, 2005	5-6
Toluene di isocyanate tar (M/s. Narmada Chematur Petrochemicals Ltd., Bharuch	M/s. Gujarat Ambuja Cement, Ltd., Kodinar, Gujarat	February, 2006	4-7
Toluene di isocyanate tar (M/s.Narmada Chematur Petrochemicals Ltd., Bharuch)	M/s. Lafarge India Ltd., Raipur, Chhattisgarh	May, 2006	5-7
Tyre chips	M/s. Grasim Industries Ltd., Reddipalayam, (TN)	April-July, 2006	9-19
Paint sludge (automobile sector)	M/s.Grasim Industries Ltd., Reddipalayam, (TN)	April-July, 2006	9-17
Refinery sludge (M/s. Chennai Petrochemicals Company Ltd., Chennai)	M/s. Grasim Industries Ltd., Reddipalayam, (TN)	April-July, 2006	9.1
CETP Pali sludge	M/s. J.K. Laxmi Cement, Sirohi, Rajasthan	December, 2007	5
Solid waste mix (GEPIL, Surat)	M/s. Lafarge India Ltd., Raipur, Chhattisgarh	Sep.-Oct.,2009	2.4
Liquid waste mix (GEPIL, Surat)	M/s. Lafarge India Ltd., Raipur, Chhattisgarh	Sep.-Oct.,2009	10.3
Liquid waste mix (GEPIL, Surat)	M/s. Ambuja Cement Ltd., Kodinar, Gujarat	Nov.,2009	1.5
Liquid organic solvent (pharamaceutical industry)	M/s. Grasim Industries Ltd., Andhra Pradesh (AP)	Dec., 2009	10.4
Phosphate sludge (Ford India Ltd., Chennai)	Madukkarai, Works, TN		0.9
Phosphate sludge (Toyota Kriloskar Motor Ltd., Bangalore)	ACC Wadi Works, KA		0.7
Grinding muck (Kirloskar Toyota Textile Machinery Pvt. Ltd., Bangalore)	ACC Wadi Works, KA		2.8
Solar evaporation pond sludge (Jubiliant Organosys Ltd., Mysore)	ACC Wadi Works, KA		1
Spent carbon (Hindustan Coca Cola Beverages Pvt. Ltd., Bangalore)	ACC Wadi Works, KA		2.7
Oily rags (Ford India Ltd., Chennai)	Madukkarai, Works, TN		0.2
ETP bio solids (Hindustan Coca Cola Beverages Pvt. Ltd., Bangalore	ACC Wadi Works KA		2.4
Green mesh with resin (Suzlon Energy Ltd., Pondicherry)	Madukkarai, Works, TN		0.6
Poly residue (SRF Ltd.)	Kymore Works, Madhya Pradesh (M.P.)		3.8

Waste co-processed	Name of the cement plant	Period of trial run	% utilization (extent of substitution)
Chemical ETP sludge (Ford India Ltd., Chennai)	Madukkarai, Works, TN		0.9
n-butanol salt (Jubilant Organosys Ltd., Mysore)	ACC Wadi Works KA		1
Chemical sludge (Toyota Kirloskar Motors Ltd., Bangalore)	ACC Wadi Works KA		2.04
Grinding dust (SKF India Ltd., Bangalore)	ACC Wadi Works KA		0.7
WTP sludge (Hindustan Coca Cola Beverages Pvt. Ltd., Bangalore)	ACC Wadi Works KA		2.6
Plastic waste	Kymore Works, (M.P.)		1.5

3.5.4. Results of Trial Runs

Detailed analytical reports of the first six trial runs in terms of clinker quality and emission composition, particulate matter, sulphur dioxide, oxides of nitrogen, dioxin, and furan are available at the CPCB. Analyses were carried out during normal operation, during co-processing and immediately after co-processing. No significant exceedances of standards or even increases over emissions at normal operation were observed. The only exception was with NOx emissions in the trial run at serial number 3 in Table 5.

Disproportionately high loadings of HW with a very high calorific value could have caused higher than normal kiln temperatures resulting in high NOx emissions (compared to coal). High levels of total organic carbon emissions upon using effluent treatment plant sludge cannot be explained since one would expect almost 100 percent destruction. It is possible to meet product (clinker and cement quality) and emission standards if suitable pre-processing is carried out and if the kiln and its air pollution control systems are operated correctly.

3.6. The way forward

Data in the preceding sections suggest that while co-processing hazardous wastes in cement plants has begun in India, a number of technical steps will have to be taken if we are to achieve co-processing levels of 32% to 47% prevalent in Europe.

Technical aspects must continue to receive attention but the law should recognize co-processing as a method of disposal in order to encourage the practice. The MoEF might like to consider including co-processing in the definition of disposal in the HW Rules, 2008. The consequential changes are discussed hereunder.

4. Proposed Amendment to HW Rules, 2008 and its Implications

4.1 In Chapter I, Section 3, Definitions, the following may be included:

(e) "Co-processing": The use of suitable waste materials in manufacturing processes for the purpose of energy and/or resource recovery and resultant reduction in the use of conventional fuels and/or raw materials through substitution. (Reference: 1. Technical guidelines on the environmentally sound co-Processing of Hazardous Waste in Cement kilns, Secretariat of Basel Convention, First revision, October 2011).

Note: (a) In the present Rule co-processing is not defined.

4.2 In Chapter I, Section 3, Definitions, the present clause (e) may be modified as under:

(f) "disposal" means any operation which does not lead to recycling or reuse and includes physico-chemical, biological treatment, co-processing and disposal in landfill.

Note: The word 'recovery' in the present Rules is deleted as co-processing involves recovery of energy and/or resource from the waste. Also co-processing is on a par with incineration, secured landfilling, and treatment.

4.3 With the above two amendments a co-processor (e.g.) a cement kiln owner becomes "operator of disposal facility" under clause 'r' of Section 3.

4.4 Consequent to para 4.1 and 4.2, Chapter-II Section 4(4) may be amended as under:

"The occupier or any other person acting on his behalf who intends to get his hazardous waste treated and disposed of by the operator of a Treatment, Storage and Disposal Facility (TSDF) or Co-Processing Facility shall give to the operator of a facility, such information as may be determined by the State Pollution Control Board".

Note: The operator of co-processing facility is on a par with the operator of a TSDF vis-a-vis Hazardous Waste Generator using the facility.

4.5 Section 11, Chapter III of the Rules may be amended as under:

The utilization of Hazardous Wastes as a supplementary resource or for energy recovery, as such or after pre-processing shall be carried out by the units only after obtaining approval from the concerned State Pollution Control Board or Pollution Control Committee. SPCBs/PCCs shall grant this approval after giving due consideration to the waste management hierarchy.

Note: Over the years SPCBs/PCCs have gained considerable experience in conducting trial runs for co-incineration and also have been delegated the power to register recyclers of HW, by the MoEF initially given to the CPCB only. The State Pollution Control Boards also authorize occupiers generating HW. In view of this, the power to approve the use of HW as a supplementary fuel by co-processors may be given to the SPCB/PCC provided they strictly follow the guidelines issued by the CPCB to conduct trial runs.

4.6 Consequent to the above, Section 19(1), Chapter VI may be amended as under to include a co-processor on a par with a TSDF operator in respect of packaging and labelling of HW.

The occupier or operator of the treatment storage and disposal facility or co-processing facility or recycler shall ensure that the hazardous waste is packaged and labelled, based on its composition, in a manner suitable for safe handling, storage and transport as per the guidelines issued by the Central Pollution Control Board from time to time.

4.7 The Rules would apply to the operator of a co-processing/disposal facility only in so far as hazardous waste is concerned. Co-processing non-hazardous waste such as RDF, plastic waste, used tyres etc., may not attract the provisions of these Rules and they will be covered by the Air Pollution Control Act, 1981 and its Rules.

Consequence of the proposed amendments

4.8 The co-processor – having now become, as per the proposed amendment, operator of a disposal facility – is required to seek authorization under Section 5 of Chapter II from the concerned SPCB in Form 1. Authorization will be valid for five years.

4.9 The co-processor shall keep records of HW co-processed by him in Form 3 and submit annual returns in Form 4 to SPCB.

4.10 The co-processor shall comply with Section 7 on storage, storage ordinarily not to exceed 90 days, maintain records and make them available for inspection.

4.11 The co-processor – now operator of a disposal facility – is bound by Sections 18(1) to 18(5) in Chapter V of the Rules in respect of safe treatment (pre-processing) storage and disposal of HW.

4.12 The co-processor shall comply with Section 21(5), Chapter VI in respect of manifest system and Section 19(1) in respect of packaging and labelling.

4.13 The co-processor shall comply with Section 24, on accident reporting, in Chapter VII.

4.14 The liability of the co-processor is laid out in Section 25, Chapter VII in respect of damages caused to a third party or the environment.

5. Notes

Sections of the Rules the co-processor must comply with and listed at 4.8 to 4.14 above – now, operator of disposal facility as per amendment proposed – may be currently prescribed to the co-processor permitted under Section 11 Chapter III, as part of the authorization issued by the SPCB following approval by the CPCB as contemplated in the Section. Those are repeated for the sake of completeness.

The objective of proposing that co-processing be given legal status as a disposal option on a par with secured landfilling and incineration is to: (a) avoid co-processing take shelter under the ambiguous provision of Section 11, Chapter III, (b) provide conditions that will help set up a nationwide programme for co-processing of HW leading to energy and/or resource recovery and preventing the environmental impacts of incinerators and landfilling.

Associated technical aspects – laying down emission standards for co-processing units; prescribing methods for sampling and analysis of the standards; developing expertise in sampling and analysis; procuring allied equipment and instrumentation; establishing preprocessing facilities – should be taken up. The amendments proposed are first steps in promoting co-processing.

Some of the aspects listed above will be addressed in four more white papers to be submitted to the MoEF, Government of India, for its consideration.

Annexure-I

Emission Standards for Hazardous Waste Incinerators (now applied to co-processing cement kilns)

Parameter	Emission standard (in mg/Nm^3 except for dioxins and furans)	
Particulate matter	50	Standard refers to half hourly average value
HCl	50	Standard refers to half hourly average value
SO_2	200	Standard refers to half hourly average value
Total Organic Carbon	20	Standard refers to half hourly average value
HF	4	Standard refers to half hourly average value
NOx (NO and NO_2 expressed as NO_2)	400	Standard refers to half hourly average value
Total dioxins and furans	0.1 ng I-TEQ/Nm^3	Standard refers to 6-8 hours sampling. Please refer to guidelines for 17 concerned congeners for toxic equivalence values to arrive at total toxic equivalence.
Cd + Tl + their compounds	0.05	Standard refers to sampling time anywhere between 30 minutes and 8 hours.
Hg and its compounds	0.05	Standard refers to sampling time anywhere between 30 minutes and 8 hours.
Sb + As + Pb + Cr + Co + Cu + Mn + Ni + V + their compounds	0.05	Standard refers to sampling time anywhere between 30 minutes and 8 hours.

WHITE PAPER-II

ON TECHNICAL GUIDELINES ON ENVIRONMENTALLY SOUND PRE-PROCESSING FACILITIES TO PREPARE HOMOGENOUS WASTE MIXESSUITABLE FOR CO-PROCESSING IN CEMENT KILNS

White Paper–II

On technical Guidelines on Environmentally sound pre-processing Facilities to prepare Homogenous waste mixessuitable for co-processing in Cement Kilns

1. Summary

This White Paper sets out technical guidelines for commissioning pre-processing facilities required for co-processing AFR in cement plants. The contents of the paper are derived/ quoted from four documents cited in the reference list.

Sections 2 and 3 of this document identify AFRs with potential for use in co-processing and comment upon their availability by state. In Sections 4 and 5, the components of the preprocessing facility, unit operations, processes, safety, and environmental aspects are described. The steps to be followed when closing a facility are outlined in Section 6.

This information will help cement or waste management companies in setting up preprocessing facilities.

2. Alternate Fuels and Raw Materials (AFR) for co-processing in cement industry

2.1 Alternate Fuels

2.1.1 Types of alternate fuels

Alternate fuels can be divided into the following classes (SINTEF 2008):

- Gaseous alternate fuels, for example coke oven gases, refinery waste gas, pyrolysis gas, landfill gas.
- Liquid alternate fuels, for example, low chlorine spent solvents, lubricating as well as vegetable oils and fats, distillation residues, hydraulic oils, insulating oils.
- Pulverized, granulated or fine crushed solid alternate fuels, for example, ground waste wood, sawdust, planer shavings, dried sewage sludge residues, residues from food production, finely crushed tyres.
- Coarse crushed solid alternate fuels, plastic waste, waste wood, re-agglomerated organic matter.
- Lump alternate fuels, for example whole tyres, plastic bales, material in bags and drums.
- Refuse derived fuel (RDF) from segregated municipal solid waste.

2.1.2 Promising alternate fuels in the country

The most promising alternate fuels in the country considering energy content, availability, CO_2 mitigation potential, Case of processing and environmental concerns are identified as under (CMA and IIP 2013).

2.1.3 Characteristics of alternate fuels

Alternate fuels may contain high concentrations of chlorides, sulphur, heavy metals, moisture, etc. Thermal substitution levels must be carefully determined in case of raw materials with high chlorine and/or sulphur content. High input of alternate fuels containing these volatiles may lead to preheater blockages necessitating a gas bypass system. High moisture content in alternate

Table 6: Promising alternate fuels available in India

Alternate fuel	Total availability (million tonnes per annum)	Estimated availability for co-processing (million tonnes per annum)
Co-processable hazardous waste (2012-13)	0.54	0.40
Used tyres (2011-13)	0.83	0.40
Industrial plastic	0.20	0.10*
RDF from MSW (urban, 2011-12)	6.88	1.37
Surplus biomass (current)	150	14.6

* from Gujarat, Maharashtra, U.P., Odisha

fuels, such as commonly found in in refuse-derived fuels may lead to reduction in kiln capacity. The availability of alternate fuels and also alternate raw materials will be different from that of conventional materials in terms of packaging, size, shape, nature and consistency and therefore may need to be pre-processed to make it acceptable in the cement kiln. The substitution rate of this waste should also be adjusted according to its quality and characteristics.

2.2 Alternate raw material

The most promising alternate raw materials based on availability, environmental concerns, CO_2 mitigation potential and ease of processing are, fly ash from coal-based thermal power plants and water quenched granulated blast furnace slag. About 200 MTA and 10 MTA, respectively, of these two wastes are generated in India, but only 36 million tonnes of fly ash were used in the cement in 2010-11.The Bureau of Indian Standards specifies a maximum of 35 percent fly ash in Portland pozzolana cement (PPC); however, the proportion of fly ash can be increased as long as the required quality of product is maintained. The annual Portland slag cement (PSC) production is about 15 million tonnes and BIS specifies a slag content of 25-70 percent in cement.

3. Statewise Availability of Identified AFRs

3.1 Alternate Fuels

3.1.1 Co-processable hazardous waste

The volume of incinerable hazardous waste in million tonnes during 2007-08 is shown in Table 7.

Table 7: Volume of incinerable hazardous waste (million tonnes) during 2007-08.

State	Incinerable waste (Mt)
Maharashtra	0.153
Gujarat	0.109
Andhra Pradesh	0.032
Rajasthan	0.023
Uttar Pradesh	0.016
Punjab	0.015
West Bengal	0.013
Tamil Nadu	0.011
Others	0.044

Source: CPCB HAZWAMS, May 2010

Currently, only about 0.1 MT to0.2 MT of hazardous waste mostly from Andhra Pradesh, Madhya Pradesh, Karnataka, Tamil Nadu, Rajasthan, and Gujarat are being co-processed in the cement industry.

3.1.2 Used tyres

A state-wise inventory of used tyres for the year 2010-11, is reported below (Table 8).

Table 8: State-wise inventory of used tyres for the year 2010-11

State	Used tyres (in thousand tonnes)
Maharashtra	102
Tamil Nadu	91
Uttar Pradesh	78
Gujarat	76
Andhra Pradesh	60
Karnataka	58
Rajasthan	47
Madhya Pradesh	43
Others	179

Source: CPCB HAZWAMS, May 2010

Tyres directly fed to the kiln do not require pre-processing but they must be shredded into chips for feeding into the calciner. The net calorific value of tyres varies between 6700 and 7700 kcal/kg

3.1.3 Industrial Plastic Waste

At present, industrial plastic waste for co-processing comes from waste-paper based paper mills. Most of the plastic waste from other sources is not significant in terms of volume as it is recycled.

Gujarat, Maharashtra, Uttar Pradesh and Odisha generate the most plastic waste in the country. The quantity of waste in the four states is, respectively, 60,000-70,000, 8,000-10,000, 20,000-25,000 and 4,000-5,000 metric tonnes per annum. There are a number of cement plants in Gujarat, Maharashtra and Odisha which can co-process plastic waste; however, there are none in Uttar Pradesh. Plastic waste would have calorific values of 2000-2500 kcal/kg as raw wet waste and about 4000 - 6500 kcal/kg as dry plastic waste. Plastic waste must be shredded to the required size in a preprocessing step.

The Central Pollution Control Board (CPCB), in its guidelines for plastic waste management (CPCB 2013) has addressed the subject from a broader perspective and includes plastic in municipal solid waste (MSW). It has suggested that plastics segregated from MSW and other wastes can be used to lay roads, as AFRs in cement and power plants, and, converted into liquid RDF (oil) (a useful alternative to LDO).

The key issue here is to ensure the availability of segregated plastic waste.

3.1.4 Refuse-derived fuel from Municipal Solid Waste (MSW)

Refuse-derived fuel is made from the dry organic fraction of MSW recovered by using mechanical biological treatment on MSW. The refuse usually comprises plastics, paper, cardboard, cloth, wood, rubber, leather. Although RDF is being used to generate power, it can be effectively used for co-processing in cement kilns as well.

There are six RDF plants in India but only two are operational mostly because RDF is not made available by municipal corporations; it would be useful to know/examine why four plants are not working. Plants making RDF from MSW should be set up to further the case of using RDF in co-processing.

About 1.37 million tonnes per annum of RDF can be produced from MSW in the major urban centers of the country.

3.1.5 Surplus biomass

The surplus biomass out of the estimated current availability of 500 Million TPA is 120-150 million tonnes per annum. This surplus corresponds to a potential (in terms of calorific value and quantity) which is almost three times the coal being used by the cement industry at present. Even if 10 percent of the surplus biomass available is used in cement plants a thermal substitution rate of more than 30% can be achieved. It would be extremely beneficial to use the huge quantity of paddy (rice) straw which is normally burnt in fields to clear them for the next crop. This annual burning leads to widespread poor air quality in the harvesting season and its removal would help solve two problems at once.

The MNRE promotes the use of surplus biomass to generate power, and co-processing in cement plants may also be considered a use for biomass.

3.2 Alternate Raw Material

3.2.1 Fly Ash

About 70 percent of all the cement produced in India is Portland pozzolana cement (PPC): flyash can be used as the source of silica in this kind of cement. Maharashtra, Gujarat, Uttar Pradesh and Andhra Pradesh generate the largest quantities of flyash per year (27.9, 23.7, 17.4 and 13.9 million tonnes, respectively) (2013-14). There are large clusters of cement plants in Andhra Pradesh, Tamil Nadu, Karnataka, Rajasthan and Madhya Pradesh which can use this fly ash. Power plants and cement plants are often located too far from each other to make the use of fly ash in cement plants viable/practical.

3.2.2 Blast furnace slag

On an average 30-50 percent more energy is used to grind the slag if slag is used. There are a number of cement plants in Jharkhand, Chhatisgarh, Karnataka, Andhra Pradesh, West Bengal and Odisha which have absorbed the slag generated in these States. The total quantity of Portland slag cement (PSC) produced in the country is only about seven percent of the total cement production; however it has the potential to grow as more slag becomes available, estimated at 10 million tonnes per year.

Granulated blast furnace slag is used as a blending material to produce PSC.

4. Pre-Processing Hazardous Waste

4.1 Waste Reception and Handling at Pre-processing Centres

Preprocessing centres could be part of the user cement manufacturing unit or a standalone centre located in the industrial cluster and operated to supply the preprocessed waste to one or many cement plants. The centre could preprocess only one type of waste or more than one mix and supply to units as per their respective acceptance criteria. Such pre-processing can include drying, shredding, grinding or mixing depending on the type of waste. Mixing and homogenization will generally improve feeding and combustion behaviour. Mixing of wastes can involve risks and should be carried out according to a prescribed recipe.

Relevant extracts on waste reception and handling from the White Paper on guidelines for transportation and storage of hazardous waste, are reproduced hereunder. The extracts deal with waste acceptance, pre-acceptance, on site acceptance, in-plant tracking system, storage and loading options, safety aspects of storage and control of odour from storage areas. These aspects are considered as being relevant to the pre-processing facility of which receipt and storage of hazardous waste are necessary components.

Extracts from White Paper on Guidelines for Storage of Hazardous Waste

Waste Acceptance

It is necessary to know the composition of the waste before it is used in order to ascertain whether it falls within the requirements of the facility's permit and will not adversely affect the process. For instance, to avoid operating problems within the kiln, the impact of hazardous waste on the total input of circulating volatile elements, such as chlorine, sulphur or alkalis, should be carefully assessed before acceptance. Specific acceptance criteria for these components should be set by each facility based on the process type and on the specific kiln conditions.

Generators of hazardous waste should, in most circumstances, know the composition, nature and problems associated with their waste, ensuring that all relevant information is passed on to those involved in its subsequent management.

Hazardous and non-hazardous waste acceptance comprises two stages: first, pre-acceptance (or screening) and on-site acceptance involve providing information and representative samples of the waste to allow operators to determine suitability before arrangements are in place for acceptance. The second stage concerns procedures when the waste arrives at the facility, to confirm previously approved characteristics.

If waste samples are not screened before acceptance and if its composition is not known on arrival at the installation, there may be problems. Inappropriate storage, mixing of incompatible substances, and accumulation of wastes could occur.

Pre-acceptance

A pre-acceptance, or pre-shipment screening protocol should ensure that only properly and safely handled hazardous waste streams are approved for shipment to the facility. Such protocol is necessary to:

1. Ensure regulatory compliance by screening out unsuitable wastes;
2. Confirm the composition, and identify parameters that can be used to verify and test waste arriving at the facility;
3. Identify any substances within the waste that may affect its processing, or react with other reactants;
4. Accurately define the range of hazards exhibited by the waste.

The operator should obtain information on the nature of the process producing the waste, including its variability. Other required descriptions include: composition (chemicals present and individual concentrations); handling requirements and associated hazards; the quantity and the form of waste (solid, liquid, sludge, etc.); sample storage and preservation techniques. Ideally, information should be provided by the waste generator. Alternatively, a system for the verification of the information provided by any intermediaries should be considered.

Systems for the provision and analysis of waste representative samples should be in place. The waste sample should be taken by a competent technician and the analysis carried out by a laboratory, preferably accredited with robust QA/AC methods and record keeping and a chain-of-custody procedure should be established. The operator should carry out a comprehensive characterization (profiling) and testing with regard to the planned processing for each new waste. No waste should be accepted without sampling and testing. The exception is unused, outdated or off-specification uncontaminated products that have appropriate Material Safety Data Sheet or product data sheets.

A Waste Analysis Plan (WAP) should be prepared and maintained to document procedures used to obtain a representative waste sample and to conduct a detailed chemical and physical analysis. A WAP should address measures used to identify potentially reactive and incompatible wastes. It should include testing of a representative sample to qualify the waste for use at the facility (pre-acceptance) and to verify its constituents (acceptance). Further testing of samples taken during or after waste pre-processing or blending should be used to verify the quality of the resultant stream.

Operators should ensure that the technical appraisal is carried out by qualified, experienced staff who understands the capabilities of the facility.

Records of pre-acceptance should be maintained at the facility for cross-referencing and verification at the waste acceptance stage. Information should be recorded and referenced, available at all times, regularly reviewed and kept up to date with respect to any changes to the waste stream.

On-site Acceptance

On-site verification and testing should confirm waste characteristics with the pre-acceptance information. Acceptance procedures should address:

1. Pre-approved wastes arriving on-site, such as a pre-booking system to ensure that sufficient capacity is available.
2. Traffic control
3. Check for documents arriving with the load
4. Load inspection, sampling and testing
5. Rejection of wastes and the discrepancy reporting procedures
6. Record keeping
7. Periodic review of pre-acceptance information.

Wastes should not be accepted without detailed written information identifying the source, composition and hazard levels.

Where facilities provide an emergency service such as the removal of spillages or fly-tipped hazardous wastes, there may be situations where the operator is unable to adhere to established pre-acceptance and/or acceptance procedures. In such instances, the operator should communicate the occurrence to the competent authorities immediately.

(a) Arrival

If sufficient storage capacity exists and the site is adequately manned, suitably qualified and trained personnel should supervise the receiving of hazardous wastes. All wastes received should be treated as unknown and hazardous until compliance with specifications has been positively verified.

A suitable description should accompany hazardous waste delivery including: name and address of the generator; name and address of the transporter; waste classification and description; volume and weight; hazards of the waste such as, flammability, reactivity, toxicity or corrosivity.

Documentation accompanying the shipment should be reviewed and approved, including the hazardous waste manifest, if applicable. Any discrepancies should be resolved before the waste is accepted. If they cannot be resolved, the waste should be rejected and sent back to the original generator, or, at its request, to an alternate facility.

Wherever possible, waste loads should be visually inspected. All containers should be clearly labelled in accordance with applicable regulations for the transport of dangerous goods and checked to confirm quantities against accompanying documentation. They should be equipped with well-fitting lids, caps and valves secure and in place, and inspected for leaks, holes, and rust. Any damaged, corroded or unlabelled container or drum should be classified as 'non-conforming' and dealt with appropriately.

All incoming loads should be weighed, unless alternative reliable volumetric systems linked to specific gravity data are available.

(b) Inspection

Wastes should only be accepted at the facility after a thorough inspection. Reliance solely on supplied written information should not be acceptable. Physical verification and analytical confirmation should be undertaken to ensure the waste meets permit specifications and regulatory requirements. All wastes, whether for processing or storage, should be sampled and undergo verification and testing, according to the frequency and protocol defined in the WAP, except for unused, outdated, off-specification or uncontaminated products.

On-site verification and testing should take place to confirm:

1. The identify and description of the waste;
2. Consistency with pre-acceptance information;
3. Compliance with the facility permit.

Techniques for inspection vary from simple visual assessment to full chemical analysis. The extent of the procedure adopted will depend upon the wastes chemical and physical composition and variations; known difficulties with certain waste types or of a certain origin; specific sensitivities of the installation concerned (for example, certain substances known to cause operational difficulties); and the existence or absence of a quality controlled specification for the waste, among others (Karstensen, 2008).

The facility should have a designated sampling or reception area where containerized waste is unloaded if adequate space is available, and temporarily stored for further sampling and sample analysis. Wastes should be segregated immediately to remove possible hazards due to incompatibility. Sampling should ideally take place within 24 hours of unloading. During this period, hazardous wastes should not be bulked, blended or otherwise mixed. Bulk wastes should be inspected and accepted for processing prior to unloading.

Sampling should comply with specific national legislation, where it exists, or with international standards. Sampling should be supervised by qualified laboratory staff. Sampling should include well-established procedures such as those developed by the American Society for Testing and Materials (ASTM), the European Committee for Standardization (CEN), the United States Environmental Protection Agency (EPA), BIS and CPCB. A record of the sampling regime for each load and justification for the selected option should be maintained.

Samples should be analyzed by a laboratory with a robust QA/QC programme, including but not limited to suitable record keeping and independent assessments. Analysis should be carried out at a time scale required by facility procedures. In the case of hazardous wastes this often requires the laboratory to be on-site.

Typically, waste should be sampled and analyzed for a few key chemical and physical parameters (fingerprint analysis) to substantiate the waste composition designated on the accompanying manifest or other documents. The selection of key parameters must be based on sufficient waste profile knowledge and testing data to ensure accurate representation. When selecting fingerprint parameters, consideration should be given to those that: identify unpermitted wastes; determine suitability within the facility's operational acceptance limits; identify potential reactivity or incompatibility; indicate any changes in composition that had occurred during transportation or storage. Should fingerprint testing results of a given waste stream fall outside the established tolerance limits, the waste may be re-evaluated for possible acceptance to prevent the unnecessary movement of waste back and forth between the generator and the installation. Re-evaluation should consider facility conditions for storage and processing; additional parameter analysis deemed appropriate by the operator and established in the WAP permit requirements.

The inspection scheme may include: assessment of combustion parameters; blending tests on liquid wastes prior to storage; control of flash point, and screening of waste input for elemental composition, for example by ICP, XRF and/or other appropriate techniques, in accordance with waste types and characteristics, and the facility waste acceptance criteria.

Wastes should be moved to the storage area only after acceptance. Should the inspection or analysis indicate a failure to meet the acceptance criteria, including damaged or unlabelled drums, such loads should be stored in a quarantine area, allocated for non-conforming waste storage, and dealt with appropriately.

All areas where hazardous waste is handled should have an impervious surface with a sealed drainage system. Attention should be given to ensuring that incompatible substance do not come into contact resulting from spills from sampling, for example, within a sump serving the sampling point. Absorbents should be available.

In accordance with national legislation and practice, suitable provisions should be made to verify that wastes received are not radioactive, such as the use of plastic scintillation detectors.

After acceptance, containerized hazardous waste should be labelled with the arrival date and primary hazard class. Where containers are bulked, the earliest arrival date of the bulked wastes should be indicated on the bulk container. Each container should be given a unique reference number for in-plant tracking.

Non-conforming Waste

The operator should have clear and unambiguous criteria for the rejection of wastes, including wastes that fail to meet the acceptance criteria, and damaged, corroded or unlabelled drums. A written procedure for tracking and reporting such non-conformance should include notification to the customer or waste generator and competent authorities.

Wastes not fulfilling the acceptance criteria of the plant should be sent back to the waste generator, unless an agreement is reached with the generator to ship the rejected waste to an alternative authorized destination.

In-plant Tracking System

An internal waste tracking system and stock control procedure should be in place, starting at the pre-acceptance stage, to guarantee the traceability of waste processing.

The tracking system, which may be paper-based, electronic, or a combination of both, should trace the waste during its acceptance, storage, processing and removal off-site. At any time, the operator should be able to identify the location of a specific waste on the facility and the length of time it has been there. Records should be held in an area removed from hazardous activities to ensure their accessibility during any emergency.

Once a waste has entered bulk storage or a treatment process, tracking individual wastes will not be feasible. However, records should be maintained to ensure sufficient knowledge is available as to what wastes have entered a particular storage facility. For example, to avoid incompatibility with incoming wastes, residues building up within a vessel between de-sludging operations should be tracked.

For bulk liquid wastes, stock control should involve maintaining a record of the route through the process. Waste in drums should be individually labelled to record the location and duration of storage.

The in-plant waste tracking system should hold a complete record generated during pre-acceptance, acceptance, storage, processing and removal off-site. Records should be kept up to date to reflect deliveries, on-site treatment and dispatches. The tracking system should operate as a waste inventory, stock control system and include as a minimum:

1. A unique reference number
2. Details of the waste generator and intermediate holders
3. Date of arrival on-site
4. Pre-acceptance and acceptance analysis results
5. Container type and size
6. Nature and quantity of wastes held on-site, including identification of associated hazards
7. Details on where the waste is physically located
8. Identification of staff who have taken any decisions on acceptance or rejection of wastes

The system adopted should be structured to report on:

1. Total quantity of waste present on-site at any one time, in appropriate units
2. Breakdown of waste quantities being stored pending on-site processing
3. Breakdown of waste quantities on-site for storage only, that is, awaiting transfer
4. Breakdown of waste quantities by hazard classification
5. Indication of where the waste is located relative to a site plan
6. Comparison of the quantity on-site against total permitted
7. Comparison of time the waste has been on-site against permitted limit

Storage and Loading Options

Appropriate waste assessment is an essential element in the selection of storage and loading options. Some issues to note are:

1. For the storage of solid hazardous waste, many plants are equipped with a bunker from where the waste is fed into the installation by cranes or feed hoppers;
2. Liquid hazardous waste and sludge are usually stored in tank farm. Some tanks have storage under an inert (e.g. N_2) atmosphere. Liquid waste may be pumped via pipelines to the kiln. Sludges can be fed by using special 'viscous-matter' pumps. Appropriate storage for liquids should meet relevant safety and design codes for storage pressures and temperature and should have adequate secondary containment;
3. Some kilns are able to feed certain substances, such as toxic, odorous liquids, by means of a direct injection device, directly from the transport container into the kiln.

A common practice is to ensure, as far as possible, that hazardous wastes are stored in the same containers (drums) that are used for transport, thus avoiding the need for additional handling and transfer.

Solid and un-pumpable pasty waste that has been degassed and does not smell can be stored temporarily in bunkers. Storage and mixing sections can be separated in the bunker. This can be achieved through several design segments. The bunker must be designed in such a way that ground emissions can be prevented.

The bunker and container storage must be enclosed unless health and safety reasons (danger of explosion and fire) exist. The air in the bunker may be removed and ducted to the kiln. In anticipating fires, monitors such as heat-detecting cameras are used, in addition to constant monitoring by personnel (control room, operator).

Larger amounts of fluid and pumpable pasty wastes are temporarily stored in tanks that must be available in sufficient numbers and sizes to accommodate reacting liquids separately (danger of explosion, polymerization).

Tanks, pipelines, valves, and seals must be adapted to the waste characteristics in terms of construction, material selection, and design. They must be sufficiently corrosion-proof, and offer the option of cleaning and sampling. Flatbed tanks are generally only deployed for large loads.

It may be necessary to homogenize the tank contents with mechanical or hydraulic agitators. Depending on the waste characteristics, some tanks must be heated indirectly and insulated. Tanks are set in catch basins that must be designed for the stored material, with bund volumes chosen so that they can hold the liquid waste in the event of leakage.

For safety reasons, hazardous waste is often accumulated in special containers, which can be delivered directly to the plant. Delivery is also taken of bulk liquids.

The delivered containers may be stored or the contents transferred. In some cases, according to a risk assessment, the waste may be directly injected via a separate pipeline into the kiln. Heated transfer lines may be used for wastes that are only liquid at higher temperature.

Storage areas for containers and tank containers are usually located outside, with or without roofs. Drainage from these areas is generally controlled, as contamination may arise.

Safety aspects of storage:

- Storage area should be kept clear of uncontrolled combustible materials
- Safety warnings, no smoking signs, fire, evacuation routes and any procedures signs should be clearly posted
- An emergency shower and eye washing station should be clearly marked and locate near the storage of liquid alternative fuels
- Automatic fire detection systems and fire control systems, especially when storing flammable liquid wastes, should be installed. Foam and carbon-di-oxide control systems for the storage of flammable liquids are advantageous. Water systems with monitors, water cannons with the option to use water or foam, and dry powder systems are also used.

Continuous automatic measurement of temperature can be carried out on the surface of waste stored in bunkers. Temperature variations can be used to trigger an acoustic alarm.

The fire protection system should be available at all times and should meet all standards and specifications of the local fire department.

- Adequate alarms should be provided to alert all personnel about emergency situations
- Communication equipment should be maintained at the site to reach a control room and the local fire department in case of fire.
- The waste liquid storage sump area should be enclosed and all vent gases from such area and storage tank should be vented to an emission control system which may be destruction in kiln. Solid materials handling systems should have adequate dust control systems.

For detailed guidelines on storage reference may be made to CPCB publication HAZWAMS Nov2008.

Control of Odour from Storage Area

Obvious preventive steps are:

- Locate storage shed with residential areas in mind
- Avoid leakages from piping, transfer points
- Enclose waste liquid storage sump area and vent gases from such areas. Storage tanks should

be vented to an emission control system. Solid materials handling systems should have adequate dust control system (CPCB 2013) Solid and unpumpable pasty waste that has been degassed and does not smell can be stored temporarily in bunkers. The air in the bunker may be removed and ducted to the kiln.

Monitoring systems capable of detecting volatile organic vapors should be placed at key process locations. All volatile organic emissions from waste storage and preprocessing facilities could be exhausted by a suction duct system, subject to acceptable duct length, to the cement kiln for complete destruction. Most solvents, VOCs are completely destroyed in the kiln. Conventional odour control unit operations/ processes include:

- Tall stacks for dispersion
- Activated carbon adsorption with hot gas regeneration followed by feeding into kiln/flaring/ tall stack dispersal of desorbed gas; alternatively the exhausted carbon can be used in the kiln as fuel.
- Biofiltration
- Wet scrubbing
- Chemical treatment with chlorine, hydrogen peroxide or chlorine dioxide
- Chilled brine condenser

Choice of technology depends on volume and composition, in terms of odour causing gas, temperature and water content. In CPCB (2013), adsorption is recommended as a standby to destruction in kiln.

Training

Employees in different sections of storage, handling, etc., should be trained in the safety aspects and compliance should be audited regularly. The Cement Manufacturers Association and CPCB should periodically conduct onsite training programmes, refresher programmes and it should be mandatory for the concerned employees to get certified. Special emphasis should be placed on personal protective equipment, use of emergency equipment such as fire extinguishers, breathing masks, sorbent materials and shower stations. Special training should be provided for personnel manning the pumping site for unloading.

Special procedures, instructions and training should be in place for routine operations such as:

- Working at a height, including proper tie-off practices and use of safety harnesses
- Restrict entry in places where air quality is poor where there are explosive mixtures, dust and other hazards present
- Provide for electrical lockouts, to prevent accidental reactivation of electric equipment undergoing maintenance
- Hot works (such as welding, cutting, etc.) in areas that may contain flammable materials.

4.2 Segregation of the Waste

Waste acceptance procedures and storage depend on the chemical and physical characteristics of the waste. Appropriate waste assessment is an essential element in the selection of storage and input operations (SINTEF 2008). A well-equipped laboratory staffed with trained manpower and subjected to quality control procedures is necessary for the assessment. The segregation techniques applied vary with the type of wastes received at the facility. Segregation relates to maintaining separation of materials to avoid hazardous mixtures and to separate incompatible wastes.

4.3 Mixing

Techniques used for waste preprocessing and mixing may include:

- Mixing and homogenizing of liquid wastes to meet co-processing of input requirements such as viscosity, composition and/or heat content
- Shredding, crushing, and shearing of packaged wastes and bulky combustible waste, for example, tyres
- Mixing of wastes in a bunker using a grab or other machine. Solid heterogeneous wastes can be mixed in a bunker or a pit before loading into transport or feed systems. In bunkers, the mixing involves blending of wastes using cranes and the crane operators can identify potentially problematic loads (e.g. baled wastes, discrete items that cannot be mixed or will cause loading/feeding problems) and ensure that these are removed, shredded or directly blended (as appropriate) with other wastes. Crane capacity must be sufficient to allow mixing and loading at a suitable rate.

4.4 General design considerations

The following factors should be considered while designing the facility:

Compatibility and Reactions are depicted in the matrix hereunder:

Compatibility and Reactions Matrix

1	Oxidising mineral acids	1											
2	Caustics	H	2										
3	Aromatic hydracarbons	H F		3									
4	Halogenated organics	H F GT	H GF		4								
5	Metals	GF H F			H F	5							
6	Metals	S	S				6						
7	Satmeted aliphatic hydracarbons	H F						7					
8	Phenols and cresols	H F							8				
9	Strong oxidising agents		H	H F		H F		H		9			
10	Strong oxidising agents	H F GT			H GT				GF H	H F E	10		
11	Water and mixtures containing water	H									GF GT	11	
12	Water reactive substances	______________ Extremely reactive, do not mix ______________ with any chemical or waste material											12

E – EXPLOSIVES; **F** – FIRE; **GF** – FLAMMABLE GAS; **GT** – TOXIC GAS;
H – HEAT GENERATION; **S** – SOLUBILIZATION OF TOXINS.

- Cement plant and the pre-processing facility layout to ensure access for day-to-day operations, emergency escape routes, and maintainability of the plant and equipment. Use of recognized standards for the design of installations and equipment. Any modification and equipment should meet the standards.
- Evaluate existing equipment refitted for a different service from a safety and performance standpoint before resuming commercial production. Document any modifications to installations and equipment. Assess operations for health and safety risks or concerns to ensure that equipment is safe and to minimize risks of endangering people or installations, or damaging the environment.
- Use appropriate procedures to assess risks or hazards for each stage of the design process. Only competent and qualified personnel should undertake or oversee such hazard and operability studies.

4.5 Pre-processing Facility Requirements

Based on the above discussion, the requirements of a pre-processing facility in a cement plant or in an industrial cluster are laid out below.

- Full-fledged laboratory with trained chemists capable of properly qualifying the wastes for pre-processing and co-processing
- Appropriate covered storage facilities with impervious floors and proper odor control arrangements
- Appropriate waste handling facilities with impervious floors and odor control arrangements.
- Appropriate equipment and systems for shredding, impregnation, screening, mixing, blending, segregation, etc., as per the desired pre-processing requirement
- Proper systems and practices for traceability of wastes
- Trained manpower in different operations involved in the preprocessing operation

- Adequately designed fire fighting facility and trained man power for emergency management.
- Proper emergency management systems for leachates
- Systems and practices to monitor the health and safety of the operating personnel.

5. Pre-Processing other Alternate Fuels (CMA and IIP, 2013)

Pre-processing for refuse derived fuel (RDF)

Municipal solid waste (MSW)

Many technologies are available and are employed worldwide for pre-processing MSW. Essentially, the process used is a mechanical biological treatment where compostable wet organics are removed and converted to manure. Recyclable portions such as glass and metal are segregated for selling. The remaining portion is shredded and sieved to remove inert material. The RDF fraction is dried and compacted in hydraulic presses to increase the bulk density to about 0.7 t/m^3 which will make transport economical. In some countries, biological drying of the MSW has been attempted which increases the yield of RDF (a portion of the wet organic fraction can also be dried and used as RDF).

For the quality of MSW usually available in India, the average yield of RDF is about 10%. The net calorific value is estimated at 2,500 kcal/kg, with 25% moisture, and with an ash content ranging between 20 and 25%.There is a large variation in the quality of the material derived as RDF from the processing of MSW and therefore pre-processing is necessary to bring the waste to a uniform consistency, calorific value, ash content, chloride content and size.

RDF sized to the acceptable size for co-processing (two dimensions) can be baled and transported to the cement plant. At the plant, it can be debaled and fired in the calciner or burner either, pneumatically or by mechanical transport. Reasonably high TSR percentages of RDF can be achieved with RDF of a commensurate quality.

The major fraction of the waste from paper mills is plastic matter (50-60%) and associated paper pulp (40-50%) on a dry basis. The waste contains 40 to 50% moisture and is left in the sun to dry. When the moisture content comes down to 20-25%, it is compressed into bales and stored.

Plastic waste is baled and transported to cement plants. There, it is shredded to the required size before firing in either the pre-calciner or kiln inlet.

The equipment used for conveying and dosing plastic waste in the cement kiln inlet or calciner consists of mechanical belt conveyors, bucket elevators and air locks with weigh feeders for accurate dosing.

Used Tyres

Used tyres are collected and stored by individual tyre dealers in India. Used tyres destined for pre-processing are transported by trucks and manually handled.
Whole-tyres directly fed to the kiln do not require any pre-processing. However, tyres must be shredded into chips for feeding to the calciner. Tyre shredders should be designed for extremely close knife tolerance to produce cleanly cut chips with minimum exposed wire, so as to prevent clogging while being delivered to the calciner.

Whole tyres enter the kiln inlet through a chute while tyre chips are injected into the pre-calciner. The tyre chips are extracted from storage and passed through a weigh feeder to a combination of belt conveyors and bucket elevator to convey the material to the pre-calciner through a double flap valve and emergency shut-off gate.

Biomass

Biomass is generally manually collected and loaded into tractor trolleys for transport over short distances. For longer distances, it is baled and transported to cement plants in trucks. At the plant, it is debaled and chipped/shredded (in case of mustard straw, rice straw, sugarcane trash, etc.) and fired in the calciner or kiln main burner either pneumatically or by mechanical transport.

6. Pre-Processing Plant Closure/ De-Commissioning (UNEP 2011)

Closure is the period directly after the facility stops normal operations. During this period the facility stops accepting hazardous waste; completes storage and processing of any wastes left on site; and disposes or decontaminates equipment, structures, and soils, restoring the site, insofar as possible, to its original condition or in keeping with the intended land use. Planning for decommissioning of the facility should be undertaken during the initial stages of the overall project. By integrating decommissioning requirements into the facility design at the outset, the site development plan should be compatible with the proper closure requirements when the operation of the facility has ended.

Operators should be required to properly close the facility in a manner that minimizes the further need for maintenance, and prevents the escape of any hazardous contaminants to the environment. To ensure this, a closure plan should be prepared identifying the steps necessary to partially or completely close the facility, including:

1. Procedures for handling removed inventory
2. Procedures for decontamination and/or disposal
3. Procedures to confirm effectiveness of decontamination, demolition and excavation, including procedures for performing sample collection and analysis
4. Health and safety plan addressing all health and safety concerns pertinent to closure activities
5. Security system to prevent unauthorized access to the areas affected by closure activities

To prevent a facility from ceasing operations and failing to provide for the potentially costly closure requirements, operators should be required to demonstrate that they have the financial resources to properly conduct closure in a manner that protects both human health and the environment.

To minimize decommissioning problems and associated environmental impacts, it is recommended for existing installations, where potential problems are identified, to put in place a programme of design improvements. These design improvements should ensure that underground tanks and piping are avoided. If replacement is not possible operators should provide secondary containment or develop a suitable monitoring programme. A procedure for the draining and cleaning out of vessels and piping prior to dismantlement, among others, should also be provided.

7. REFERENCES

1. Guidelines for co-processing of AFR and treatment of HW in cement kilns, Sino-Norwegian Project, 2006-09, Draft March 2008.
2. Action plan for enhancing the use of AFR in Indian Cement Industry, CMA and IIP, July 2013.
3. Action plan with Indicative guidelines for plastic waste management, CPCB, March 2013.
4. Technical Guidelines on the environmentally sound co-processing of hazardous waste in cement kilns, UNEP, Basel Convention, October, 2011.
5. Karl. H. Karsensten. Norwegian Institute of Air Research, Norway, 2008.

WHITE PAPER–III

ON EMISSION STANDARDS FOR CO-PROCESSING OF ALTERNATE FUEL AND RAW MATERIALS (AFR) AND HAZARDOUS WASTES IN CEMENT PLANTS AND METHODS OF MONITORING EMISSIONS

White Paper–III

On Emission Standards for Co-Processing of Alternate Fuel and Raw Materials (AFR) and Hazardous Wastes in Cement Plants and Methods of Monitoring Emissions

1. Summary

A summary of the emission standards for cement plants for co-processing Alternate Fuel/Raw Material (AFR), including hazardous waste, proposed in this White Paper, is provided below:

(EFFECTIVE FROM 01.08.2015)
Units at 760 mm Hg, dry air, 10 percent oxygen 273 K

Parameter, Unit	Not to exceed	Relevant Note
1. Particulate Matter		
mg/Nm^3	50	A, B
kg/t of clinker	0.125	
2. Sulphur dioxide		
mg/Nm^3	100	A, C
relaxable upto 400 mg/Nm^3 by concerned SPCB in special cases		
3. Oxides of Nitrogen, expressed as NO_2		A, C, D
mg/Nm^3	new – 600 Existing – 800	
4. Metals		B
mg/Nm^3 Mercury and its compounds	0.05	
Cadmium and thallium and their compounds	0.05	
Sb+As+Pb+Co+Cr+Cu+Mn+Ni+V	0.5	
5. Acid Gases		A, B
mg/Nm^3 Hydrogen Chloride	10	
Hydrogen Fluoride	1	
6. Dioxins and Furans ng I-TEQ/Nm^3	0.1	B

Notes:

A: Continuous monitoring is required. Grab monitoring will not be considered for conformity check instead an average over 72 hours should be reported.

B: Method of analysis as prescribed in Methods and Standards operating practices of Emission Testing in Hazardous Waste incinerators, LATS, CPCB, September, 2007.

C: Method of analysis as prescribed in Emission Regulation Part III, published by CPCB

D: New – Cement Plants Commissioned after 01.08.2015
Existing – Cement Plants Commissioned before 01.08.2015.

2. Steps in Evolving Standards for Industrial Effluents and Emissions

2.1 General

At the national level standards for industrial effluents and emissions for various classes of industries such as pesticide, iron and steel, are arrived at keeping in mind achievability with affordability, and the best available technology. If the ratio of annual burden for treatment of liquid waste to annual turnover of a typical industry in the class is less than one percent, then it is considered affordable. The calculation of annual burden is based on annualized capital investment, and operation and maintenance cost. The best available technology for control of air emissions is limited to what is indigenously available. These national level standards – called the Minimum National Standards (MINAS) – were developed by the Central Pollution Control Board (CPCB) for various classes of industries and notified by the Ministry of Environment and Forests (MoEF) under the Environment Protection Act, 1986. These standards, however, could be (can be) made stricter, only stricter, by the State Pollution Control Boards (SPCB) and prescribed to individual units taking into account the local environmental requirement.

The CPCB studies each class of industry to identify, quantity and characterize the effluent and emission streams. The manufacturing process is also studied in detail so as to suggest in-plant control measures such as changes in raw material, process, operating conditions, reuse, recycling. Combinations of treatment processes are selected, their costs estimated, and achievable parameters for effluent quality arrived at with corresponding burden-to-turnover ratios. All these steps are discussed with representatives of the concerned industry and standards arrived at. The process described above is documented in the Comprehensive Industry Documents (COINDS) published by the CPCB. A similar exercise is under taken for air emissions; here the best available control technology forms the basis for arriving at the standards.

2.2 Emission Standards for Cement Kilns

The subject of this paper, wherein emission and effluent standards are developed for co-processing of Hazardous Waste (HW) in cement kilns, does not strictly fit into the narration of the preceding paragraphs. The reason is the emission standards are already prescribed for cement kilns under the Environment (Protection) Act, 1986, Rule 3, Schedule I, Serial Number 10. The standards for particulate matter are 400 mg/Nm^3 and 250 mg/Nm^3 for cement production capacities of up to 200 t/day and greater than 200 t/day, respectively. No other emission parameter is considered. The concerned regulatory board (SPCB) may fix stringent standards at 250 mg/Nm^3 and 150 mg/Nm^3, respectively, if the location so warrants. It also prescribes that grab sampling should not to be considered for conformity check where continuous monitors are installed and that the averaging period should not exceed 72 hours. The SPCBs have set a limit of 50 mg/Nm^3 for new plants based on the best available technology for dust control (fabric filters) and 150 mg/Nm^3 for old plants. In this context, emission standards for cement kilns which substitute around 10 to 18 percent of their fuel requirement with hazardous waste via co-processing have to be developed. It would be advantageous to make environmental best practices part of the prescribed standard.

This White Paper attempts to summarize the nature of modifications required in the standards for kilns in operation, in terms of parameters and their concentration.

2.3 Emission standards for cement kilns – proposed

(Reference: Paper presented by CPCB at the workshop on corporate sustainability on March 22, 2013)

It is proposed that standards for particulate matter be made stricter and that standards for oxides of nitrogen and sulphur dioxide be prescribed: load-based standards are also proposed. The proposals are as under:

Particulate Matter

- Plants commissioned on or after 3.2.2006 – 50 mg/Nm^3, 0.125 kg/t of clinker. The load-based standard seems to have been calculated on 2500 m^3/t of clinker in kiln emissions. The Cement Manufacturers Association, (CMA) however, gives a figure of 3600 m^3/h/t.
- Plants located in urban areas or critically polluted areas and commissioned before 3.2.2006 – 100 mg/Nm^3, 0.25 kg/t
- Plants located in other areas and commissioned before 3.2.2006–150 mg/Nm^3, 0.375 kg/t
- Effective 1.8.2014, the standards are 50 mg/Nm^3 and 0.125 kg/t for all plants.

Oxides of nitrogen: mg/Nm^3 at 10 percent oxygen

- New plants – 600 mg/Nm^3
- Existing Plants – 1000 mg/Nm^3 *(commissioned on or after notification)*

Standard effective from 1.8.2015 – 800 mg/Nm^3

Sulphur dioxide: mg/Nm^3 at 10 percent oxygen for cement plants having sulphur content in raw meal

- Less than or equal to 0.5 percent – 100 mg/Nm^3
- More than 0.5 percent – 1000 mg/Nm^3

3. Co-processing in cement kilns – brief description.

(**Source:** Technical Guidelines, UNEP/CHW.10/6/Add/3/Rev.1, 11, November 2011)

3.1 Brief description of cement manufacture

The total installed capacity in the country in 2013 was 350 million tons/year (MTA) while production was 174.29 MTA. Thermal energy required is 734 kcal/kg of clinker.

Cement production involves the heating, calcining and sintering (clinkering) of an accurately defined proportion of calcareous and argillaceous materials which produces clinker. Clinker is then cooled and ground with additives such as gypsum fly ash to produce cement. The raw material consists essentially of calcium carbonate in the form of limestone, clay or shale. The raw materials may contain metals and halogens in amounts that depend on the geological formations from which the they are mined. The fuel used in India for heating, calcining and sintering is coal, which, in turn, may contain sulphur, trace metals and halogens, in quantities that vary with the location of the mine. The typical composition of raw material and coal used in clinker production is furnished in Annexure I. Cement clinker is burnt in rotary kilns in one of four types of arrangement: dry, semidry, wet or semi wet. Typically 1.5 to 1.7 tonnes of raw material are required per tonne of clinker produced, and 140-180 kg of coal of calorific value 5000 kcal/kg is required. This amount of energy maintains a temperature of over 2000°C in the kiln.

Clinker burning is the most important phase of the production process in terms of the environmental impact associated with cement manufacture. Depending on the specific production process, emissions to air, to land and to water occur, apart from noise. The key pollutants released to air are particulates, nitrogen oxides and sulphur dioxide. Other emissions include carbon monoxide (CO), carbon dioxide, polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (PCDDs, PCDFs), volatile organic compounds (VOC), metals and their compounds, hydrogen chloride (HCl) and hydrogen fluoride (HF). The composition of air emissions is variable and depends on the raw materials and fuels used and the process followed.

3.2 Brief description of co-processing of hazardous waste in cement kilns

Co-processing of hazardous waste (HW) in cement kilns allows the recovery of the energy and minerals value from waste while cement is being produced. The process characteristics in clinker kilns ensure the complete breakdown of the raw materials into their component oxides and the recombination of the oxides into the clinker minerals. The essential process characteristics, for the use of hazardous and other wastes fed to the kiln via appropriate feed points are summarized as follows:

1. Maximum temperatures of approximately 2000°C (main firing system, flame temperature) in rotary kilns;
2. Gas retention times of about 8 seconds at temperatures above 1200°C in rotary kilns;
3. Material temperatures of about 1450°C in the sintering zone of rotary kilns;
4. Oxidizing gas atmosphere in rotary kilns;
5. Gas retention time in the secondary firing system of more than 2 seconds at temperatures above 850°C; in the precalciner;
6. Solids temperatures of 850°C in the secondary firing system and/or the calciner;
7. Uniform burnout conditions for load fluctuations due to the high temperatures at sufficiently long retention times;
8. Destruction of organic pollutants because of high temperatures at sufficiently long retention times;
9. Sorption of gaseous components such as HF, HC_1, and SO_2 on alkaline reactants;
10. High retention capacity for particle-bound heavy metals;
11. Short retention times of exhaust gases in the temperature range known to lead to formation of PCDDs/PCDFs;

12. Simultaneous material recycling and energy recovery through the complete use of fuel ashes as clinker components;
13. Product-specific wastes are not generated due to a complete material use into the clinker matrix (although some cement plants dispose of cement kiln dust, or bypass dust);
14. Chemical-mineralogical incorporation of non-volatile heavy metals into the clinker matrix.

The two important general principles in co-processing are: 1. additional emissions and negative impacts on human health must be avoided; 2. the quality of the clinker/cement must remain unchanged. Requirements for co-processing are: 1. best available technology for air pollution prevention and control with continuous emission monitoring; 2. exit gas conditioning/cooling and temperature less than 200°C in control devices to prevent dioxin formation. The operator of the co-processing plant should develop a waste evaluation procedure to assess health and safety of workers and public, plant emissions, operations and product quality. Variables that should be considered when selecting waste include:

1. Kiln operating parameters
2. Emissions
3. Clinker, cement and final product quality

Hazardous wastes suitable, subject to trial runs for co-processing in cement kilns, are listed by CPCB in Appendix A of the document, Guidelines on co-processing in cement/power/steel industry, February 2010. The protocol for trial runs is detailed in the document. Waste not recommended for use are also listed in the document are as under:

- Biomedical waste
- Asbestos-containing waste
- Electronic scrap
- Entire batteries
- Explosives
- Corrosives
- Mineral acid waste
- Radioactive waste
- Unsorted municipal garbage

Acceptance criteria for fuel value and energy value are stated in Annexure 5 and schematically presented in Annexure 4 of the document. The gas resulting from co-processing HW in the kiln shall be held for at least two seconds at 950°C and if the HW contains more than one percent of halogenated organic substances (expressed as chlorine) the kiln temperature should be 1100°C. HW shall not be fed unless the above stated temperatures are attained and maintained.

4. Sources and Composition of Gaseous Emissions and Liquid Effluent – measures/methods of Control

4.1 Gaseous emissions

(**Source:** Technical Guidelines, UNEP/CHW Particulate matter, November, 2011)

Cement production involves drying, heating, calcining, clinkerization and cooling of materials through direct contact with hot gases. It also involves pneumatic material transport and material classification and separation. At the end of these processes, air, gases and pulverized materials have to be separated.

Incomplete separation gives rise to dust emissions, that is particulates from:

- Kiln/raw mill main stack
- Clinker cooler stack
- Cement mill stack
- Material transfer point dedusting air outlets

By providing bag filters or upgraded ESPs emission particulate levels as low as 10 mg/Nm^3 can be achieved. This may be compared with 50 mg/Nm^3 proposed by the CPCB for particulate matter standards. (Section 2.3)

Sulphur dioxide results from the oxidation of sulphides or elemental sulphur contained in the fuel or raw material (in a favourable oxygen and temperature regime). Typical characteristics of coal used in cement kilns in the country are furnished in Annexure I. However, the alkaline nature of the cement particles allows SO_2 to be absorbed, reducing its emission to the atmosphere. The range of emissions reported is mostly below 100 mg/Nm^3, but can rise sometimes to 3000 mg/Nm^3 depending upon the levels of volatile sulphur compounds contained in the raw material. The best available technology to reduce emissions is absorbent addition or wet scrubbing, resulting in less than 50 to less than 400 mg/Nm^3, (daily average value), again, depending on the sulphur content of the raw material. This may be compared to CPCB's proposed standard of 100 and 1000 mg/Nm^3 (Section 1.3). Of relevance here is the height, in general, of the main stack, which the Cement Manufacturer's Association gives as between 60 and 80 meters. A 70 m stack may emit roughly 5 kg/h of SO_2 without impacting air quality as per the CPCB norm of $H=14(Q)^{0.3}$ where H=stack height, and Q is the SO_2 emission rate in kg/h.

Nitrogen Oxides

Thermal NOx results from the oxidation of molecular nitrogen in air in the kiln's burning zone where temperature is more than 1200°C. Fuel NOx results from the oxidation of nitrogen in the fuel at lower combustion temperatures; the range of total uncontrolled raw emissions is 300 to 2000 mg/Nm^3. NOx emissions may be reduced by applying the following measures/ techniques individually or in combination:

1. Primary measure: flame cooling, low NOx burners, mid-kiln firing, addition of mineralizers to improve the burnability of raw meal, process optimization.
2. Staged combustion, also in combination with a pre-calcinator and the use of optimized fuel mix
3. Selective non-catalytic reduction
4. Selective catalytic reduction.

The associated emission levels are: (in mg/Nm^3, daily average)

Preheater kilns – 200-450 mg/Nm^3

Lepol/long rotary kilns – 400-800 mg/Nm^3

These may be compared with 600 mg/Nm^3 for new, and 800 mg/Nm^3 for existing plants, effective 01.08.2015, proposed by the CPCB, (Section 2.3).

The CPCB measured the levels of the pollutants discussed above in 44 kilns. The results along with proposed standards are presented in Table 9.

The CPCB recorded a maximum concentration of (NOx above 1000 mg/Nm^3) in nine out of fourteen cases. Optimization of pre-processing is reported to effect 20 percent reduction in NOx emissions, and, low NOx burners, a 40 percent reduction.

Low emission levels of SO_2 and PM may be noted. If petcoke or high sulphur content coal is used then SO_2 levels may be higher.

Emission of Organic Compounds

Vapours of organic compounds are emitted mainly by the evaporation and/or cracking of the constituents of petroleum and kerogens found in the raw material mix. Uncontrolled emissions are usually below 50 mg/Nm^3 and can be kept low by avoiding feeding raw material with a high content of volatile organic compounds via the raw material feeding route. Sufficient residence time is needed to destroy organic compounds.

Acid Gases

Typical concentrations of HCl and HF are under 10 mg/Nm^3 and 1 mg/Nm^3, respectively. Emissions of the

Table 9: Levels of pollutants in cement kilns measured by CPCB.

NOx: mg/Nm^3 at 10 percent oxygen	< 200	200-500	500-800	800-1000	> 1000	
	< 200	200-500	500-800	800-1000	> 1000	
Number of kilns	2	15	19	7	1	44 kilns
Proposed standards: (in mg/Nm^3)	600 for new; 800 for existing w.e.f. 1.8.2015, 1000 till then.					

SO_2 mg/Nm^3 at 10 percent oxygen	< 10	10-100	100-400	> 400		
Number of kilns:	22	18	1	3		44 kilns
Proposed standards: (in mg/Nm^3)	Less than 0.5 percent sulphur in raw meal – 100; greater than 0.5 percent – 1000.					

P. M. mg/Nm^3 at 10 percent oxygen	< 50	50-100				
Number of kilns:	10	4				14 kilns
Proposed Standards: (in mg/Nm^3)	New-50; Old 100 or 150; mass 0.125/0.25 or 0.375 kg/t					

acid gases can be kept within limits by controlling raw material quality, fuel quality and AFR mix. Acid gases may combine with alkalis to form fine particles which are difficult to remove.

Heavy Metals

The input materials may contain heavy metals which then appear in the emissions from the kiln. The typical composition is furnished in Appendix I. Most of the time, emissions remain below detection limits, excepting for mercury in some cases. The following measures in combination or individually may be adopted to minimize metal emissions:

- Control over content of materials input including AFR
- Using effective dust removal systems.

Associated emission levels are: mercury less than 0.05 mg/Nm^3, cadmium and thallium, less than 0.05 mg/Nm^3, Sb+As+Pb+Cr+Co+Cu+Mn+Ni+V, less than 0.5 mg/Nm^3.

The non-volatile nature of most heavy metals allows them to be incorporated into the clinker, but some of the volatile components such as mercury, thallium are emitted.

Polychlorinated dibenzo–p–dioxins (PCDD) and Polychlorinated dibenzo furans (PCDF)

If chlorine and hydrocarbon precursors are available in sufficient quantities in the temperature range of 200°C to 450°C in or after the preheater and in the air pollution control device, PCDD and PCDF are likely to be formed. Although limited data are available, measurements from all over the world show emission levels below I-TEQ, dry gas 273K, 101.3 kPa and 10 percent oxygen. The following measures to keep emissions low that is, less than 0.1 ng I-TEQ/Nm^3 are applicable:

- Controlling
  (1) kiln raw material inputs: chlorine, copper and volatile organic carbon
  (2) fuel input: chlorine and copper
- Limiting/avoiding the use of waste containing chlorinated organic materials
- Quick cooling of kiln exhaust gas to lower than 200°C, minimizing residence time and oxygen content in zones at 300 to 450°C
- Stop feeding waste at start up/shut down.
- Avoid feeding fuels with a high content of halogens (e.g. chlorine) in secondary firing.

4.2 Results of trial runs

Five trial runs using tyre chips, treatment plant sludge, TDI tar, and refinery sludge were conducted at four cement plants during 2005-2006. Officials from the CPCB and the plant monitored the overall performance – clinker quality, process parameters – and emission quality. Metals, acid gases, dioxin and furans, PM, SO_2, NOx were measured in the emissions. The details of AFR used and corresponding emission quality are summarized in Appendix II.

The standards proposed in this document are based on these results and those found in the literature. The proposed standards as in Section 5.2 are also stated for comparison.

4.2.1 Dioxin and Furans

Holcim monitored dioxin and furan concentrations in 153 co-processing cement kilns during 2001 and 2002. The levels of dioxin and furan were found to be 0.041ng I-TEQ/Nm^3 for 71 kilns, and 0.030ng I-TEQ/Nm^3 for 82 kilns. The minimum and maximum values measured were 0.0001 and 0.292 ng TEQ per Nm^3 (Technical Guidelines, Reference 1).

In another study of 110 cement kilns, the average was 0.016ng I-TEQ/Nm^3, the minimum and maximum being less than 0.001 and 0.163 ng I-TEQ/Nm^3. The above data appear to be representative of normal operation rather than during co-processing, but this was not clear from the source where this information was obtained. Our trial runs (Annexure II), indicate a maximum of 0.133 ng I-TEQ/Nm^3. Data from dry preheater and precalciner cement kilns in developing countries suggest emission levels much lower than 0.1ng I-TEQ/Nm^3.

International standards are 0.1ng I-TEQ/Nm^3 which is the value proposed in this document as the standard; however, as more data becomes available from co-processing plants we may review this.

4.2.2 Metals

Best available technology (BAT) to minimize metal emission is by selection of low metal content AFR, especially, mercury, as also an effective dust removal system.

BAT associated emission levels are: mercury less than 0.05 mg/Nm^3; cadmium + thallium less than 0.05 mg/Nm^3, Sb+As+Pb+Cr+Co+Cu+Mn+Ni+V less than 0.5 mg/Nm^3. Levels as low as these were obtained during our trial runs.

4.3.3 Acid gases

Except for one case where industrial effluent treatment plant sludge was being co-processed, levels of the acid gases were much below the current HW incinerator standards. Therefore stricter standards than the current 10 mg/Nm^3 and 1 mg/Nm^3, are proposed for HCl and HF, respectively.

4.4 Liquid Effluent

Spillage in HW storage/handling areas, drum washings, etc., may result in contaminated waste water discharge. General standards for the discharge of pollutants covering 33 parameters are prescribed in Schedule VI of the Environment Protection Act, Rule 3, 1986. Parameters include heavy metals, pH, phenolic compounds, fluoride, suphide and also a bioassay test. There are well known physico-chemical and biological treatment processes for treating the wastewater to meet the standards, if required.

5. Best Environmental Practices

Sources: (1) Guidelines for co-processing of alternative fuels and raw materials, Sino–Norwegian Project 2006-2009, Draft, 25, March 2008. (2) Technical guidelines on environmentally sound co-processing UNEP/CHW.10/6/Add Nov-2011)

5.1 In Sections 2 and 3 above, the best environmental practices (BEP) and best available technology (BAT) measures to control pollution are interwoven. However, important BEPs are restated or stated hereunder.

5.2 In the selection of waste for co-processing:

- Excessive alkali, sulphur and chloride and high moisture content, ash content should be avoided
- High levels of fluorine will affect setting time and strength of cement and so should be avoided
- Negative list of CPCB to be followed.

5.3 In kiln operation:

- Process control optimization including computerized automatic control system
- Use of modern fuel feed system such as gravimetric solid fuel feed system, feed cut-off when operating conditions deviate from limits
- Feeding homogenous raw materials and fuels
- Smooth and stable kiln process operating close to set points
- No feeding of AFR during start-up and shut-down
- Kiln exhaust gas temperature to be reduced to less than 200°C
- Main fuel input, 65-85 percent, to be in pulverized form, with remaining coarsely crushed or lumpy.
- Content of sulphur, nitrogen, chlorine, fluorine metals and volatile organic compounds to be specified and carefully controlled
- Feeding of waste to the kiln must ensure exposure to sufficient temperature, more than 900°C, sufficient retention time, good mixing conditions and oxygen supply
- Constant quality and feed rate of AFR must be ensured. Feed point to be chosen suitable to the AFR. HW should only be introduced in the high burner, pre-calciner burner, etc. POP and highly chlorinated organics only at the main burner
- Procedures for stopping waste feed in the event of an equipment malfunctioning or other emergency must be in place. The co-processor should set out system controls and set points which could provide for automatic shut down of HW supply/intake
- Setting up a laboratory with all infrastructure, trained manpower, inter laboratory quality checks, all specific to the HW/AFR being co-processed.

6. Proposed Standards and Analytical Methods

6.1 Preamble

The rationale for effluent and emission standards was set out in Section 2. Co-processing HW in cement kilns emerges from Sections 3 and 4, as an essentially emission causing activity requiring emission standards to be set. Accordingly, as per Section 2, best available technology (BAT) would form the basis for the standards. In Section 4, while discussing emission characteristics applicable, BAT and achievable/achieved levels of pollutants are discussed, and in Section 5 best environmental practices (BEP) to achieve the levels with BAT are discussed.

The CPCB has proposed emission standards for cement kilns for SO_2 and NOx; currently only particulate matter is covered. The CPCB has laid down that the emission standards for particulate matter prescribed for cement kilns by the concerned SPCB shall be applicable during co-processing in the cement kiln also. It follows that the proposed standard for SO_2 and NOx will also be applicable to co-processing cement kilns. In respect of other parameters, acid gases, metals, dioxins, furans, reported standards/results of emission monitoring and results generated by the CPCB and industry during trial runs (refer to Annexure II). The basis for arriving at the proposed standards are contained in Section 4.2 above.

Accordingly, standards for co-processing AFR in cement kilns are proposed for the consideration of the MoEF as under:

6.2 Proposed Standards for AFR Co Processing in Cement Kilns

(Units: mg/Nm^3, 760 mm Hg, dry air, 10 percent oxygen, 273 K, half hours, averaged value (unless otherwise stated).

Applicable from 1.8.2015 up to 31.7.2020

6.2.1 Parametric standards

6.2.1.1 Particulate matter

- Concentration in emissions from kiln stack shall not exceed 50 mg/Nm^3 at any time. Mass of emission shall not exceed 0.125 kg/t of clinker.
- Method of measurement: (a) continuous recording monitor (b) reference method as in Methods and SOPs of emissions testing in hazardous waste incinerator, LATS, CPCB, Sep. 2007 Chapters 1 and 2.
- Control measure/equipment: ESP or bag (fabric) filters.

6.2.1.2 Sulphur dioxide

The CPCB proposes a standard of 100 mg/Nm^3 and 1000 mg/Nm^3 for kilns using raw meal with less than 0.5% sulphur and more than 0.5% sulphur, respectively. The rationale for a tenfold difference over a thin divide is not clear. CPCB data on cement kilns – 44 of them – indicate 22 units emit less than 10 mg/Nm^3, and 18 emit less than 100 mg/Nm^3: these were not co-processing HW. Further, the stack heights being 60-80m, significant dispersion could be achieved; our policy for SO_2 control has been so. The CPCB might like to consider revising the proposed standard of 1000 mg/Nm^3 to 100 mg/Nm^3 with a proviso that it could be relaxed up to 400 by the SPCB depending upon the sulphur content of the fuel used; the unit may also be asked to install a taller stack or a wet scrubber, if blending with low sulphur fuel or raw material is determined by the SPCB as not being feasible or adequate to meet the 100 mg/Nm^3 standard. To sum up, the recommended standard is 100 mg/Nm^3 relaxable up to 400 mg/Nm^3 by the SPCB on a case to case basis.

- Method of measurement: (a) continuous recording monitor (b) reference method as in Emission Regulation Part III, published by the CPCB
- Control measure/equipment: blending the fuel-raw material mix with low sulphur fuel/material, or tall stack or wet scrubber.

6.2.1.3 Oxides of Nitrogen

For oxides of nitrogen, expressed as NO_2, the CPCB has proposed 600 mg/Nm^3 for units set up after the notification and 800 to those operating before. Thirty six out of 44 cement plants monitored by the CPCB emitted less than 800 mg/Nm^3, while seventeen emitted under 500 mg/Nm^3. The proposed standards will also apply to co-processing plants.

- Method of measurement: (a) Continuous recording monitor (b) Reference method as in emission regulation Part-III published by the CPCB.
- Control measure/equipment: Primary measure flame cooling, low NOx burners, mid-kiln firing, addition of mineralizers to improve burn ability of the raw meal, process optimization staged combustion, also in combination with a pre-calciner, and using an optimized fuel mix.

6.2.1.4 Metals

The discussion in Section 3.2 is relevant to metals, acid gases and dioxins and furans.

- Mercury and its compounds, 0.05 mg/Nm^3
- Cadmium and thallium and their compounds – 0.05 mg/Nm^3
- Sb+As+Pb+Co+Cr+Cu+Mn+Ni+V and their compounds, 0.05 mg/Nm^3.
- Method of measurement: Atomic absorption spectroscopy (AAS) or Inductively Coupled Argon Plasma Emission Spectroscopy (ICAP) as per the

CPCB publication LATS, September 2007, pages 62 to 97.

- Control measures/equipment: (a) Control over contents of material inputs including AFR (b) Using effective dust removal system.

6.2.1.5 Dioxins (PCDD) and furans (PCDF) not to exceed 0.1ng I-TEQ/Nm^3

- Method of measurement: Separation by high resolution gas chromatography (HRGC) and measured by high resolution mass spectrometry (HRMS) as per the CPCB publication LATS, September 2007, pages 98-156.
- Control measures/equipment: (a) Controlling raw material inputs, chlorine, copper and volatile organic carbon, as well as fuels. (b) Limiting/avoiding wastes containing chlorinated organics. (c) Quick cooling of kiln exhaust gas to lower than 200°C, minimizing residence time and oxygen content at zones at 300°C to 450°C. (d) Stop feeding waste at startup/shutdown.

6.2.1.6 Acid gases

As mentioned earlier, concentrations normally encountered are 10 mg/Nm^3 and 1 mg/Nm^3 for HCl and HF, respectively (Section 3.1). The CPCB has prescribed 50 mg/Nm^3 and 4 mg/Nm^3 for HCl and HF from HW incinerators, respectively, which may be high for co-processors. Therefore 10 mg/Nm^3 for HCl and I mg/Nm^3 for HF are proposed for co-processors of AFR.

- Method or measurement: Ion chromatography as per the CPCB publication LATS, Sep. 2007 pages 39-61
- Control measures/equipment: Control of raw material, fuel quality and that of AFR.

6.2.2 Best Environment Practices (BEP)

BEP listed in Section 5 above may be considered part of the standards.

6.3 Additional Control Equipment

A frequently asked question is whether additional air pollution control equipment (APCE) is needed to meet co-processing demands. It may be seen from the above for all parameters that no additional APCE is required and that the choice of raw material, fuel, AFR, and control of operating conditions may be the only measures needed to meet the proposed standards. However if standards are not met, then activated carbon filters could be used. For volatile organic compounds, metals, ammonia, ammonium compounds, hydrogen chloride, hydrogen fluoride, activated charcoal has removal efficiencies greater than 90 percent. Residual dust may also be removed from the exhaust gases by adsorption on activated carbon. For volatile organic compounds bacterial bed filters could also be considered.

6.4 Suggestions for Review of the Proposed Standards/additional Parameters

The proposed standards herein above may be revised in 2018 for application from 31.7.2020. For example, the PM standard could be 10 mg/Nm^3. It is expected that over the coming years more and more data on field emissions, efficiency of in-plant control measures, setting up pre-processing plants, experience in kiln feeding will be available which will help in a review of the standards. Additional/surrogate parameters such as TOC, VOC may be provided.

6.5 Laboratories for Testing Compliance

There are two aspects to the testing, sampling and analysis. There are many laboratories accredited by the National Board for Accreditation of Laboratories (NABL) in the Department of Science and Technology, Government of India. These include BARC, ONGC, IOC, Hindustan Dorr Oliver, SGS India. NABL is a member of the International Laboratory Accreditation Co-operation. It has to be verified whether these laboratories could analyze samples although it is unlikely that any of them would carry out sampling.

SGS India, Mumbai, Vimta Lab Hydrabad, CPCB laboratory are equipped for sampling and analysis of all the parameters, dioxins and furans included.

6.6 Allowable Violation of Standards

The SPCBs may, in the consent to operate, include a clause permitting the plant to exceed the emission standards momentarily, where continuous monitors are installed; testing for conformity however, should be done over a 72 hour averaging period. The violation should have been caused by malfunctioning of manufacturing and/or pollution control equipment. This is provided in the Environment Protection Act, 1986.

7. Emission monitoring schedule

7.1 The co-processor shall have trained manpower on its rolls to, at the least, collect stack samples as per the procedures laid down by the CPCB. Analysis, especially of metals and dioxins, furans and acid gases could be carried out in recognized/accredited laboratories. Sample processing laboratories shall be established with qualified personnel.

7.2 Self-monitoring by reference method

Dioxins, furans, metals acid gases – once a year
PM, SO_2, NOx – once a month

Continuous emission monitors to be calibrated once a year and installed for PM, SO_2, NOx and acid gases, and for exhaust volume, humidity, temperature, oxygen, CO, volatile organic compounds and pressure.

7.3 Regulatory monitoring by SPCB

Once a year, for all parameters by the reference method.

8. Suggested Contents of Authorization

(**Source:** Reference: Norway-China Project document, March 2008)

8.1 Authorization issued to co-processors by SPCB should contain provisions for making them legal requirements. These conditions should be discussed with the operator and mutually agreed to, with both parties signing the document. These conditions are proposed to ensure best operating conditions which are prerequisites, or even only measures in some cases, to meet the prescribed emission standards.

8.2 Contents of the authorization

A: Procedures and requirements

- Plant organization and components description of the plant, organizational structure, location, environment management system (EMS), laboratory facilities, product quality control routines, clinker process technology; raw material fuel sources, feeding; baseline emissions without AFR, continuous monitoring equipment, exit gas conditioning and cooling, air pollution control devices, AFR equipment receiving, storage and preprocessing, feeding and control, health, environment, emergency and safety issues, water/power sources.
- The information above should be documented by plant pictures, topographical and geographical maps indicating nearby resources.
- Description of the intended AFR, its sources, processing, supply, quality control and assurance
- Input evaluation of the use of AFR
- Procedures for the implementation and maintenance of pollution prevention and occupational health and safety standards
- Negative list, that is, wastes not permitted at all to be fed
- For the waste(s) permitted for the plant, type, volume/mass/percentage of input, quality and characteristics, origin and main supplier, requirements and procedures for control, sampling and analysis on receipt, preprocessing storage requirement, requirements and conditions for feeding to the process on start-up and shut down as well as requirements for interlocks and set points for stopping waste feed
- Procedures and requirements for collection and analysis of process and environmental samples as well as health check of employees.

B. Monitoring and control of combustion

The cement plant must provide input limits and operational set points for each of the categories of alternate fuel, alternate raw material and hazardous waste permitted. The authorization must describe baseline conditions such as:

1. Normal good and stable kiln/process operation without feeding of AFRs/hazardous wastes
2. Normal readings of the continuous emission monitoring equipment (CEM) and CO level without feeding of AFRs/hazardous wastes
3. Normal values for cement quality without feeding of AFRs/hazardous wastes
4. Stable smooth kiln/process operation with controlled and separate feeding of AFRs/hazardous wastes
5. Readings of the CEM and CO-levels with controlled and separate feeding of AFRs/hazardous wastes,
6. Values for cement quality with controlled and separate feeding of AFRs/hazardous wastes; and further
7. Operational modes, i.e. differences in direct compound mode when it comes to emissions
8. Emission limit values/window for the CEMs, O_2 and for CO levels

9. Conventional raw meal and fuel feed requirements
10. Kiln production and kiln speed requirements
11. Maximum kiln coating temperatures (if relevant)
12. Minimum kiln inlet and outlet temperatures
13. Minimum retention time at specific temperatures
14. Minimum kiln inlet and outlet oxygen concentration (CEM)
15. Procedures for operation of the air pollution control devices and maximum "down-time", as well as requirements for exhaust gas conditioning
16. Operation procedures when loss of draft in the firing hood or fan stoppage
17. Operation procedures in the event of kiln ring formation or cyclone blockage
18. Operation procedures in the event of major fugitive emissions
19. Operation procedures for recycling of dusts.

C. Air pollution control

1. All exit gases must be cleaned and discharged through stacks of minimum height as under: Source height, m diameter, m applicable parameter
2. Emission standards – Parametric as in Section 5.2 and 5.6 or as in Summary
3. Emission monitoring schedule as in Sections 6.2 and 6.3.

D. Best Environmental Practices

As appropriate, from Sections 2, 3, 4 and 5.2.2.

E. Period of validity of the Authorization as determined by SPCB.

F. Other legal conditions as per the HW (Management, Handling and Transboundary Movement) Rules, 2008.

Notes

In the preceding sections an attempt is made to evolve the standards for emission from cement kilns co-processing alternate fuels and raw materials (AFR) based on available literature and limited emission monitoring results generated by CPCB and the industry. The guiding principle has been maintaining emission limits with or without AFR. As more data from self and regulatory monitoring emerges the standards can be refined.

Annexure I

Typical Characteristics of Coal Petcoke Used in Cement Industries in the Country

UNIT %

Proximate Analysis	1	2	3	4
Moisture content	2.2	2.3	2.2	7.5
Ash content	3.2	34.3	32.4	0.7
Volatile matter	22.6	21.8	22.4	10.2
Fixed carbon	20.4	21.4	21.2	88.2

Ultimate Analysis	1	2	3	4
Carbon	28.6	29.8	78.6	
Hydrogen	2.1	2.0	3.9	
Sulphur	1.0	1.0	1.0	
Nitrogen	2.4	2.0	0.4	4.5
Oxygen	12.1	9.3	10.9	
Gross Calorific Value kcal/kg	2896	2712	5240	9310

1. Gujarat Ambuja Cements, Kodinar
2. Rajashree Cement, Gulbarga
3. Grasim Industries, Reddipalayam (Ultimate Analysis on dry basis)
4. Petcoke – India Cements Dalavai

Typical Composition of Limestone Used in Cement Industries in the Country

	Plant 1 (in ppm)	Plant 2 (in ppm)
Thorium	1.4	1.5
Cadmium	< 0.05	< 0.05
Mercury	<1	<1
Copper	10	9
Arsenic	<5	<5
Vanadium	18	<10
Lead	<5	27
Manganese (as MnO_2)	<0.05	0.07
Chromium	18	<15
Nickel	6	<5
Antimony	12	<10
Cobalt	<5	<5
Sulphur	350	373

Source: India Cement at Dalavai and Sankari

Annexure II

Emission Results After Conventional Control in Trial Runs Using AFRs
(Source: CPCB)

1. Rajashree Cement, Karnataka, 2800 tpd
   Waste: Effluent treatment plant sludge @ 5 to 6% of BASF INDIA, 3415 Kcal/kg, Sulphur 3.2%
   When: January 16 to February 8, 2005
2. Gujarat Ambuja Cement, Kodinar
   Waste: TDI Tar of Normada Chemtaur Petrochemicals @ 4 to 7%, Sulphur< 0.01, 7874 kcal/kg.
   When: February 12 to March 3, 2006
3. Lafarge India Ltd, Raipur
   Waste: TDI tar of Normada Chemtaur Petrochemicals @ 5 to 7%
   When: May 12 to 31, 2006
4. Grasim Industries, Reddipalayam
   Waste: (i) Tyre chips CP2 456 mg/kg, 11515 kcal/kg, F 83 mg/kg @ 10 to 20%
   (ii) refinery sludge 3763 kcal/kg @ 10 to 20%.

A: Pre coinceneration; **B:** During co-incineration; **C:** Post co-incineration; **D:** Proposed standard in this document.

Trial Run 1 **Unit=mg/Nm^3unless otherwise stated**

	Concentrations			
	A	B	C	D
Particulate Matter	164	160	178	50
Sulphur dioxide	6	9	9	100
Oxides of Nitrogen	435	564	387	800
Hydrogen chloride (HCl)	1	24	4	10
Hydrogen Fluoride (HF)	0.6	7	3	1
TOC	160	212	2	Not specified
Dioxins and furans ng I-TEQ/Nm^3	0.003	0.004	0.003	0.1

Trial Run 2

Sb+As+Pb+Cr+Co+Cu +Mn+Ni+V – micro gram/Nm^3	7.2	7.6	7.2	Total nine metals 500 = 0.5 mg/Nm^3
Dioxins and furans ng I-TEQ/Nm^3	0.133	0.020	0.015	0.1

Trial Run 3

Particulate Matter	51	53	52	50
Sulphur dioxide	4	4	4	100
Oxides of nitrogen	419	581	608	800
Dioxins and furans ng I-TEQ/Nm^3	0.011	0.005	0.011	0.1

Trial Run 4

		10%/20%		
Lead $\mu g/Nm^3$	6	5/5.2	6	Total nine metals – 500 = 0.5 mg/Nm^3
Arsenic	1.1	1.3/1.4	1.2	
Antimony	15	14/14.5	15	
Dioxins and furans ng I-TEQ/Nm^3	0.018	0.014/0.024	--	0.1

(Concentrations rounded off)

WHITE PAPER–IV

ON INCREASING THE PERCENTAGE UTILIZATION OF FLY ASH GENERATED BY COAL-BASED POWER STATIONS AND REFUSE DERIVED FUELS (RDF) IN CEMENT PLANTS

White Paper–IV

On Increasing the Percentage Utilization of Fly Ash Generated by Coal-Based Power Stations and Refuse Derived Fuels (RDF) in Cement Plants

Summary

This White Paper suggests steps that will maximize the use of refuse-derived fuel including that from MSW and other wastes (used tyres, biomass and industrial plastics) and fly ash, as raw material in cement plants.

1. Objective of the Paper

1.1 Background

India is the second largest cement producer in the world with a total installed capacity of 349 million tonnes as on March 2013. The requirement of coal in this industry is 32 to 35 million tonnes per annum. Large amounts of coal are being imported as domestic coal production is not able to cope with the demand despite our large coal reserves (estimated at 84 billion tonnes). In the above context and that of meeting the environmental challenges posed by solid wastes generated by industries, population and agricultural operations and by the fly ash generated by coal based power plants, utilization of alternate fuels and raw materials (AFR) in cement plants assumes great national importance. The potential for reducing greenhouse gas emissions through waste utilization in cement kilns is an added advantage. At present, the thermal substitution rate (TSR) of the cement industry in the country ranges between 0.5 to 1 percent while in some developed countries their figure is as high as 60 percent. There is considerable scope, however, in the country to improve the TSR with all the attendant benefits.

2. Refuse Derived Fuels (RDF) for Cement Plants

2.1 Candidate RDFs

Supportive action of the Government will help in setting up plants to convert MSW into RDF which can be used as a partial fuel in cement kilns; this will help solve problems related to the management of MSW and associated GHG emissions. In technical papers RDF refers mostly to MSW because certain derivative processes – mechanical, biological – are needed to convert MSW into RDFs. Even though used tyres, biomass and industrial plastics are wastes and require some preprocessing, they should also be considered as RDF.

Based on energy content, availability, potential for addressing environmental concerns, ease of processing and carbon dioxide mitigation potential, the following candidate refuse-derived fuels have been identified. The list does not include hazardous wastes.

- RDF from municipal solid waste
- Biomass
- Industrial plastics.

2.2 Availability of base material for use as RDF and environmental implications

Municipal solid waste

The total quantity of municipal solid waste generated in the India is about 68million tonnes (2011-12) from urban sources alone. The state-wise share is shown in Table 10 below.

Table 10: State-wise quantities of MSW generated (2011-12)

Maharashtra	17
West Bengal	12
Uttar Pradesh	10
Tamil Nadu	9
Delhi	9
Andhra Pradesh	9
Karnataka	6
Gujarat	5
Rajasthan	4
Madhya Pradesh	3
Others	16

There are a number of cement plants in Maharashtra, Gujarat, Rajasthan Andhra Pradesh, Karnataka and Tamil Nadu, where the MSW generated can be used. The quantity of MSW that can be converted to RDF from all major urban areas is 1.37 MTA.

Biomass

According to the Ministry of New and Renewable Energy (MNRE), the current availability of biomass in the country is about 500 MTA of which the surplus is about 120-150 MTA. S source wise breakdown is shown in Table 11:

Table 11: Source-wise availability of biomass in India (MTA)

Rice straw	167
Rice husk	22.3
Mustard straw	18.1
Corn straw	23
Sugarcane trash	5.9
Coconut husk	4.7
Groundnut shells	1.6

The quantity of rice straw and husk generated in West Bengal, Punjab, Uttar Pradesh and Andhra Pradesh is 20 to 30 MTA Rice husk is currently used as an alternate fuel in cement plants in Chattisgarh, Gujarat and Tami Nadu.

The Ministry of New and Renewable Energy promotes the use of surplus biomass to generate power. The use of surplus biomass in co-processing should also be promoted.

Used Tyres

A state-wise inventory for the year 2010-11, of used tyres is reported in Table 12.

Table 12: State-wise inventory of used tyres

State	Used Tyres, Thousand Tonnes
Maharashtra	102
Tamil Nadu	91
Uttar Pradesh	78
Gujarat	76
Andhra Pradesh	60
Karnataka	58
Rajasthan	47
Madhya Pradesh	43
Others	179

Industrial Plastic Waste

At presently industrial plastic waste for co-processing comes mainly from paper mills which use waste paper as raw material. Most plastic waste from other sources is recycled.

Gujarat, Maharashtra, Uttar Pradesh and Odisha generate the country's largest amounts of plastic waste. (60,000-70,000; 8,000-10,000; 20,000-25,000; and 4,000-5,000 tonnes per annum). In Gujarat, this waste is used in cement plants but Maharashtra and Uttar Pradesh do not have as many plants as Gujarat. Calorific values are 2000-2500 kcal/kg in raw waste and 3500-4000 kcal/kg in processed waste. Shredding the waste to 25 mm is the preprocessing requirement.

Environmental Concerns

MSW
- Public health aspects due to improper land disposal
- Large land area required for land filling
- Energy content unused

Biomass
- Practice of burning biomass to clear fields causes air pollution;
- Indiscriminate disposal of fly ash and bottom ash from boilers/ furnaces using biomass

Used tyres
- Burning at low temperature such as in brick kilns results in emission of toxic gases.

2.3 Making Refuse-derived fuels

Converting MSW to RDF

Many technologies are available and used worldwide but the process is essentially a mechanical biological treatment one in which compostable wet organics are removed and converted to manure. Recyclable portions such as glass and metal waste are segregated and sold. The remaining portion is shredded and sieved to remove inert matter. The portion left over is dried and compacted in hydraulic presses to increase the bulk density to about 0.7 t/m^3 which allows economical transportation. In some countries, attempts have been made to dry the MSW biologically which increases the yield of RDF (a portion of the wet organic fraction is also recovered as dried RDF).

The average yield of RDF for typical MSW generated in India is estimated to be 10%. The net calorific value is about 2,500 kcal/kg with 25% moisture, and an ash content of 20 to 25%.

RDF sized to less than 25 mm (two dimensions) is baled and transported to a cement plant where it is debaled, fired in the calciner or burner, either pneumatically or by mechanical transport. Reasonably high thermal substitution rates can be achieved; the quality of RDF determines how high the TSR will be.

Biomass

Biomass is generally collected manually and loaded on to tractor trolleys for transport over short distances. For longer distances, it is baled and transported to cement plants in trucks. At the plant, it is debaled and chipped/shredded (in case of mustard straw, rice straw, sugarcane trash, etc.) and fired in the calciner or kiln main burner, either pneumatically or by mechanical transport.

Used Tyres

Used tyres are collected and stored by individual tyre dealers in India. These tyres, which require pre-processing, are transported by trucks and lorries and handling is manual.

For feeding tyre chips to in the calciner, tyres need to be shredded to produce cleanly cut chips with minimum exposed wire, thus preventing clogging while being delivered to the calciner.

Whole tyres enter the kiln inlet through a chute while tyre chips are injected into the pre-calciner. The tyre chips are extracted from storage and passed through a weigh feeder to a combination of belt conveyors and bucket elevator to convey the material to the pre-calciner through a double flap valve and emergency shut-off gate.

Industrial Plastic Waste (from paper mills)

The major fraction of the waste from paper mills is plastic matter (50-60%) and associated paper pulp (40-50%) on a dry basis. The waste contains 40 to 50% moisture and is left in the sun to dry. When the moisture content comes down to 20-25%, it is compressed into bales and stored or transported to cement plants.

There, it is shredded to reduce the size to 25 mm before firing in either the pre-calciner or kiln inlet. Industrial plastic waste can typically replace 5-20% of primary fossil fuel used in cement plants with 30% replacement being achieved in some Japanese plants.

The equipment used for conveying and dosing plastic waste consists of mechanical belt conveyors, bucket elevators and air locks with weigh feeders for accurate dosing.

2.4 Current status of utilization of RDF

MSW-RDF

Out of six RDF plants in the country located near Hyderabad, Vijayawada, Jaipur, Chandigarh, Mumbai and Rajkot only the ones in Jaipur and Chandigarh are operational. No details are available although it is estimated that co-processing of an estimated 1.3 MTA of MSW can replace about 0.9 MTA of coal in the cement industry.

Biomass

Rice husk is currently used as an alternate fuel in cement plants in Chandigarh, Gujarat and Tamil Nadu. Groundnut shells are used in cement plants in Gujarat, Tamil Nadu and Odisha.

Used Tyres

Used tyres – whole and chips – are used in some cement plants but their use is far greater in brick kilns, boilers and material recovery (retreading).

Industrial Plastics

Dried, shredded plastic waste from paper plants are being co-processed in cement plants in Gujarat, Odisha and Chattisgarh.

2.5 Recommendations for improving RDF utilization rate

2.5.1 For the Government's consideration

Refuse-derived fuel from MSW

The target date for local bodies to set up waste processing facilities was 31.12.2003 in the Solid Waste (Management and Handing) Rules, 2000, in Schedule I. The Rules consider pelletisation an accepted process for disposal. The Government may consider the following steps:

- Identification and evaluation of appropriate technologies to make RDF from pre-processed MSW

- Critical study of current legal and administrative framework, government infrastructure and policies and recommendation of any reforms to support MSW-to-RDF programmes
- Preparation of a technical memorandum of MSW-to-RDF global technology transfer
- Evolving investment and funding strategies for developing technologies to cement MSW to RDF.

Specifically,

1. Setting up a demonstration project in public-private partnership mode that addresses all the pillars of sustainability namely technical, institutional and financial.
2. RDF co-processing inclusion by MNRE under their waste-to-energy scheme
3. RDF use for co-processing to be acknowledged as a CSR activity, which would unlock finances for this action that will have major societal benefits by partly solving the huge problem of MSW.

Used Tyres as Alternate Fuel

- Recommend ban on current practices of disposing used tyres in brick kilns, boilers that create environment pollution.

Biomass as Alternate Fuel

- Represent to MNRE for including biomass co-processing in cement industry in their action agenda for utilizing surplus biomass as green fuel
- Captive/neighborhood energy crop plantation carried out by the cement industry to be considered as CSR activity
- Burning of crop residue, in situ, may be regulated where cement plants show keenness to procure the residue.

Industrial Plastic as Alternate Fuel

- Replicate Gujarat model of encouraging plastic waste of processing in cement plants in other states of India. (Note: The Gujarat Model is detailed in Appendix I)
- Normalization of policy with regard to categorization of plastic waste that facilitates its transportation across States

3. Ways to Maximize Fly Ash Utilization in Cement Plants

3.1 Background

During 2010-2011, the cement industry used 36 million tonnes of fly ash to make PPC, about 49 percent of total flyash generated. About 70 percent of all cement produced (350 MTA) is PPC with the ash content varying upto a maximum of 35 percent, as prescribed by the Bureau of Indian Standards. It is estimated that nearly 140 MTA of coal fly ash is produced in the country (all flyash does not go into cement production).

The main obstruction in increasing the use of flyash in the cement sector is the fact that coal-based power stations and cement plants are rarely located close to one another which means that a lot of money must be spent to transport fly ash. There are also obstructions resulting from the low use of PPC in the building industry and the limit placed on ash content in PPC at 35% by the BIS; a higher ash content, say 40 percent, in PPC is acceptable in many civil engineering works.

3.2 Suggested steps

For consideration of the Government

- Take up with BIS the point about increasing the maximum permissible maximum content of flyash in PPC from 35 percent to 40 percent.
- Section 3(3) of the Flyash Management Rules state that all local authorities shall specify use of flyash/flyash based products in building byelaws and regulations; compliance with this Section should be stressed and taken up with the State Governments. Future coal-based power plants may be linked with dedicated cement plants
- The CSR activity mentioned in Section 4, that follows, could have far-reaching consequences and should be considered and discussed with representatives from the power and cement sectors.

For the consideration of cement plants

- The CSR policy may spell out steps to be taken up to popularize PPC, its use and manufacture
- Link up with selected power plants for setting up grinding units.

For the consideration of power plants

- May provide silos for storing dry flyash with proper unloading facilities to supply to cement plants
- The CSR activity suggested in Section 4 (below) may be considered.

4. Role of Corporate Social Responsibility Policy

The Companies Act, 2013, was notified in August, 2013, and 98 sections have been notified as coming into force on September 12, 2013. Section 136 laying down aspects of corporate social responsibility have since been notified or will be shortly notified. The following suggestions are made in the context of the theme of this paper and Section 136 of the Act and Draft Rules. The Ministry of Environment and Forests is requested to consider these suggestions and take them up with the cement industry and coal-based thermal power plants, and their respective administrative ministries.

Background

Schedule VII in the CSR Act contains the list of activities that may be included in the CSR policy of companies covered by the Act. Environmental sustainability is included in the list. The draft rules provide that companies may collaborate or pool resources with other companies when carrying out activities related to CSR.

Suggestions

- Co-processing AFR should find a place in the CSR policy of all cement plants.
- As part of its CSR activities, the National Thermal Power Corporation, may establish clinker grinding units at selected plants taking into account proximity to new cement plants and the seriousness of the issue of flyash management.
- Capacity commensurate with 35 percent flyash for PPC cement plants to work with urban local bodies in the vicinity to set up plants making fuel from MSW for their consumption. The capital cost could come from the plant's CSR funds while the plant could be operated and maintained by the local body with or without private participation.

The NTPC and cement industry may seek help from the National CSR HUB at TISS, Mumbai.

5. References

1. Action Plan for enhancing the use of AFR in Indian Cement Industry – CMA-IIP in partnership with HOLTECH, 2013
2. Background paper at International Conference on MSW held at Anna University, Sep 2007

WHITE PAPER–V

ON GUIDELINES FOR TRANSPORT AND STORAGE OF HAZARDOUS WASTE FOR CO-PROCESSING IN CEMENT PLANTS

White Paper–V

ON GUIDELINES FOR TRANSPORT AND STORAGE OF HAZARDOUS WASTE FOR CO-PROCESSING IN CEMENT PLANTS

1. Summary

This White paper suggests guidelines and proposes amendment in the existing guidelines for transportation and Storage of hazardous waste that is important for promoting its co-processing in cement plants.

2. Definitions

Definitions of certain terms connected with transport and storage of hazardous waste used in the paper are reproduced here from the Hazardous Wastes (Management, Handling and Transboundary Movement) Rules 2008, prescribed under the Environment Protection Act, 1986.

Authorization: means permission for generation, handling, collection, transport, treatment, reception, storage, recycling, reprocessing, recovery, reuse and disposal of hazardous wastes granted under Sub-rule (4) of Rule 5;

Central Pollution Control Board (CPCB): means the Central Pollution Control Board constituted under Sub-section (1) of Section 3 of the Water (Prevention and Control of Pollution) Act 1974;

Facility: means any establishment wherein the processes incidental to the handling, collection, reception, treatment, storage, recycling, recovery, reuse and disposal of hazardous wastes are carried out;

Hazardous waste site: means a place for collection, reception, treatment, storage of hazardous waste and its disposal to the environment which is approved by the competent authority;

Manifest: means transporting document prepared and signed by the occupier or his representative authorized in accordance with the provisions of these Rules;

Occupier: in relation to any factory or premises, means a person who has, control over the affairs of the factory or the premises of includes in relation to any hazardous waste, the person in possession of the hazardous waste;

Operator of disposal facility: means a person who owns or operates a facility for collection, reception, treatment, storage or disposal of hazardous wastes;

State Pollution Control Board (SPCB) means the State Pollution Control Board or the Pollution Control Committee (PCC) constituted under Sub-Section (1) of Section 4 of the Water (Prevention and Control of Pollution) Act 1974;

Storage: means storing any hazardous waste for a temporary period, at the end of which such waste is processed or disposed of;

Transport: means off-site movement of hazardous wastes by air, rail, road or water;

Transporter: means a person engaged in the off-site transportation of hazardous waste by air, rail, road or water;

3. Legal Aspects

The procedures for management, handling and movement of hazardous waste are laid down in the Hazardous Waste Management Rules, 2008. The sections below are reproduced from these Rules.

3.1 Procedure for Handling Hazardous Waste

In Chapter II of the Rules, responsibilities of the occupier, operator of storage facility and transporter are laid down. They are required to obtain authorization from the concerned SPCB applying for it in the prescribed **Form 1**. The authorized person shall keep a record of waste handled by him in the prescribed **Form 3** and submit annual return to the SPCB in **Form 4**. The authorization in the prescribed form, **Form 2**, subject to conditions laid down therein shall be valid for five years, open to renewal. Occupier and operator of facilities shall store the waste for only 90 days, save for special reasons. The occupier shall ensure that the waste is transported to disposal facility which will, after the proposed amendments, include co-processing cement plants or recyclers, etc., in accordance with the Rules.

3.2 Treatment, Storage and Disposal Facility for Hazardous Waste

Chapter V, Rule 18, deals with the responsibilities of the operator of Treatment, Storage and disposal facility (TSDF) which include identification of sites for establishing the facility; design and setting up the facility as per technical approval from SPCB for design and layout; responsibility for safe and environmentally sound operation of the TSDF, its closure and post closure as per guidelines issued by CPCB; and maintaining records of waste handled in the prescribed **Form 3**.

3.3 Packaging, Labeling and Transport of Hazardous Waste

Chapter VI, Rules 19, 20, and 21, mainly deal with the responsibility of occupier – generator of the waste – to provide the transporter with information on the hazardous nature of the waste and measures to be taken in an emergency in the prescribed **Form 11**, and to mark the containers of waste as per the prescribed **Form 12**. Again, as per Rules 20(3) and 20(4), it is the occupier who has to obtain clearance from SPCBs other than his, in case TSDF to which he is sending the waste is located in another State or the transporter has to pass through other State(s).

Rule 19(2) lays down that the labelling and packaging shall be easily visible and be able to withstand physical conditions and climatic factors.

Rule 21 prescribes the manifest system in which the transporter has a major role. The occupier is required to prepare six copies of the manifest in **Form 13**, colour coded as under, duly signed by the transporter. The purpose of each of the six copies are also stated below:

Chapter VII, Rule 24, prescribes that the transporter or operator of facility (storage) or occupier shall report immediately to the SPCB occurrence of any accidents during transportation, at the facility or site, as the case may be, in the prescribed **Form 14**.

Rule 25(1) lays down liability of the transporter, operator of storage facility and occupier for damages caused to environment or third party due to improper handling.

Rule 25(2) provides for the SPCB to levy financial penalties onthe operator of the storage facility for any violation of the Rules.

Rule 26 provides for appeal against relevant orders of the SPCB in **Form 15**.

Forms 1 to 4, and 11 to 15 referred to above are reproduced from the Rules in Appendix I to this paper. These forms are concerned with transporter and/or operator of storage facility.

Copy number with Color code	Purpose (2)
Copy 1 (White)	To be forwarded by the occupier to the State Pollution Control Board or Committee.
Copy 2 (Yellow)	To be carried by the occupier after taking signature on it from the transporter and rest of the four (4) copies to be carried by the transporter.
Copy 3 (Pink)	To be retained by the operator of the facility after signature.
Copy 4 (Orange)	To be returned to the transporter by the operator/recycler after accepting waste.
Copy 5 (Green)	To be returned by the operator of the facility to State Pollution Control Board/ Committee after treatment and disposal of wastes.
Copy 6 (Blue)	To be returned by the operator of the facility to the occupier after treatment and disposal of hazardous material/wastes.

4. Guidelines for Packaging and Labelling Hazardous Waste

The guidelines for packaging and labelling hazardous waste are detailed in the CPCB's document, Guidelines on co-processing in cement/power/steel industry, February 2010. These are reproduced below.

4.1 Packaging

The containers must be able to withstand normal handling and retain integrity for a minimum period of six months. In general, packaging or hazardous substances must meet the following requirements:

1. All packaging materials including containers shall be of such strength, construction and type as not to break open or become defective during transportation.
2. All packaging materials including containers shall be so packed and sealed that spillages of hazardous wastes/substances are prevented during transportation due to jerks and vibrations caused by uneven road surface.
3. Re-packing material including that used for fastening must not be affected by the contents or form a dangerous combination with them.
4. Packaging material should be such that there will be no significant chemical or galvanic action among any of the material in the package.

The containers when used for packaging of the hazardous wastes shall meet the following requirements:

1. Containers shall be of mild steel with suitable corrosion-resistant coating and roll-on roll-off cover, which may either be handled by articulated crane or by a hook lift system comfortably for a large variety of wastes. Other modes of packaging, like collection in 22 liter plastic drums, cardboard cartons, PP and HDPE/LDPE containers etc., also work for a variety of wastes. However, all such containers should be amenable to mechanical handling.
2. They should be leak proof.
3. In general, the containers for liquid hazardous waste should be completely closed/sealed. There should be no gas generation due to any chemical reaction within the container and should be devoid of air vents. Containers should be covered with a solid lid or a canvas to prevent emissions of any sort including spillage, dust etc., and to minimize odour generation both at the point of loading as well as during transport.
4. Containers used for transport of waste should be able to withstand the shock loads due to vibration effect/undulations of pavements, etc.
5. Containers should be easy to handle during transportation and emptying.
6. As far as possible, manual handling of containers should be minimized. Appropriate material handling equipment is to be used to load, transport and unload the containers. Drums should not be rolled on or off vehicles.
7. Where a two-tier or three-tier storage is envisaged the frame should have adequate strength to hold the containers.
8. One-way containers (especially 16-liter drums) are also allowed. Loads are to be properly placed on vehicles. Hazardous waste containers are not to overhang, perch, lean or be placed in other unstable base. Load should be secured with straps, clamps, braces or other means to prevent movement and loss. Design of the container should be such that it can be safely accommodated on the transport vehicle.
9. Dissimilar wastes shall not be collected in the same container. Wastes shall be segregated and packed separately.

4.2 Labelling

There are two types of labelling requirement:

1. Labelling of individual transport containers (ranging from a pint-size to a tank); and,
2. Labelling of transport vehicles.

All hazardous waste containers must be clearly marked with the contents. The marking must be irremovable, waterproof and firmly attached. Previous content labels shall be obliterated when the contents are different. Proper marking of containers is essential.

Containers that contain hazardous waste shall be labelled with the words "HAZARDOUS WASTE" in Vernacular language, Hindi/English. The information on the label must include the code number of the waste, the waste type, the origin (name, address, telephone number of generator), hazardous property (e.g. flammable), and the symbol for the hazardous property (e.g. the red square with flame symbol).

The label must withstand the effects of rain and sun. Labelling of containers is important for tracking the wastes from the point of generation up to the final point of disposal. The following are the requirements for labelling:

- The label should contain the name and address of the facility*/occupier, where it is being sent for co-processing, i.e., container shall be provided with a general label as per Form 12 of the Rules.
- Emergency contact phone numbers shall be prominently displayed viz; the phone number of concerned Regional Officer of the SPCB/PCC, Fire Station, Police Station and other agencies concerned.

Explanation: As a general rule, the label has to state the origin/generator of the waste. He/she and only he/she – is responsible and shall know, in case of any accident/spillage, etc., what kind of waste it is, what hazard may be posed and what measures should be taken. The second in the line is the collector/transporter/disposer, who has to know the risk and what to do to minimize risks and hazards.

4.3 Notes

4.3.1 On packaging

The present guidelines, (Section 4.1) are generally qualitative or descriptive of the packaging material. It will be useful to specify the material of which the container is made for a particular waste. For example, liquid hazardous waste – double hung steel drum e.g.16 gauge steel coated inside with epoxy.

The generator of waste is most likely to conform to **Form 12**, a legal requirement. It is suggested that **Form 12** may be revised to include spillage control, risk involved, volume of waste, water and ash content, calorific value, concentration of chlorides, fluorides, sulphur and heavy metals. It may be examined whether the UN Dangerous Goods Transport Labeling (SINTEF 2008) can be adopted. These labels indicate nature of waste – explosives, flammable liquids/solids, oxidizing substance, corrosive substance, etc.

*Facility means any establishment wherein the processes incidental to the handling, collection, reception, treatment, storage, recycling, recovery, reuse and disposal of hazardous waste are carried out. Co-processing is an activity that may consist of recovery or reuse or disposal of hazardous waste(s) combination.

5. Guidelines for Collection and Transport of Hazardous Waste

The guidelines for transport of hazardous waste are detailed in the CPCB's document, Guidelines on co-processing in cement/power/steel industry, February 2010. These are reproduced below.

5.1 Safe transport of hazardous waste to the site for utilization as a supplementary resource or for energy recovery or after processing is the collective responsibility of the occupier (waste generator) and operator of the facility. The detailed guidelines for collection and transport of hazardous waste are reproduced in Appendix II, A.

5.2 Notes

The occupier/hazardous waste generator, is responsible for packaging and labelling the waste and then handing them over to the transporter with copies of the manifest for ultimate delivery to the operator of the disposal facility. In the context of this paper the operator is the operator of the co-processing cement kiln. Thus in the chain of generation to destruction of the hazardous waste, the role of transporter is minimal.

The main concerns, however, are human exposure, accidental release to the environment and contamination of other streams at the occupier's place during collection. Recommended practices to prevent contamination include (SINTEF 2008):

- Ensure no leakage, holes, rust, high temperature (>25°C if possible)
- Adequate spill containment measures
- Ensure plastic sheeting or absorbent mats under containers before opening
- Use dedicated pumps, tubing and drums (=dedicated) to transfer liquid waste
- Remove hazardous waste either by removing the drain plug or by pumping with a peristaltic pump and Teflon or silicon tubing.

6. Guidelines for Storage of Hazardous Waste

Guidelines for the storage of hazardous waste are detailed in the Technical Guidelines on environmentally sound co-processing hazardous waste in cement kilns, Secretariat of Basel Convention, 2012. These guidelines are reproduced below.

6.1 Waste acceptance, non-conforming waste

This section applies to the storage or preprocessing facilities at the co-processor cement kiln as well as a standalone pre-processing facility from which the hazardous waste is sent to the co-processor(s).

6.1.1 Waste acceptance

Prior knowledge of the waste is necessary to ensure that it falls within the requirements of the facility's permit and will not adversely affect the process. For instance, to avoid operating problems within the kiln, the impact of hazardous waste on the total input of circulating volatile elements, such as chlorine, sulphur or alkalis, requires careful assessment prior to acceptance. Specific acceptance criteria for these components should be set by each facility based on the process type and on the specific kiln conditions.

Generators of hazardous waste should in most circumstances know the composition, nature and problems associated with their waste, ensuring that all relevant information is passed on to those involved in its subsequent management.

Hazardous and non-hazardous waste acceptance comprises two stages: pre-acceptance (or screening) and on-site acceptance. Acceptance involves the provision of information and representative samples of the waste to allow operators to determine its suitability. The second stage involves confirmation that the waste conforms to characteristics that had been previously approved.

6.1.2 Pre-acceptance

A pre-acceptance, or pre-shipment screening protocol should ensure that only properly and safely handled hazardous waste streams are approved for shipment to the facility. Such a protocol is necessary to:

1. Ensure regulatory compliance by screening out unsuitable wastes;
2. Confirm the details relating to composition, and identify verification parameters that can be used to test waste arriving at the facility;
3. Identify any substances within the waste that may affect its processing, or react with other reactants;
4. Accurately define the range of hazards exhibited by the waste.

The operator should obtain information on the nature of the process producing the waste, including its variability. Other required descriptions include: composition (chemicals present and individual concentrations); handling requirements and associated hazards; the quantity and the form of waste (solid, liquid, sludge, etc.); samples storage and preservation techniques. Ideally, information should be provided by the waste generator. Alternatively, a system for the verification of the information provided by any intermediaries should be considered.

Systems for the provision and analysis of waste representative samples should be in place. The waste sample should be taken by a competent technician and the analysis carried out by a laboratory, preferably an accredited one with robust QA/AC methods and record keeping and a chain-of-custody procedure should be considered. The operator should carry out a comprehensive characterization (profiling) and testing with regard to the planned processing for each new waste. No waste should be accepted without sampling and testing. The exception is unused, outdated or off-specification uncontaminated products that have appropriate Material Safety Data Sheets or product data sheets.

A Waste Analysis Plan (WAP) should be prepared and maintained to document procedures used to obtain a representative waste sample and to conduct a detailed chemical and physical analysis. A WAP should address measures used to identify potentially reactive and incompatible wastes. It should include testing of a representative sample to qualify the waste for use at the facility (pre-acceptance) and to verify its constituents (acceptance). Further testing of samples taken during or after waste pre-processing or blending should be used to verify the quality of the resultant stream.

Operators should ensure that the technical appraisal is carried out by qualified, experienced staff who understand the capabilities of the facility.

Records of pre-acceptance should be maintained at the facility for cross-referencing and verification at the waste acceptance stage. Information should be recorded and referenced, available at all times, regularly reviewed and kept up to date with any changes to the waste stream.

6.1.3 On-site acceptance

On-site verification and testing should confirm waste characteristics with the pre-acceptance information. Acceptance procedures should address:

1. Pre-approved wastes arriving on-site, such as a pre-booking system to ensure that sufficient capacity is available.
2. Traffic control;
3. Check for documents arriving with the load;
4. Load inspection, sampling and testing;
5. Rejection of wastes and the discrepancy reporting procedures;
6. Record keeping;
7. Periodic review of pre-acceptance information.

Wastes should not be accepted without detailed written information identifying the source, composition and hazard levels.

Where facilities provide an emergency service such as the removal of spillages or fly-tipped hazardous wastes, there may be situations where the operator is unable to adhere to established pre-acceptance and/or acceptance procedures. In such instances, the operator should communicate the occurrence to the competent authorities immediately.

(a) Arrival

If sufficient storage capacity exists and the site is adequately manned, suitably qualified and trained personnel should supervise the receiving of hazardous wastes. All wastes received should be treated as unknown and hazardous until compliance with specifications has been positively verified.

A suitable description should accompany hazardous waste delivery including: name and address of the generator; name and address of the transporter; waste classification and description; volume and weight; hazards of the waste such as, flammability, reactivity, toxicity or corrosivity.

Documentation accompanying the shipment should be reviewed and approved, including the hazardous waste manifest, if applicable. Any discrepancies should be resolved before the waste is accepted. If they cannot be resolved, the waste should be rejected and sent back to the original generator, or at its request, to an alternate facility.

Where possible, waste loads should be visually inspected. All containers should be clearly labeled in accordance with applicable regulations for the transport of dangerous goods and checked to confirm quantities against accompanying documentation. They should be equipped with well-fitting lids, caps and valves secure and in place and inspected for leaks, holes, and rust. Any damaged, corroded or unlabelled container or drum should be classified as 'non-conforming' and dealt with appropriately.

All incoming loads should be weighed, unless alternative reliable volumetric systems linked to specific gravity data are available.

(b) Inspection

Wastes should only be accepted at the facility after thorough inspection. Reliance solely on supplied written information should not be acceptable. Physical verification and analytical confirmation should be undertaken to ensure the waste meets permit specifications and regulatory requirements. All wastes, whether for processing or storage, should be sampled and undergo verification and testing, according to the frequency and protocol defined in the WAP, except for unused, outdated, off-specification or uncontaminated products.

On-site verification and testing should take place to confirm:

1. The identify and description of the waste;
2. Consistency with pre-acceptance information;
3. Compliance with the facility permit.

Techniques for inspection vary from simple visual assessment to full chemical analysis. The extent of the procedures adopted will depend upon waste chemical and physical composition and variation; known difficulties with certain waste types or of a certain origin; specific sensitivities of the installation concerned (for example, certain substances known to cause operational difficulties); and the existence or absence of a quality controlled specification for the waste, among others (Karstensen, 2008).

The facility should have a designated sampling or reception area where containerized waste is unloaded if adequate space is available and temporarily stored for further sampling and sample analysis. Wastes should be segregated immediately to remove possible hazards due to incompatibility. Sampling should ideally take place within 24 hours of unloading. During this period, hazardous wastes should not be bulked, blended or otherwise mixed. Bulk wastes should be inspected and accepted for processing prior to unloading.

Sampling should comply with specific national legislation, where it exists, or with international standards. Sampling should be supervised by laboratory staff and in those countries where regulations do not exist, qualified staff should be appointed. Sampling should include well-established procedures such as those developed by the American Society for Testing and Materials (ASTM), the European Committee for Standardization (CEN), the United States Environmental Protection Agency (EPA), the BIS and the CPCB. A record of the sampling regime for each load and justification for the selected option should be maintained.

Samples should be analyzed by a laboratory with a robust QA/QC programme, including but not limited to suitable record keeping and independent assessments. Analysis should be carried out at a timescale required by facility procedures. In the case of hazardous wastes this often requires the laboratory to be on-site.

Typically, waste should be sampled and analyzed for a few key chemical and physical parameters (fingerprint analysis) to substantiate the waste composition designated on the accompanying manifest or other documents. The selection of key parameters must be based on sufficient waste profile knowledge and testing data to ensure accurate representation. When selecting fingerprint parameters, consideration should be given to those that: identify unpermitted wastes; determine suitability within the facility's operational acceptance limits; identify potential reactivity or incompatibility; indicate any changes in composition that had occurred during transportation or storage. Should fingerprint testing results of a given waste stream fall outside the established tolerance limits, the waste may be re-evaluated for possible acceptance to prevent the unnecessary movement of waste back and forth between the generator and the installation. Re-evaluation should consider facility conditions for storage and processing; additional parameter analysis deemed appropriate by the operator and established in the WAP; permit requirements.

The inspection scheme may include: assessment of combustion parameters; blending tests on liquid wastes prior to storage; control of flash point, and screening of waste input for elemental composition, for example by ICP, XRF and/or other appropriate techniques, in accordance with waste types and characteristics, and the facility waste acceptance criteria.

Wastes should be moved to the storage area only after acceptance. Should the inspection or analysis indicate a failure to meet the acceptance criteria, including damaged or unlabelled drums, such loads should be stored in a quarantine area, allocated for non-conforming waste storage, and dealt with appropriately.

All areas where hazardous waste is handled should have an impervious surface with a sealed drainage system. Attention should be given to ensuring that incompatible substances do not come into contact resulting from spills from sampling, for example, within a sump serving the sampling point. Absorbents should be available.

In accordance with national legislation and practice, suitable provisions should be made to verify that wastes received are not radioactive, such as the use of plastic scintillation detectors.

After acceptance, containerized hazardous waste should be labelled with the arrival date and primary hazard class. Where containers are bulked, the earliest arrival date of the bulked wastes should be indicated on the bulk container. Each container should be given a unique reference number for in-plant tracking.

6.1.4 Non-conforming waste

The operator should have clear and unambiguous criteria for the rejection of wastes, including wastes that fail to meet the acceptance criteria, and damaged, corroded or unlabelled drums. A written procedure for tracking and reporting such non-conformance should include notification to the customer or waste generator and competent authorities.

1. Identify the hazards posed by the rejected wastes;
2. Label rejected wastes with all information necessary to allow proper storage and segregation arrangement to be put in place;
3. Segregate and store rejected wastes safely pending removal within no more than five working days, where possible.

Wastes not fulfilling the acceptance criteria of the plant should be sent back to the waste generator, unless an agreement is reached with the generator to ship the rejected waste to an alternative authorized destination.

6.1.5 In-plant tracking system

An internal waste tracking system and stock control procedure should be in place, starting at the pre-acceptance stage, to guarantee the traceability of waste processing and enabling the operator to:

1. Prepare the most appropriate waste blend;
2. Prevent unwanted or unexpected reactions.
3. Ensure that the emissions are either prevented or reduced;
4. Manage wastes throughput.

The tracking system, which may be paper-based, electronic, or a combination of both, should trace the waste during its acceptance, storage, processing and removal off-site. At any time, the operator should be able to identify the location of a specific waste on the facility and the length of time it has been there. Records should be held in an area removed from hazardous activities to ensure their accessibility during any emergency.

Once a waste has entered bulk storage or a treatment process, tracking individual wastes will not be feasible. However, records should be maintained to ensure sufficient knowledge is available as to what wastes have entered a particular storage facility. For example, to avoid incompatibility with incoming wastes, residues building up within a vessel between de-sludging operations should be tracked.

For bulk liquid wastes stock control should involve maintaining a record of the route through the process. Waste in drums should be individually labelled to record the location and duration of storage.

The in-plant waste tracking system should hold a complete record generated during pre-acceptance, acceptance, storage, processing and removal off-site. Records should be kept up to date to reflect deliveries, on-site treatment and dispatches. The tracking system should operate as a waste inventory, stock control system and include as a minimum:

1. A unique reference number;
2. Details of the waste generator and intermediate holders;
3. Date of arrival on-site;
4. Pre-acceptance and acceptance analysis results;
5. Container type and size;
6. Nature and quantity of wastes held on-site, including identification of associated hazards;
7. Details on where the waste is physically located;
8. Identification of staff who have taken any decisions on acceptance or rejection of wastes.

The system adopted should be structured to report on:

1. Total quantity of waste present on-site at any one time, in appropriate units;
2. Breakdown of waste quantities being stored pending on-site processing;
3. Breakdown of waste quantities on-site for storage only, that is, awaiting transfer;
4. Breakdown of waste quantities by hazard classification;
5. Indication of where the waste is located relative to a site plan;
6. Comparison of the quantity on-site against total permitted;
7. Comparison of time the waste has been on-site against permitted limit.

6.2 Time limits for storage of hazardous waste

(As detailed in the CPCB's document, Guidelines on co-processing in cement/power/steel industry, February 2010)

The occupier or reprocessor/reuse/co-processor of facility may store the hazardous waste for a period not exceeding ninety days of the permitted quantity for reprocessing/reuse and shall maintain a record of sale transfer, storage and reprocessing of such wastes and make these records available for inspection. Provided that the SPCB may extend the said period for reprocessors and facility operators up to six months of their annual capacity (Section 3.6 CPCB 2010). The detailed guidelines for storage of incinerable hazardous waste are reproduced in Appendix II, B.

6.3 Notes

The guidelines in Appendix II, B are based on the recommendations of an expert committee constituted by the CPCB under the chairmanship of Shri R.K. Garg. Some topics from the recommendations are stated below.

6.3.1 Storage capacity, storage time

Some conclusions from the SINTEF 2008 document are presented below.

The guidelines at Appendix II, B Clause 1(c) state adequate storage capacity for incinerable waste as 25 percent of annual utilization. As in para 6.2 above maximum permissible storage time for all hazardous waste is three months (90 days in the HW Rules), but may go up to six months in some cases. Quoting from SINTEF 2008 para 7.2, "storage of hazardous waste should be for as brief a period as possible. Recommended maximum storage times are:

- 10 days for waste mixtures and hazardous waste
- 21 days for hazardous waste impregnated substrates
- For non-hazardous AFR storage time is limited by the designed storage capacity and installed fire suppression system."

From the view point of the co-processor the liability of supply of waste is an important factor in determining the storage capacity. For good operational practice a continuous supply is desirable which will also reduce the storage capacity/time at the co-processing facility. The guiding principle is that volume of storage and storage time should be minimized. The former should be determined by the installed fire protection system and the latter on the type of material, its health and safety risks such as toxicity, reactivity, flammability, explosion potential, storage condition (SINTEF 2008)

The above discussion suggests that the present storage capacity/time prescriptions needs to be examined in respect of co-processors (cement plants) as well as other stakeholders.

6.3.2 Storage and loading options

(from SINTEF 2008)

Appropriate waste assessment is an essential element in the selection of storage and loading options. Some issues to note are:

1. For the storage of solid hazardous waste, many plants are equipped with a bunker from where the waste is fed into the installation by cranes or feed hoppers;
2. Liquid hazardous waste and sludge are usually stored in tank form. Some tanks have storage under an inert (e.g. N_2) atmosphere. Liquid waste may be pumped via pipelines to the kiln. Sludges can be fed by using special "viscous-matter" pumps. Appropriate storage for liquids should meet relevant safety and design codes for storage pressures and temperature and should have adequate secondary containment;
3. Some kilns are able to feed certain substances, such as toxic, odorous liquids, by means of a direct injection device, directly from the transport container into the kiln.

A common practice is to ensure, as far as possible, that hazardous wastes are stored in the same containers (drums) that are used for transport, thus avoiding the need for additional handling and transfer.

Solid and unpumpable pasty waste that has been degassed and does not smell can be stored temporarily in bunkers. Storage and mixing sections can be separated in the bunker. This can be achieved through several design segments. The bunker must be designed in such a way that ground emissions can be prevented.

The bunker and container storage must be enclosed unless health and safety reasons (danger of explosion and fire) exist. The air in the bunker may be removed and ducted to the kiln. In anticipating fires, monitors such as heat-detecting cameras are used, in addition to constant monitoring by personnel (control room, operator).

Larger amounts of fluid and pumpable pasty wastes are temporarily stored in tanks that must be available in sufficient numbers and sizes to accommodate reacting liquids separately (danger of explosion, polymerization).

Tanks, pipelines, valves, and seals must be adapted to the waste characteristics in terms of construction, material selection, and design. They must be sufficiently corrosion-proof, and offer the option of cleaning and sampling. Flatbed tanks are generally only deployed for large loads.

It may be necessary to homogenize the tank contents with mechanical or hydraulic agitators. Depending on the waste characteristics, some tanks must be heated indirectly and insulated. Tanks are set in catch basins that must be designed for the stored material, with bund volumes chosen so that they can hold the liquid waste in the event of leakage.

For safety reasons, hazardous waste is often accumulated in special containers, which can be delivered directly to the plant. Delivery is also taken of bulk liquids.

The delivered containers may be stored or the contents transferred. In some cases, according to a risk assessment, the waste may be directly injected via a separate pipeline into the kiln. Heated transfer lines may be used for wastes that are only liquid at higher temperature.

Storage areas for containers and tank containers are usually located outside, with or without roofs. Drainage from these areas is generally controlled, as contamination may arise.

6.3.3 Safety aspects of storage

(from SINTEF 2008)

Storage area should be kept clear of uncontrolled combustible materials:

- Safety warnings, no smoking, fire, evacuation route and any procedures signs should be clearly posted
- An emergency shower and eye washing station should be clearly marked and located near the storage of liquid alternative fuels
- Automatic fire detection systems and fire control systems, especially when storing flammable liquid waste should be installed. Foam and carbon dioxide control systems for the storage of flammable liquids advantageous. Water systems with monitors, water cannons with the option to use water or foam, and dry powder systems are also used.

Continuous automatic measurement of temperature can be carried out on the surface of waste stored in bunkers. Temperature variations can be used to trigger an acoustic alarm.

The fire protection system should be available at all times and should meet all standards and specifications of the local fire department.

- Adequate alarms should be provided to alert all personnel about emergency situations
- Communication equipment should be maintained at the site to reach control room and local fire department in case of fire.
- The waste liquid storage sump area should be enclosed and all vent gases from such area and storage tank should be vented to an emission control system which may be destruction in kiln. Solid materials handling systems should have adequate dust control systems.

6.3.4 Control of odour from storage area

From SINTEF 2008 and CPCB's report on Odour Pollution Control 2008.

Obvious preventive steps are:

- Location of storage shed vis-a-vis residential/areas
- Avoid leakages from piping, transfer points
- Waste liquid storage sump area should be enclosed and all vent gases from such astorage tank should be vented to an emission control system. Solid materials handling systems should have adequate dust control system
- Solid and unpumpable pasty waste that has been degassed and does not smell can be stored temporarily in bunkers. The air in the bunker may be removed and ducted to the kiln. Duct length is a factor to be considered.

Control options are: Monitoring system capable of detecting volatile organic vapours should be placed at key process locations. All volatile organic emissions from waste storage and preprocessing facilities could be exhausted by a suction duct system, subject to acceptable duct length, to the cement kiln for complete destruction. Most solvents, VOC are completely destroyed in the kiln. Conventional odour control unit operations/processes include

- Tall stack for dispersion
- Activated carbon adsorption with hot gas regeneration followed by feeding into kiln/flaring/ tall stack dispersal of desorbed gas; alternatively the exhausted carbon can be used in the kiln as fuel.
- Bio filtration
- Wet scrubbing
- Chemical treatment with chlorine, hydrogen peroxide or chlorine dioxide.
- Chilled brine condensor.

Choice of technology depends on volume and composition of the gas emitted, and its odour temperature and moisture content Adsorption is recommended as a standby to destruction in kiln (SINTEF 2008).

6.3.5 Training

Employees in sections dealing with storage, handling etc., should be trained in the safety aspects and compliance should be audited regularly. CMA and CPCB should periodically conduct onsite training programmes, refresher programmes and it should be mandatory for the concerned employees to get certified. Special emphasis should be placed on personal protective equipment, use of emergency equipment such as fire extinguishers, breathing masks, sorbent materials and shower stations. Special training should be provided to personnel manning the pumping site for unloading.

Special procedures, instructions and training should be in place for routine operations such as:

- Working at a height, including proper tie-off practices and use of safety harnesses
- Confined space entry where air quality, explosive mixtures, dust and other hazards may be present
- Electrical lockouts, to prevent accidental reactivation of electric equipment undergoing maintenance
- Hot works (such as welding, cutting, etc.) in areas that may contain flammable materials.

6.3.6 Laboratory

Co-processor should have a well-equipped laboratory to check waste characteristics to assess suitability for acceptance as AFR and verify the declarations in the manifest. Refer Para 6.1 above on the responsibilities of the laboratory.

7. References

1. Guidelines on Co-processing in Cement/Power/Steel industry Central Pollution Control Board, February 2010.
2. Technical Guidelines on the environmentally sound Co-Processing of Hazardous Wastes in Cement kilns, Secretariat of Basel Convention, 11 November, 2012.
3. Guidelines for Co-processing of alternative fuels and raw material and treatment of organic hazardous wastes in cement kilns, Sino-Norwegian Project 2006-2009, SINTEF, 25 March 2008.
4. Hazardous Wastes (Management, Handling and Transboundary Movement) Rules, 2008.
5. Guidelines for storage of incinerable Hazardous Wastes by the Operators of Common Hazardous Waste Treatment, storage and disposal facilities and captive HW incinerators, CPCB November 2008 (R.K. Garg Committee Report).
6. Guidelines on Odour Pollution and its Control, CPCB May 2008. (P.C. Tyagi Committee Report).
7. Karl. H. Karsensten. Norwegian Institute of Air Research, Norway, 2008.

Annexure I

Forms 1 to 4 and Forms 11 to 15 from Hazardous Wastes (Management, Handling and Transboundary Movement) Rules, 2008

Form-1

[See Rules 5(3) and (7)]

Application for Obtaining Authorization for Collection/Reception/Treatment/Transport/Storage/ Disposal of Hazardous Waste*

From:

………………………………..
………………………………..

To

The Member Secretary,

…………… Pollution Control Board/………………….. Pollution Control Committee ……………………

Sir,

I / We hereby apply for authorization/renewal of Authorization Sub-rule under (3) of Rule 5 of the Hazardous Wastes (Management, Handling and Transboundary Movement) Rules 2008 for collection/reception/treatment/transport/storage/disposal of hazardous waste.

FOR OFFICE USE ONLY

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1. Code No.:
2. Whether the unit is situated in a critically polluted area as identified by Ministry of Environment and Forests;

TO BE FILLED IN BY APPLICANT

Part – A: General

3. (a) Name and address of the unit and location of activity:

   (b) Authorization required for (Please tick mark appropriate activity/activities:

   (i) Collection

   (ii) Reception

   (iii) Treatment

   (iv) Transport

   (v) Storage

   (vi) Disposal

   (c) In case of renewal of authorization previous authorization number and date:

*delete whichever is not applicable

4. (a) Whether the unit is generating hazardous waste as defined in these Rules :
   (b) If so the type and quantity of wastes (in Tonnes/KL) :
5. (a) Total capital invested on the project (in Rupees) :

(b) Year of commencement of production :
(c) Whether the industry works general / 2 shifts/ round the clock :

6. (a) List and quantum of products and by-products (intones/KL) :
(b) List and quantum of raw material used (in Tonnes/KL) :

7. Furnish a flow diagram of manufacturing process showing input and output in terms of products, waste generated including for captive power generation and demineralised water.

Part-B: Hazardous Waste

8. Hazardous Waste;
(a) Type of hazardous waste generated as defined under these Rules :
(b) Quantum of hazardous waste generated :
(c) Source and waste characteristics :
(Also indicate wastes amenable to recycling, reprocessing and reuse)
(d) Mode of storage within the plant, method of disposal and capacity :
(Provide details)

9. Hazardous waste generated as per these Rules from storage of hazardous chemicals as defined under the Manufacture, Storage and Import of Hazardous Chemicals Rules 1989

Part-C: Treatment, Storage and Disposal Facility

10. Detailed proposal of the facility (to be attached) to include
(i) Location of site (provide map) :
(ii) Name of waste processing technology :
(iii) Details of processing technology :
(iv) Type and Quantity of waste to be processed per day :
(v) Site clearance (from local authority, if any) :
(vi) Utilization programme for waste processed (Product Utilization) :
(vii) Method of disposal (details in brief be given) :
(viii) Quantity of waste to be disposed per day :
(ix) Nature and composition of waste :
(x) Methodology and operational details of landfilling/incineration :
(xi) Measures to be taken for prevention and control of environmental Pollution including treatment of leachates :
(xii) Investment on Project and expected returns :
(xiii) Measures to be taken for safety of workers working in the plant :

Place: **Signature: ……………..**

Date: **Designation: ……………..**

From-2

[See Rules 5(4)]

Form for Grant/Renewal of Authorisation by SPCB/PCC for Occupiers, Reprocessors, Reusers and Operators of Facilities for Collection, Reception, Treatment, Storage, Transport and Disposal of Hazardous Waste

1. Number of authorization and date of issue:

2. ………………… of …………………….is here by granted an authorization to operate a facility for collection, reception, treatment, storage, transport and disposal of hazardous waste on the premises situated at ………………………………………………..

3. The authorization granted to operate a facility for generation, collection, reception, treatment, storage, transport and disposal of hazardous waste.

4. The authorization shall be in force for a period of ………………………………………..

5. The authorization is subject to the conditions stated below and such conditions as may be specified in the rules for the time being in force under the Environment Protection Act, 1986.

Signature of Issuing Authority
Designation and Seal

Date:

Terms and conditions of authorization

1. The authorization shall comply with the provisions of the Environment Protection Act, 1986, and the Rules made there under.
2. The authorization or its renewal shall be produced for inspection at the request of an officer authorized by the SPCB/PCC.
3. The person authorized shall not rent, lend, sell, transfer or otherwise transport the hazardous waste without obtaining prior permission of the SPCB/PCC.
4. Any unauthorized change in personnel, equipment as working conditions as mentioned in the application by the person authorized shall constitute a breach of his authorization.
5. It is the duty of the authorized person to take prior permission of the SPCB/PCC to close down the facility.
6. An application for the renewal of an authorization shall be made as laid down in under these Rules.
7. Any other conditions for compliance as per the Guidelines issued by the MoEF or CPCB.

Form-3

[See Rule 5(6) and 22(1)]

Format for Maintaining Records of Hazardous Waste by the Occupier or Operator of a Facility

1. Name and address of the occupier of operator of a facility:
2. Date of issuance of authorization and its reference number:
3. Descriptions of hazardous waste:

Physical from with description	Chemical form	Total volume (m^3) and weight (in kg.)

4. Description of storage and treatment of hazardous waste:

Date	Method of storage of hazardous waste	Date	Method of treatment of hazardous waste

5. Details of transportation of hazardous waste:

Name and address of the consignee of package	Mode of packing of the waste for transportation	Mode of transportation to site of disposal	Date of transportation

6. Details of disposal of hazardous waste:

Date of disposal	Concentration of hazardous constituents in the final waste form	Site of disposal (identify the location on the relevant layout drawing for reference)	Method of disposal	Persons involved in disposal

7. Data on environmental surveillance:

Date of measurement	Analysis of grounder water			Analysis of soil samples			Analysis of air samples		Analysis of any
	Location of sampling	Depth of sampling	Data	Location of sampling	Depth of sampling	Data	Location of sampling	data	Other samples (give details)

8. Details of hazardous waste sold/auctioned to the recyclers or re-processors or re-users:
9. Details of hazardous waste reused or recycled:

Date	Total Quantity of hazardous waste generated	Details of hazardous waste of minimization activity	Material received	Final Quantity of waste generated	Net reduction in waste generation quantity and percentage

Date:………………… **Signature:……………………**

Place:……………….. **Designation:………………..**

Form-4

[See Rule 5(6) and 22(1)]

Format for Filing Annual Returns by the Occupier or Operator of Facility

[To be submitted by Occupier/Operator of disposal facility to SPCB/Pollution Control Committee by 30th June of every year for the preceding period April to March]

1.	Name and address of the generator/operator of facility	:				
2.	Name of the authorized person and full address with telephone and fax number	:				
3.	Description of hazardous waste	:	Physical form with description		Chemical form	
4.	Quantity of hazardous waste (in MTA)	:	Type of hazardous waste		Quantity (in Tonnes/KL)	
			(a)			
			(b)			
			(c)			
			…………………		…………………..	
5.	Description of Storage	:				
6.	Description of Treatment	:				
7.	Details of transportation	:	Name & address of consignee	Mode of packing	Mode of transportation	Date of transportation
8.	Details of disposal of hazardous waste	:	Name & address of consignee	Mode of packing	Mode of transportation	Date of transportation
9.	Quantity of useful materials sent back to the manufacturers* and others*	:	Name and type of material sent back to Manufacturers*		Quantity in Tonnes/KL	
			Others			

Date:…………………

Place:………………..

Signature:……………………

Designation:………………..

Form-11

[See Rule 20(2)]

Transport Emergency (Term) Card

[To be carried by the transporter during transportation of hazardous waste, Provided by the Occupier or Operator of a Facility]

1. Characteristics of Hazardous waste:

S. No.	Type of Wastes	Physical Properties	Chemical Constituents	Exposure Hazards	First Aid Requirements

2. Procedure to be followed in case of fire :
3. Procedure to be followed in case of spillage/accident/explosion :
4. For expert service, please contact :
5. For expert service, please contact :
   (i) Name & Address
   (ii) Telephone No.

(Name and Signature of Occupier/authorized representation)

Form-12

[See Rule 20(2)]

Marking of Hazardous Waste Container

HAZARDOUS WASTE*

Handle with Care:

Waste Category No.............................

Compatible Group..............................

Total Quantity ....

Date of Storage..................................

Contents and State of the Waste:

Sender's Name & Address

Phone...

E-mail..

Tel. & Fax No...................................

Contact Person.................................

Receiver's Name & Addrss

Phone...

E-mail..

Tel. & Fax No.....................................

Contact person..................................

In case of emergency please contact...

Note:

1. Background colour of label – fluorescent yellow
2. The words 'HAZARDOUS WASTES' & 'HANDLE WITH CARE' to be prominent and written in red in Hindi, English and in Vernacular Language
3. Label should be of non-washable material.

*Delete whichever is not applicable

Form-13

[See Rule 21(1)]

Hazardous Waste Manifest

1.	Occupier's Name & Mailing Address (including Phone No.)	: …………………………………………………………………
2.	Occupier's Registration No.	: …………………………………………………………………
3.	Manifest Document No.	: …………………………………………………………………
4.	Transporter's Name & Address (including Phone No.)	: …………………………………………………………………
5.	Type of Vehicle	: …………………………………………………………………
6.	Transporter's Registration No.	: …………………………………………………………………
7.	Vehicle Registration No.	: …………………………………………………………………
8.	Designated Facility Name & Site	: …………………………………………………………………
9.	Facility's Registration No.	: …………………………………………………………………
10.	Facility's Phone	: …………………………………………………………………
11.	Waste Description	: …………………………………………………………………
12.	Total Quantity	: ……………………………………………m^3 of MT
13.	Consistency	: (Solid/Semi-Solid/Sludge/Oily/Tarry/Slurry)
14.	Transport Description of Wastes	:
15.	Containers	Number Type
16.	Total Quantity	: ……………………………………………m^3 or MT
17.	Unit Wt/Vol.	: ……………………………………………m^3 of MT
18.	Waste Category Number	: …………………………………………………………………
19.	Special Handling Instructions & Additional Information	: …………………………………………………………………
20.	Occupeir's Certificate	: I hereby declare that the contents of the consignment are fully and accurately described above by proper shipping name and are categorized, packed, marked, and labeled, and are in all respects in proper condition for transport by road according to applicable national government regulations.

Type Name & Stamp: Signature: Month Day Year

21. 'Transporter Acknowledgement of Receipt of Wastes'

Type Name & Stamp: Signature: Month Day Year

22. Discrepancy Note Space : …………………………………………………………………

23. Facility Owner or Operator's Certification of Receipt of Hazardous Waste

Type Name & Stamp: Signature: Month Day Year

Form-14

[See Rule 24]

Format of Accident Report

[To be submitted by the Occupier or Operator of a facility and the transporter to the SPCB/PCC]

1. The date and time of the accident : ....
2. Sequence of events leading to accident : ....
3. The hazardous waste involvement in accident : ....
4. The date for assessing the effects of the accident : ....
5. The emergency measures taken : ....
6. The steps taken to alleviate the effects of accidents : ....
7. The steps taken to prevent the recurrence of such an accident : ....

Date:…………………..

Place:………………….

Signature:……………………

Designation:………………..

Annexure II

Detailed Guidelines for collection, transportation and storage of incinerable hazardous waste – Reference: **Source 1.**

A. Guidelines for Collection & Transportation of Hazardous Wastes

The occupier of the hazardous waste shall ensure that wastes are packaged in a manner suitable for safe handling, storage and transport. Labeling on packaging is readily visible and material used for packaging shall withstand physical conditions and climatic factors.

1. The occupier shall ensure that information regarding characteristics of wastes particularly in terms of being Corrosive, Reactive, Ignitable or Toxic is provided on the label.
2. The transport of hazardous waste containers shall be in accordance with the provision of the Hazardous Waste (Management, Handling and Transboundary Movement) Rules, 2008, (herein after referred as HW (M, H & TBM) Rules) and the rules made by the Central Government under the Motor Vehicle Act, 1988 and other guidelines issued from time to time.
3. The occupier shall provide the transporter with the relevant information in Form 11, regarding the hazardous nature of the waste and measures to be taken in case of an emergency and shall mark the hazardous wastes containers as per Form 12.
4. All hazardous waste containers shall be provide with a general label as given in Form 12 of the HW (M, H & TBM) Rules.
5. In case of transportation of hazardous waste through a State other than the State of origin or destination, the occupier shall intimate the concerned State Pollution Control Boards before he hands over the hazardous waste to the transporter.
6. Manifest System (Movement Document to be used within the country only)
   i. The occupier shall prepare six copies of the Manifest in Form 13 comprising of colour code indicated below and all six copies shall be signed by the transporter:

Copy number with Color code (1)	Purpose (2)
Copy 1 (White)	To be forwarded by the occupier to the State Pollution Control Board or Committee.
Copy 2 (Yellow)	To be carried by the occupier after taking signature on it from the transporter and rest of the four (4) copies to be carried by the transporter.
Copy 3 (Pink)	To be retained by the operator of the facility after signature.
Copy 4 (Orange)	To be returned to the transporter by the operator/recycler after accepting waste.
Copy 5 (Green)	To be returned by the operator of the facility to State Pollution Control Board/Committee after treatment and disposal of wastes.
Copy 6 (Blue)	To be returned by the operator of the facility to the occupier after treatment and disposal of hazardous materials/wastes.

   ii. The occupier shall not forwarded copy 1 (white) to the State Pollution Control Board, and in case of hazardous waste is likely to be transported through any transit State, the occupier shall prepare an additional copy each for information to such State and forward the same to the concerned State Pollution Control Board before he hand over the hazardous waste to the transporter.
   iii. No transporter shall accept hazardous waste from an occupier for transport unless it is accompanied by copies 3 to 6 of the manifest.
   iv. The transporter shall submit copies 3 to 6 of the manifest duly signed with date to the operator of the facility along with the waste consignment.
   v. Operator of the facility upon completion of co-processing of the hazardous waste shall forward copy 5 (green) to the State Pollution

Control Board and copy 6 (blue) to the occupier and the copy 3 (pink) shall be retained by the operator of the facility.

vi. The occupier shall provide the transporter with relevant information in Form 11 (i.e. Transport Emergency (TERM) Card) of the HW (M, H & TBM) Rules regarding the hazardous nature of the wastes and measures to be taken in case of an emergency.

Responsibilities of the hazardous waste transporter

Transport of hazardous wastes shall be responsible for:

1. Obtaining requisite authorization from SPCB/PCC for transport of hazardous waste (in addition to any other permission that may be required under the Motor Vehicle (Amendment) Act of 1981).
2. The transport vehicles shall be designed suitably to handle and transport the hazardous wastes of various characteristics.
3. The transporting should follow all the Rules pertaining to transportation of hazardous waste as stipulate under HW (M. H & TM) Rules, 2008.
4. Transporting the wastes in closed container at all time.
5. Delivery the wastes at designated points only.
6. Informing SPCB/PCC is Form 14 of the HW (M, H & TBM) Rules, or local authority, occupier/operator of a facility, and others concerned immediately in case of spillage, leakage or other accidents during transportation.
7. The transporter shall train the driver with regard to the emergency response measures to be taken during the transportation of waste.
8. Cleanup in case of contamination.
9. Cleaning of vehicles shall be carried out at designated places as authorized by SPCB/PCC.

Transportation Requirement

The following are the requirements pertaining to the transportation of hazardous waste:

1. Vehicle used for transportation shall be in accordance with the provisions under the Motor Vehicle Act, 1988, and rules made thereunder.
2. Transporter shall possess requisite copies of the certificate (valid authorization obtained from the concerned SPCB/PCC for transportation of waste by the waste generator and operator of a facility) for transportation of hazardous waste.
3. Transporter should have valid "Pollution under Control Certificate" (PUCC) during the transportation of hazardous waste and shall be properly displayed.
4. Vehicle shall be painted preferably in blue colour with strip of 15 to 30 cm width running centrally all over the body. This is to facilitate easy identification.
5. Vehicle should e fitted with mechanical handling equipment as may be require for safe handling and transportation of the wastes.
6. The words "HAZARDOUS WASTE" shall be displayed on all sides of the vehicle in Vernacular Language, Hindi and English.
7. Name of the facility operator or the transporter, as the case may be shall be displayed.
8. Emergency phone numbers and TREM Card in Form 11 of HW (M, H & TM) Rules, 2008.
9. Vehicle shall be fitted with roll-on/roll-off covers if the individual containers do not possess the same.
10. Carrying of passengers is strictly prohibited and those who associate with the waste haulers shall be permitted only in the cabin.
11. Transporter shall carry documents of manifest for the wastes during transportation as required under Rule 21 of the HW (M, H & TM) Rules, 2008.
12. The trucks shall be dedicated for transportation of hazardous wastes and they shall not be used for any other purpose.
13. Each vehicle shall carry first-aid kit, spill control equipment and fire extinguisher.
14. Hazardous Waste transport vehicle shall run only at a speed specified under Motor Vehicle Act in order to avoid any eventuality during the transportation of hazardous waste.
15. Educational qualification for the driver shall be minimum of 10th pass (SSC). The driver of the transport vehicle shall have valid driving license of heavy vehicles from the State Road Transport Authority and shall have experience in transporting the chemicals.
16. Driver (s) shall be properly trained for handling the emergency situations and safety aspects involved in the transportation of hazardous wastes.

17. The design of the trucks shall be such that there is no spillage during transportation.

B. Guidelines for Storage

Storage Requirement (for incinerable Hazardous Waste Only):

1. Flammable, ignitable, reactive and non-compatible wastes should be stored separately and should never be stored in the same storage shed.
2. Storage area may consist of different sheds for storing different kinds of hazardous wastes and sheds should be provided with suitable openings.
3. Adequate storage capacity (i.e. 25 % of the annual capacity of the hazardous waste utilization as a supplementary resource or for energy recovery, or after processing) should be provided in the premises.
4. Storage area should be designed to withstand the load of material stocked and any damage from the material spillage.
5. Storage area should be provided with the flameproof electrical fittings and it should be strictly adhered to.
6. Automatic smoke, heat detection system should be provided in the sheds. Adequate fire fighting systems should be provided for the storage area, along with the areas in the facility.
7. There should be at least 15 m distance between the storage sheds.
8. Loading and unloading of wastes in storage sheds should only be done under the supervision of the well trained and experienced staff.
9. Fire break of at least 04 meter between two blocks of stacked drums should be provided in the storage shed. One block of drum should not exceed 300 MT of waste.
10. Minimum of 1 meter clear space should be left between two adjacent rows of pallets.
11. The storage and handling should have at least two routes to escape in the event of any fire in the area.
12. Doors and approaches of the storage area should be of suitable sizes for entry of fork lifts and fire fighting equipment;
13. The exhaust of the vehicles used for the purpose of handling, lifting and transportation within the facility such as forklifts or trucks should be fitted with the approved type of spark arrester.
14. In order to have appropriate measures to prevent percolation of spills, leaks, etc., to the soil and ground water, the storage area should be provided with concrete floor or steel sheet depending on the characteristics of waste handled and the floor must be structurally sound and chemically compatible with wastes.
15. Measures should be taken to prevent entry of runoff into the storage area. The storage area shall be designed in such a way that the floor level is at least 150 mm above the maximum flood level.
16. The storage area floor should be provided with secondary containment such as proper slopes as well as collection pit so as to collect wash water and the leakages/spills, etc.
17. All the storage yards should be provided with proper peripheral drainage system connected with the sump so as to collect any accidental spills in roads or within the storage yards as well as accidental flow due to fire fighting.

2. Storage drums/containers

1. The container shall be made or lined with the suitable material, which will not react with, or in other words, is compatible with the hazardous wastes proposed to be stored.
2. The stacking of drums in the storage area should be restricted to three high on pallets (wooden frames). Necessary precautionary measures should be taken so as to avoid stack collapse. However, for waste having flash point less than 65.5°C the drums should not be stacked more than one high.
3. No drums should be opened in the storage sheds for sampling, etc., and such activity should be done in designated places outside the storage areas;
4. Drums containing wastes stored in the storage area should be labelled properly indicating mainly type, quantity, characteristics, source and date of storing, etc.

3. Spillage/leakage control measures

1. The storage areas should be inspected daily for detecting any signs of leaks or deterioration if any. Leaking or deteriorated containers should be removed and ensured that such contents are transferred to a sound container.

2. In case of spills/leaks/dry adsorbents/cotton should be used for cleaning instead of water.
3. Proper slope with collection pits be provided in the storage area so as to collect the spills/leakages.
4. Storage areas should be provided with adequate number of spill kits at suitable locations. The spill kits should be provided with compatible sorbent material in adequate quantity.

4. Record keeping and maintenance

Proper records with regard to the industry – wise type of waste received, characteristics as well as the location of the wastes that have been stored in the facility need to be maintained.

5. Miscellaneous

1. Smoking shall be prohibited in and around the storage areas;
2. Good housekeeping need to be maintained around the storage areas;
3. Signboards showing precautionary measures to be taken, in case of normal and emergency situations should be displayed at appropriate locations;
4. To the extent possible, manual operations with in storage area are to be avoided. In case of manual operation, proper precautions need to be taken, particularly during loading/unloading of liquid hazardous waste in drums;
5. A system for inspection of storage area to check the conditions of the containers, spillages, leakages, etc., should be established and proper records should be maintained;
6. The wastes containing volatile solvents or other low vapour pressure chemicals should be adequately protected from direct exposure to sunlight and adequate ventilation should be provided;
7. Tanks for storage of liquids waste should be properly dyked and should be provided with adequate transfer systems;
8. Storage sites should have adequate & prompt emergency response equipment systems for the hazardous waste stored on-site. This should include fire fighting arrangement based on the risk assessment, spill management, evacuation and first aid;Immediately on receipt of the hazardous
9. waste, it should be analyzed and depending upon its characteristics its storage should be finalized;
10. Only persons authorized to enter and trained in hazardous waste handling procedures should have access to the storage site;
11. Mock drill for onsite emergency should be conducted regularly and records maintained.

6. Recommended Storage time and the Quantity of the Incinerable Hazardous Wastes

Normal storage of incinerable hazardous wastes at the facility site for utilization as a supplementary resource or for energy recovery, or after processing should be restricted to maximum of 3 months. However State Pollution Control Board/Pollution Control Committee may extend the period up to 6 months in accordance with the Hazardous wastes (M, H& TM) Rules, 2008.

7. Hazard Analysis and Safety Audit

For every facility which uses waste as a supplementary resource or for energy recovery, a preliminary hazard analysis should be conducted. A safety audit, internally, by the facility operator every year, and, externally, once in two years by a reputed expert agency should be carried out and same should be submitted to the SPCB/PCC.

Such conditions should be stipulated by SPCBs while granting authorization under the HW (M, H & TBM) Rules to the operators.

(Primary Source: Report of Garg Committee on Storage constituted by CPCB, 2007)

Composition of the Forum of Regulators

1. **Shri. Hardik Shah** Member Secretary Gujarat Pollution State Control Board	....	Chairman
2. **Dr. B. Sengupta** Ex. Member Secretary CPCB	....	Member Convener
3. **Representative** Ministry of Environment & Forests Government of India	....	Member
4. **Representative** Central Pollution Control Board	....	Member
5. **Member Secretary** Rajasthan State Pollution Control Board	....	Member
6. **Member Secretary** Andhra Pradesh State Pollution Control Board	....	Member
7. **Representative** Tamil Nadu State Pollution Control Board	....	Member
8. **Representative** Maharashtra State Pollution Control Board	....	Member
9. **Representative** Odisha State Pollution Control Board	....	Member

Permanent invitees

10. Representative of Cement Manufactures Association (CMA)
11. Representative of Ultra Tech Cement Ltd.
12. Representative of Geocycle India, ACC Ltd
13. Representative of Holtec
14. Representative of Institute for Industrial Productivity (IIP)