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Key properties on solid recovered fuels to be used for establishing a classification system

Haupteigenschaften von festen Sekundärbrennstoffen als Grundlage zur Erstellung eines Klassifizierungssystems

Propriétés clés des combustibles solides de récupération a utiliser pour établir un systeme de classification

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This Technical Report was approved by CEN on 7 August 2006. It has been drawn up by the Technical Committee CEN/TC 343.

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Foreword

This document (CEN/TR 15508:2006) has been prepared by Technical Committee CEN/TC 343 “Solid recovered fuels”, the secretariat of which is held by SFS.

This document has been drafted on request of CEN/TC 343 Working Group 2 “Fuel Specifications and Classes”. The WG wanted to establish a classification system using practical data on Solid Recovered Fuel (SRF) composition and use. Therefore some delegates involved in the production and use of SRF offered to draft this document.

The WG decided on a classification system based on a limited number of properties. Originally the WG asked for a document covering 7 key properties of SRF: NCV, moisture, ash, Cl, Hg, Cd + Tl and sum of heavy metals. The first draft of the document was discussed at the WG meeting in Lyon on 15 and 16 September 2003. The properties of SRF and the experience with the different technologies were accounted for in the proposed classification system. The emission limit values of the Waste Incineration Directive played a decisive role in establishing the maximum possible content of heavy metals in SRF used as substitute fuel in different technologies.

The WG decided at the meeting in Lyon to reduce the number of key properties from 7 to 3: NCV, Cl and Hg content.

Topics were added covering the questions that had been raised at the Lyon meeting:

— justification of units chosen (Annex C);

— justification of the use of 50th/80th percentile values (Annex E);

— evaluation of data and influence on boundaries of classes (Annex E);

— justification of the boundaries of classes (Annex H).

The main adjustments were made in Clause 5. Annex E and Tables 18 and 20 of Clause 5 have been written with support of Ms Sabine Flamme of INFA.

Concerning the questions raised at the Brussels meeting on 9 and 10 February 2004 and the meeting in Obourg on 24 September 2004, the following modifications have been made:

— the classification of Cd and Tl has been evaluated using practical data. A classification system for Cd has been added if it comes to a need for that;

— additional evaluation of proposed classes of Cl and NCV with practical data has been included.

In making acknowledgements, we would like to express appreciation to the members of CEN/TC 343/WG 2, the members of ERFO and particularly to those companies for making available data and information from their experience with the production and use of Solid Recovered Fuel.

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February 2005

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Introduction

Energy intensive industries are looking for alternative fuels in order to save primary fuels, and by doing so, enforce the development of sustainable development.

The waste management sector industry has developed, for many years, ways to produce secondary fuels e.g. SRFs with reliable qualities, which are used successfully regarding economic and environmental aspects.

However, this way of recovery is not optimized because of some practical uncertainties like:

— obtaining permits to use SRF as an energy source;

— transborder shipment regulation and problems in creating a European market for SRF;

— unclear classification of the SRF in the EC waste list;

— doubt about reliable qualities of some SRF;

— doubt about effect on the processes and installations.

Therefore CEN has received the mandate to establish a set of standards for solid recovered fuel (SRF) prepared from non hazardous waste. CEN/TC 343 has decided to separate the task in five different working groups (WG 1 to 5).

WG 2 has received the task to prepare a proposition of classification system, classes and specifications.

The following Technical Report gives a technical approach based on the processes of final users that have been identified as being (potentially) interested and qualified for the use of SRF on the one hand, and the practical and actual experience of SRF produced in Europe on the other hand.

SRF may only be used by installations complying with the emission limit values set by the Waste Incineration Directive (WID). This Technical Report is based on the characteristics that the SRF should present, in order to fulfil the criteria of the WID and the technical request of the installations. That does not alter the fact that other properties are also of interest considering the specific requirements for different users.

The classification system, the classes and the specifications that are proposed in this Technical Report should help the authorities in writing the permits, be a help for the final user to understand easily what has to be taken into account when dealing with SRF and should increase the positive perception of the public on the use of SRF by saving of natural resources. For example about 50 % of the primary fuel consumption of cement kilns and a substantial share of hard coal and lignite for power production could be substituted by waste. The potential for European Solid Recovered Fuels in 2005 is estimated at more than 10 Mt/a [1], which corresponds to a CO_2-reduction of more than 10 Million tpa. (In this figure only the biogenic fraction and C/H ratio were considered. The reduction due to less emission of methane from landfills would be a factor ~3 of this).

It is of importance to mention that the standardization concerns big SRF streams. It surely does not exclude the possibility to use alternative fuels with other limits or specifications than those presented in this Technical Report. In that case, the waste fuel will not be standardized.

Selection of properties for classes and specifications: a classification system is a system of classes with limit values and valid for all kind of users. Specifications concern specific information related to potential risks for different technologies and plants. Implementing such a system should facilitate trans-boundary shipments, permitting and control for the user of standardized recovered fuels (SRF).

CEN/TC 343/WG 2 has agreed that key properties mentioned below will be used to establish the classification and the specification system for SRF. These properties are significant for one or more of the following aspects: economics (NCV), technology (Cl) and emission (Hg + Cd). Cl has to be mentioned because of the great importance in corrosion, slagging and fouling of boilers. It has been suggested to consider both Cd and Tl. However, the concentration of Tl in SRF is practically nil (see also Annex I), applying this element as part of an environmental parameter would be meaningless.

Table 1 — Key combinations of properties and aspects

Properties	*Key aspect*
NCV Cl [a] Hg + Cd	Economics Technology Emission
[a] Cl may influence emissions of HCl and some heavy metals as chlorides. However, the effect is estimated to be negligible. An influence on the formation of PCDD and PCDF is unlikely under the process conditions in a coal fired power plant and a cement kiln.	

1 Scope

This Technical Report gives background information on key properties to be used for establishing a classification system for solid recovered fuels (SRFs), and a proposal for the classification system and classes for SRF.

2 Overview of practical data

2.1 Specification of users

2.1.1 General

At present the main end-user is the cement industry. But also in lime kilns, SRF has successfully been used for many years. As the technology of cement kilns and lime kilns is very similar in this Technical Report, cement kiln also stands for lime kiln except for heavy metals. However, the market opportunities in the potential bigger market of the power generation sector are increasing. The fourth sector that may become a substantial outlet for SRF is cogeneration CHP (district heating) [1]. Main technologies involved are cement kilns, pulverized coal fired power plants and FBC (fluidized bed combustion) plants. See also Annex A.

2.1.2 Cement industry

The cement industry has a broad experience in the use of waste derived fuels. Hazardous and non hazardous wastes are processed and used as secondary fuel or a mixture of secondary fuel and raw material. Originally the substitution of primary fuels was practised by wet processes, which have higher specific energy consumption than the dominant dry process for the production of clinker. But the use of waste derived fuels, including SRF, is also increasing in the dry process. Cl may cause substantial problems in the dry process in blocking the pre-heater with condensed volatile chlorides. Using a so-called salt bypass increases the tolerance for Cl in the input. Table 2 shows the requirements for SRF. Figures are based on specifications from the end-users from e.g. Belgium, Germany and France.

Table 2 — Specifications [2]

	Unit	*CK*
NCV	MJ/kg ar	5/10 to 12/22 [a] (mean values)
Cl [b]	% ar	0,5 to 1,0 (mean)
		1 to 3,0 (max.)

CK = cement kiln or clinker kiln

[a] There is no maximum value for NCV. The combination of material and energy recovery together in clinker kiln allows the use of poor calorific values, because the ash content in the SRF does not contribute to the energy input.

[b] Cl specification depends on the composition of the input. At high substitution rates, the limits are in the range of 3 % for a cement kiln with a by-pass (depending on the K, Na content) and for a kiln without this system 0,5 % to 1,0 %. For a cement kiln with a wet process, the maximum for Cl is 6 %.

2.1.3 Coal fired power plants

The experience of the power generating plants with SRF is limited to a few plants in Germany and The Netherlands that are using SRF since 2000 but still on a small scale. RWE Umwelt and RWE Power are carrying out the demonstration project RECOFUEL within the 6th Framework programme of the EU to use quality assured SRFs in lignite fired boilers.

Pulverized coal plants are dominant in the power generating sector. The technologies differ for brown coal and hard coal, as these coals have widely divergent heating values and material properties. Hard coal fired power plants using a dry bottom boiler (DBB) have less flexibility to the shape and dimensions of SRF than the wet bottom boiler (WBB) molten slag systems with cyclones. Table 3 shows the requirements for SRF. The data are based on specifications from end-users in The Netherlands and Germany.

Table 3 — Specifications [2]

	Unit	Hard coal DBB	Hard coal WBB	Brown coal DBB
NCV	MJ/kg ar	13,5 (mean) 11 to 18 (range)	17 (mean) 13 to 22 (range)	13,5 (mean) 11 to 18 (range)
Cl [a]	% dry	0,6 (mean) 1,3 (max.)	1,1 (mean) 2,5 (max)	0,5 (mean) 0,6 (max.)/1,0 (max.) [b]

DBB = dry bottom boiler pulverized coal, dry ash

WBB = wet bottom boiler pulverized coal, molten slag

[a] The Cl-concentration of the total fuel mix should be kept <0,2 % to 0,4% to prevent high temperature corrosion. The maximum allowable Cl % depends on the design and materials chosen. In The Netherlands the maximum is usually 0,2 %. In the UK the maximum is higher (0,4 %) as the plants are designed for coal with a high Cl content.

[b] The maximum values vary for different companies. Mean and max.-values are close for a specific end-user.

2.1.4 FBC

Fluidized bed combustion plants (FBC) are used i.e. for district heating in Scandinavia and cogeneration (CHP) using mainly biofuels. Table 4 shows the requirements for SRF. The data are based on specifications of the end-users in Sweden, Italy and Germany.

Table 4 — Specifications [2]

	Unit	FBC
CV	MJ/kg ar	13,5 (mean) 9 to 18 (range)
Cl [a]	% ar	0,4 (mean) 0,5 (max.)/0,8 (max.)/1,4 (max.)

[a] The maximum allowable Cl-content depends on the design of the plant and composition of the input. The mean and max values are close for a specific end-user.

2.1.5 Overview

Table 5 — Overview of specifications (end-users)

	Unit	**Cement**	Hard coal DBB	WBB	Brown coal DBB	FBC	FBC(AC) [a]
NCV	MJ/kg ar mean/max.	5/11/22 (mean)	13,5/18	17/22	13,5/18	13,5/18	13,5/18
Cl	% ar mean/max.	0,5 to 1,0/3	0,5/1,0	1,0/2,0	0,4/0,5 to 0,7	0,4/1,4	0,4/1,4

[a] AC: active coal used as absorbent.

2.2 Orientation values of mercury and cadmium

The emission of heavy metals is an important topic in the market development of SRF although concerning the WID the heavy metal emissions by co-combustion plants are not considered any longer separately for heavy metals originating from SRF at one hand and at the other hand primary fuels, because the mixing rule has been deleted for these properties. The values derived in Annex D only have an orientation character. The fuel mix, the raw material and the specific transfer factor of the plant involved together determine the actual emissions. Specifications provided by potential producers and users are often influenced by local limit values. This would not be a sound basis for a European classification system. But using the practical data on the transfer factors (see Annex B for background information) and the values of the WID for the several technologies the maximum concentration in the SRF may be calculated according to the equation mentioned in Annex C.

Table 6 — Overview of calculated orientation values of Hg and Cd

	Unit	**Cement**	**Hard coal power plants** DBB	WBB	**Brown coal power plants** DBB	FBC	FBC(AC) [a]
Hg	mg/MJ ar max.	0,08-0,33	0,065	0,034	0,085	0,028	0,26
Cd		6,90	1,21	0,25	0,42	0,63	85

[a] AC: active coal used as absorbent.

The values for Hg and Cd have to be understood as maximum average (see also E.1.3) that can be used in a process operation that comply with the transfer factor taken in the example above for the use of waste as a fuel. It is of importance that each plant that wants to use secondary fuel first makes a study to determine what are the transfer factors for each metal. The result shows significant differences between the processes and technologies used. It means that some technologies are not able to use the same fuels as others due to different transfer factors.

3 Overview of secondary fuel and SRF qualities

Tables 7 to 10 give an overview of the composition of secondary fuels. The data are based on analysis of fuels produced in several EU Member States. See also Annex F.

SRFs derived from MSW have generally a lower NCV than the SRFs derived from selected commercial waste, which have a range that corresponds to the NCV of a mixture of biomass and plastics. The maximum of Hg for

SRF derived from MSW is higher. However, the maximum for Hg is not substantially higher than for SRF derived from commercial waste when Tunka is excluded. The SRFs produced for cement kilns show a great range for all properties, indicating the flexibility of the cement kilns.

Secondary fuels may also contribute to the substitution of raw materials. This is often the case with secondary fuels used by cement kilns. Therefore two SFR categories are presented, one low in ash and one high in ash. The NCV value is low for the SRF types with a high ash content. This has a direct effect on the values for Hg using the unit mg/MJ as can be seen in Table 7.

Table 7 — Overview of SRF with low and high ash content

		SRF low in ash [a]		SRF high in ash [a]	
	Unit	Median range	80th Percentile range	Median range	80th Percentile range
NCV	MJ/kg ar	11,7 to 25,5	12,8 to 25,8	3,2 to 10	3,4 to 12,0
Cl	% ar	0,04 to 1,7	0,07 to 2,0	0,07 to 0,77	0,14 to 0,82
Hg	mg/MJ ar	0,004 to 0,042	0,005 to 0,137	< 0,05 to 0,406	0,064 to 0,781
Cd + Tl	mg/MJ ar	0,008 to 0,121	0,008 to 0,264	0,26 to <0,93	0,26 to 0,94

[a] Boundary 20 % d. See also Annex G for the maximum values of heavy metals.

Table 8 — Overview of SRF derived from MSW

	Unit	Median range	80th Percentile range
NCV	MJ/kg ar	9,8 to 19,9	11,4 to 22,2
Cl	% ar	0,23 to 0,79	0,43 to 0,88
Hg	mg/MJ ar	0,006 to 0,069	0,009 to 0,079
Cd + Tl	mg/MJ ar	0,050 to 0,311	0,084 to 0,380

Table 9 — Overview of SRF derived from commercial waste

	Unit	Median range	80th Percentile range
NCV	MJ/kg ar	13,0 to 31,0	14,0 to 31,6
Cl	% ar	0,04 to 0,60	0,07 to 1,0
Hg	mg/MJ ar	0,004 to 0,019	0,005 to 0,064
Cd + Tl	mg/MJ ar	0,008 to 0,060	0,008 to 0,129

Table 10 — Overview of SRF produced for cement kilns

	Unit	Median range	80th Percentile range
NCV	MJ/kg ar	3,2 to 25,5	3,4 to 25,8
Cl	% ar	0,07 to 1,7	0,14 to 2,0
Hg	mg/MJ ar	<0,02 to 0,406	<0,02 to 0,781
Cd + Tl	mg/MJ ar	<0,12 to <0,93	<0,12 to 0,94

4 Summary of existing quality systems for SRF (for the chosen properties only)

Table 11 — Summary of existing national standards

		Finland			Germany		Italy		
	Unit	Class I	Class II	Class III	median	80th percentile	Units	standard	High qual,
NCV							MJ/kg ar	>15	>19
Moisture							% ar	<25	<15
Ash							% d	<20	<15
Cl	% d	<0,15	<0,5	<1,5			% ar	<0,9	<0,7
Hg	mg/kg d	<0,1	<0,2	<0,5	0,6	1,2	mg/kg d	<7 [c]	<1
Cd + Tl	mg/kg d	<1,0	<4,0	<5,0	5	11		-	<4
Sum HM	mg/kg d				351 [a]/1 049 [b]	1 080 [a] /2 460 [b]	mg/kg d	<1 040	<350

NOTE 1 Finland: Tl is not mentioned. NCV is not mentioned either. Use 20 MJ/kg d for the calculations and 15 % moisture.

NOTE 2 Germany: [a] SRF produced from specific wastes, [b] SRF produced from MSW. Actually, there exists no 80th percentile value for Cu (SRF from production specific waste, class 1) and Pb + Cu (SRF from HCF of MSW, class 2). According to the latest information received, these values will probably be 500 (Cu), 500 (Pb) and 1 000 (Cu) respectively.

The NCV values for heavy metals are up to 16 MJ/kg d. for class 2 derived fuels and 20 MJ/kg d. for class 1. Use 15 MJ/kg ar and 15 % moisture for calculations for class 2 and 20 MJ/kg ar and 15 % moisture for class 1.

NOTE 3 Italy: The HM Sb, Co and V are not mentioned. The NCV is a minimum value. Value for Cu concerns soluble components. Value for Pb concerns the volatile part. Use the minimum NCV (calculated for d) for the calculations. The value for the standard quality in the table for the concentration of Hg [c] is the sum of Cd + Hg.

NOTE 4 Preceding the implementation of national standards producers of SRF have developed their own quality systems [1].

Table 12 — Summary of existing standards, adapted and presented in uniform units

		Finland			Germany [a]		Italy	
	Unit	Class I	Class II	Class III	Median	80th percentile	standard	High qual,
NCV	MJ/kg						>15	>19
Moisture	ar						<25	<15
Ash	%						<15	<13
Cl	% ar	<0,13	<0,42	<1,3			<0,9	<0,7
Hg	mg/MJ ar	<0,005	<0,01	<0,025	<0,026/0,034	<0,051/0,068	<0,35 [b]	<0,045
Cd + Tl	mg/MJ ar	<0,05	<0,2	<0,2	<0,17/0,23	<0,38/0,51	-	<0,180
Sum HM	mg/MJ ar				<14,9/59,4	<45,9/139,4	<52 [c]	<15,6 [c]

[a] Different values for SRF derived from production specific waste (first figure) and SRF produced from MSW (second figure).

[b] Cd + Hg. There is no separate value for this quality in the Italian standard, see also Note 3 of Table 11.

[c] The sum property does not include several HM, see also Note 3 of Table 11.

5 Classes

5.1 Resolutions of CEN/TC 343/WG 2 Specifications and classes

The WG defined classification as: "The grouping of SRF's into classes defined by boundary values for chosen fuel characteristics, to be used for trading as well as for information of permitting authorities and other interested parties". Initially the WG adopted in the 1st resolution 7 properties for the characterisation of SRF: NCV, ash, moisture, Cl, Hg, Cd + Tl, sum of heavy metals. These properties were used in earlier drafts of this classification report. However, in resolution 3 the number of key-properties was reduced from 7 to 3 (Table 13). The main argument being the complexity of the classification with so many. The properties chosen represent the following aspects: economic value (NCV), technological restrictions (Cl) and environmental impact (Hg).

After long discussion the WG adopted in its 3rd resolution the following structure for the characteristics of SRF classes for each of the three selected fuel characteristics.

Table 13 — SRF classes

Classification property	**Desig-nation**	**Unit**	**Classes**				
			1	**2**	**3**	**4**	**5**
Net calorific value	NCV	MJ/kg ar	<10	<15	<20	<25	>25
Classification property			**1**	**2**	**3**	**4**	**5**
Chlorine	Cl	% d	<0,3	<0,6	<0,9	< 3,0	>3,0
Classification property			**1**	**2**	**3**	**-**	**-**
Mercury	Hg	mg/kg	<x	<y	<z	-	-