The RECOFUEL-project - Demonstration of co-firing of Solid Recovered Fuels in European lignite fired power plants

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SUMMARY:
The Recofuel project aimed in the demonstration of quality ensured SRF (Solid Recovered Fuel) production and co-combustion with lignite. During the project different test campaigns in two power plants showed the feasibility of the co-combustion in terms of emission limits, ash composition and influence ath the boiler behaviour. The following paper shows also the development of the fuel quality during the project by enhanced sorting technics. Therefore an ambitious test program for the fuel based on the European standardisation development was part of the project.

1. THE EU-PROJECT RECOFUEL

The disposal of untreated Municipal Solid Waste (MSW) in the EU countries is regulated by the EC Directive 1999/31 and forces a reduction of the biodegradable quantities disposed off to landfills in the coming decade. In the context of the Community waste strategy (COM (96) 399 Final), the production and thermal utilisation of Solid Recovered Fuels (SRF) – fuels derived from non-hazardous waste streams - could be a key element in a future environmentally friendly waste management system and a contribution to reduce CO_2 emissions from fossil fuels.

Within the scope of the European Demonstration Project RECOFUEL, SRF co-combustion has been successfully demonstrated in two different lignite fired boiler of RWE Power AG in Germany. A 600 MWel pulverised lignite-fired boiler in Weisweiler was used for a two weeks measurement campaign in 2005. The demonstration was continued at the 235 MWth Circulating Fluidised Bed (CFB) lignite fired boiler with combined heat power generation in Berrenrath in three phases over a 17-month period in 2007 and 2008 with two measurement campaigns in April and November 2007. During the campaigns a maximal thermal share of 4% was investigated in the pulverised fired boiler and a thermal share of 20% (approx. 6Mg/h SRF) for the CFB. The total amount of approx. 5.000 Mg of SBS®1 (Subsitutionsbrennstoff) in the pulerised coal boiler and ca. 60.000Mg of SBS®1 in the CFB was co-fired. The SRF production and quality control was beside emmisions, operational behaviour, corrosion and ash disposal one of the main topics.

2. SRF-PRODUCTION

The project coordinator REMONDIS GmbH delivered the high quality SRF - SBS®1 - during all phases of the project. This is a quality ensured SRF according to the German standards of RAL-GZ 724, but also complying with the European standards (CEN TC 343) that are in validation. The input materials for the SBS®1 – production are different kinds of high calorific fractions from municipal solid waste, bulky waste and mixed commercial wastes as well as a little amount of production specific wastes.

Based on the results of the internal supervision (quality control) and especially the quality of the different high calorific fractions, different technical improvements of the pre-treatment/sorting process as well as of the SRF-production have been realized (see also Figure1).

The main aim of the different measures is to stabilize and homogenize the load of the different NIR-devices (NearInfraRed) in order to raise the efficiency/selectivity of the separation process especially with respect to chlorine.

Beside these technical measures different organisational measures have been set into force (i.e. new work orders) to reduce interface problems between ABA (waste treatment plant) and AKEA (SRF production plant).

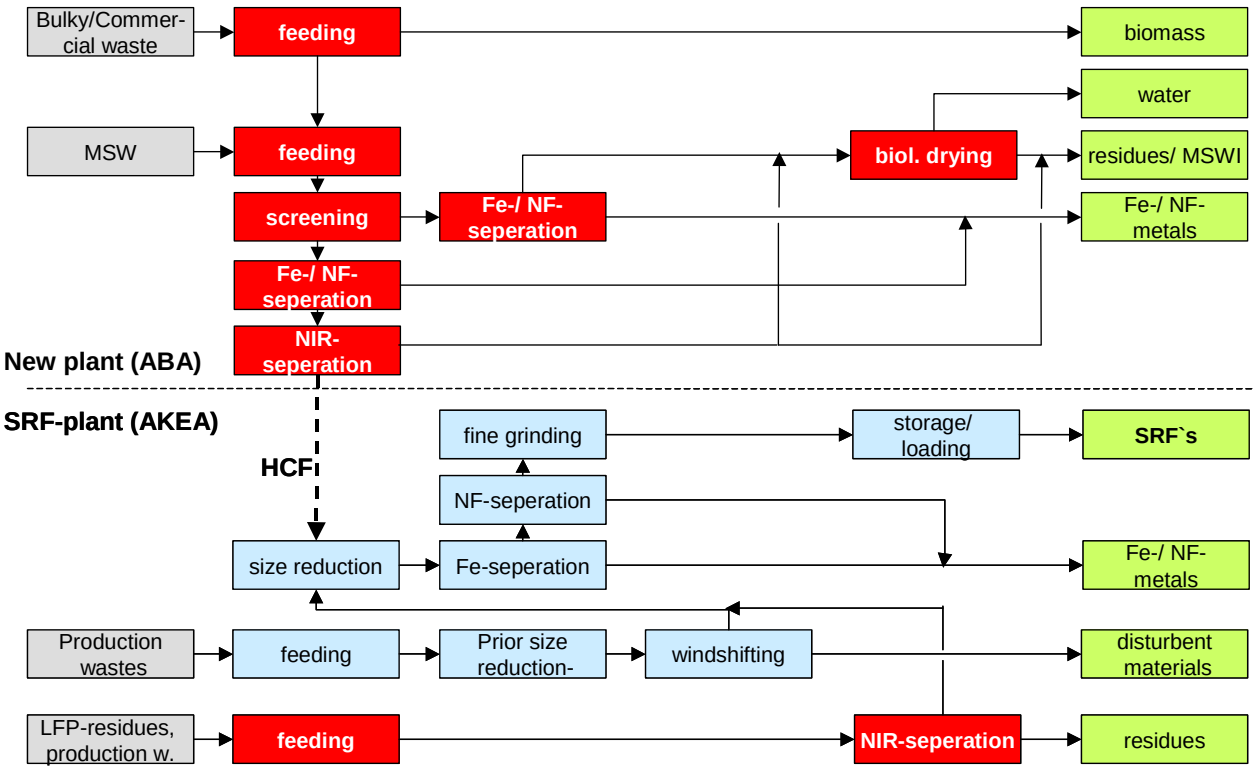

Figure 1: Extension of the VZEK (Verwertungszentrum) in Erftstadt, simplified flow sheet (red: new components, blue: old/existing components, grey: input materials, green: output materials)

2.1 Further extension of input materials

The recipe of Table 1 summarizes the development of the average "recipe" of SBS®1 according to the market developments and the results of utilisation. HCF (High Calorific Fraction) from bulky waste has been the dominating component of SBS® in 2006. Within 2007 the share of HCF from mixed commercial wastes has been increased successfully. The relevance of production specific wastes has been reduced since 2006.

Table 1: Adaptation of the “recipe” of SBS®1_E

Input material	2004 Weis-weiler	2005 Weis-weiler	2006 Berren-rath	2007 Berren-rath
Production specific waste (high Al-content)	30	0	0	0
Production specific waste (low Al-content)	0	25	10	10
High Calorific Fraction from MSW	70	75	38	39
High Calorific Fraction from bulky waste	0	0	50	40
High Calorific Fraction from mixed commercial waste	0	0	2	11

Efforts to raise the share of HCF

In order to improve the economy of the sorting process the share of HCF/SBS® has been increased from 27% of the total input of ABA in 2006 to 36% in 2007. This was achieved without reducing the quality of SBS®1. Figure 3 shows, that on the contrary, the SBS®1-quality was even improved.

Characterisation of the produced SBS®-qualities

SBS®1 has achieved a rather good homogeneity in comparison to other SRF`s (especially SRF`s based on HCF`s from MSW/bulky waste/mixed commercial wastes) but even compared to coal (in this case lignite) taking into account the relative standard deviation or the ratio of 80./50.percentile for S, Cl, Na and K.

Since several years the resulting class code for SBS®1 according to the compliance rules of CEN/TS 15359 is stable:

NCV: 4, Cl: 2, Hg: 1

Repeated problems of detection limits have to be taken into account especially for Tl, As, Se and Be (half dl, tables 2 – 3) and from time to time for Cd and Hg too.

In addition to the above mentioned tables the biogenic content of SBS®1 has been analysed within the external certification procedure for 2006 and 2008 according to RAL-GZ 724. The values are very well comparable to table 2. The resulting emission factor (with respect to C_{fossil}) is 25 - 30 t CO_2/TJ.

Improvement/optimisation of produced HCF and SBS®-qualities

As a result of different technical and organisational measures HCF and SBS®-qualities have been improved with respect to quality level and homogeneity.

Figure 2 elucidates the stabilized quality of HCF from MSW for Cl (reduced maximum value/standard deviation), whereas the Cl-level of HCF from bulky waste has been reduced significantly (mean value). Chloride (inorganic Cl)-concentration can not be influenced by NIR-technology, but by improvements of the screening system.

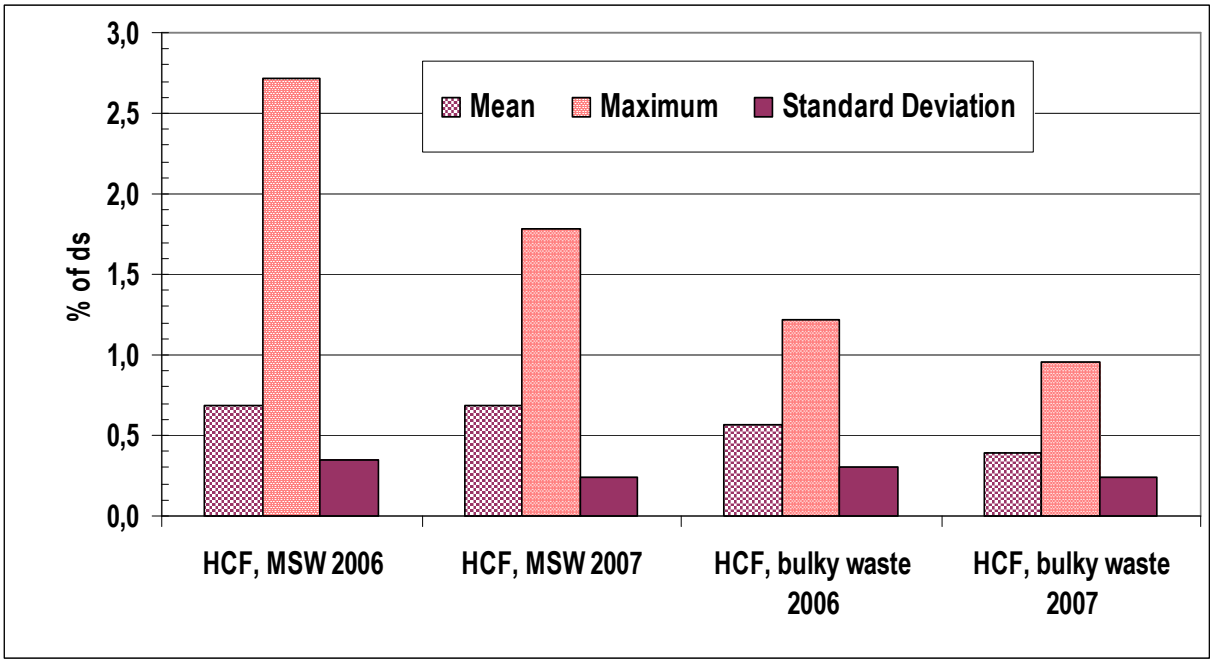

Figure 2: Development of Cl-values of HCF from MSW and of HCF from bulky waste (data assays till December 2007)

Figure 3 shoes the development of parameters influencing the fouling or corrosion potential of SBS®1_E. Al_{total}, K and Na have been reduced significantly; Cl-values have almost been reduced to the level of 2004, before the coming into force of the German landfill directive, 01.06.2005 (see also Figure 4).

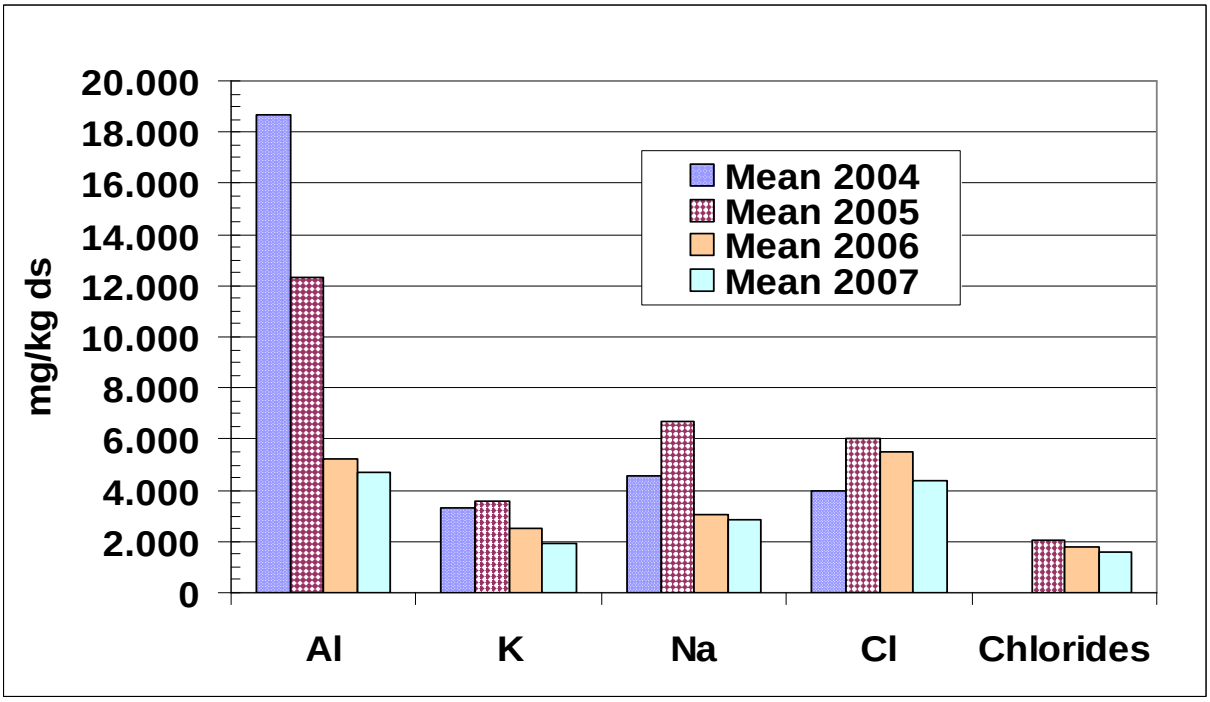

Figure 3: Development of parameters with fouling or corrosion potential for SBS®1_E (Analysis of total aluminium according DIN EN ISO 11885 E22)

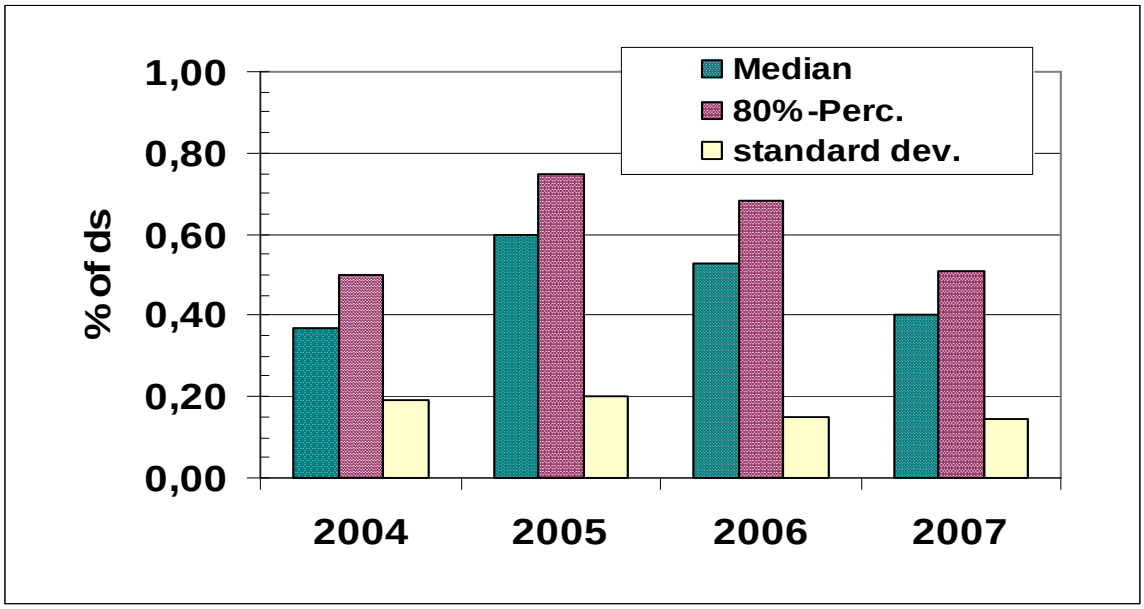

Figure 4: Development of Cl-values for SBS®1_E incl. standard deviation

Table 2: Overview of the main parameters of SBS®1_E

	Unit	Lignite from the Rhine (Inden), Mean	SBS 1 Mean 2004 - 2005	SBS 1 Mean 2006	SBS 1 Mean 2007
Short analysis					
Net. Calorific Value	MJ/kg o.s.	8,15	14,1	13,6	14
H_2O	% o.s.	58,8	29	22,7	22,6
Ash	% o.s.	3,0	10,3	9,6	9,3
Chlorine	% o.s.	0,02	0,34	0,42	0,34
Volatile	% o.s.	n.a.	55	57	47,1
Elementary analysis					
C_{org}	% o.s.	24,8	33,5	32,8	36,4
H	% o.s.	2,2	5,5	4,7	5,1
O	% o.s.	10,6	20,3	28,4	24,3
N	% o.s.	0,4	0,5	1,5	1,6
S	% o.s.	0,2	0,1	0,2	0,2

3. SRF USE IN LIGNITE FIRED POWER PLANTS

The first measurements took place at two 600 MW_{el} boilers of the RWE power plant Weisweiler which are of pulverized lignite fired type. To test the general handling of the fuel and the measurement possibilities there has been pretrials in 2004 with approx. 500Mg SBS. Figure 5 shows the fuel handling via the existing paper sludge handling system.

In March 2005 followed a two weeks test campaign with 4500 Mg SBS cofired at 2% and 4% thermal share. The aims of all measurement campaigns were to investigate the influence of fuel parameter on combustion process and boiler behaviour, the formation of ash, the emissions and the possible corrosion effects during co-combustion.

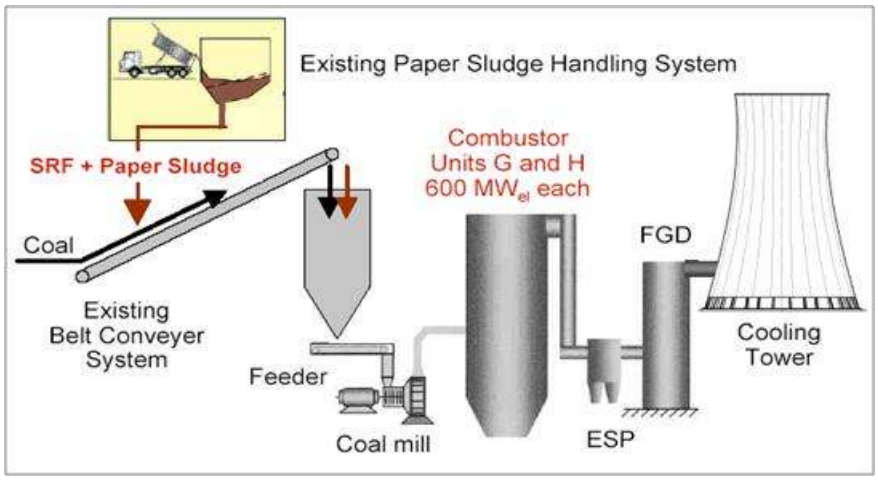

Figure 5.Fuel feeding system of the Weisweiler PP.

The deposits and possible corrosion effects were investigated by deposition and online corrosion probes. Fuel and ash samples were also taken periodically. The overall results for both campaigns showed no critical influence of co-combustion of high quality SRF.

After the tests in Weisweiler a second power plant was used for further investigation. The CHPP (Combined Heat and Power Plant) Berrenrath has two 235 MW_{th} CFB boiler were SBS and sewage sludge are cofired with rheinish lignite. Since the beginning of the co-incineration of SBS®1 in Berrenrath in 2003 more than 200.000 Mg have been used till May 2008. During the investigation phase of the RECOFUEL-project from beginning 2007 until May 2008 ca. 80.000 Mg have been co-incinerated.

Figure 6 shows a sketch and the technical data of the CFB-boiler of the Berrenrath PP, with the furnace on the left side, the cyclones and solid recirculation loop in the middle and the heat recovery section on the right. The sewage sludge is premixed with the coal shortly before the feeding point and there are two additional feeding points at the bottom of the furnace for the SBS close to the entrance of the recirculated solids.

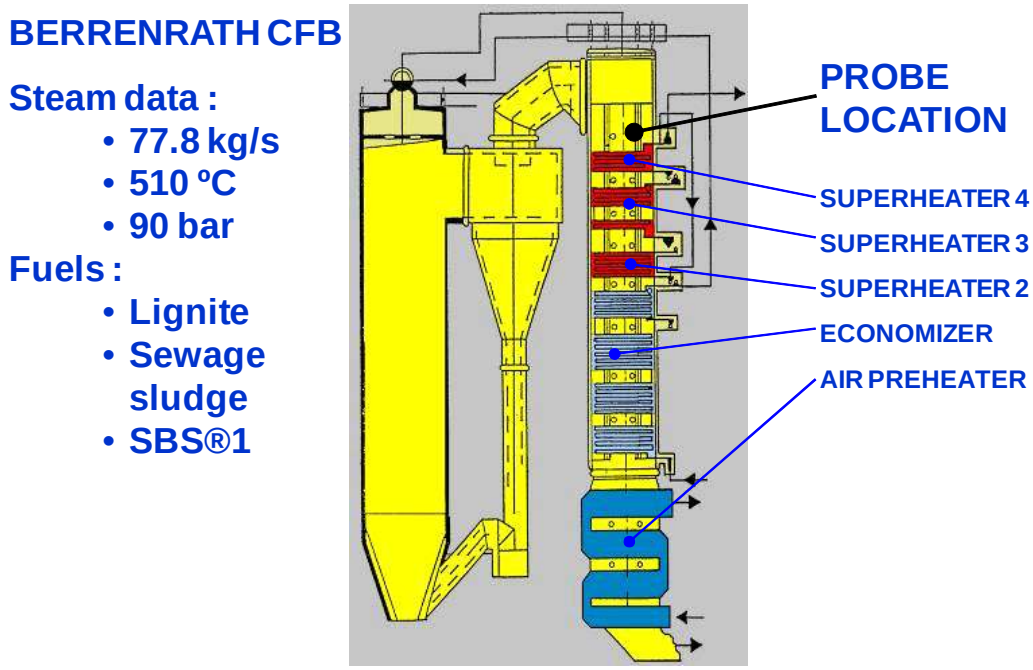

Figure 6 CFB Boiler at the Berrenrath CHPP

Aim of these measurement campaigns was to cover many representative operational conditions as fluctuations in fuel input streams and quality, single and two point feeding, total boiler load etc. The main focus was the fouling and corrosion behavior of the fuel mixture. The following measurements were done:

- Gas measurements to analyse the raw gas composition near the probe
- Deposition and corrosion probe
- Emission measurement at the stack
- HCl online raw gas measurement
- HCl – wet – raw gas measurement
- Online corrosion measurement

4. RESULTS OF THE TEST CAMPAIGNS

The tests and measurements in both power plants under different conditions showed the general feasibility of the co-combustion of the quality ensured SRF. The emission limits were in all cases well below the limits. As example the emissions of the Weisweiler power plant during co-combustion are shown in table 3 in comparison to the German legal situation.

Table 3: Co-combustion emissions at Weisweiler PP

Parameter		SRF co-combustion	German Legislation (17. BlmSchV)
Fly ash	mg/m^3	1,5	10
TOC	mg/m^3	0,5	10
HCl	mg/m^3	<0,1	20
HF	mg/m^3	<0,1	1
Hg	$\mu g/m^3$	7	30
Σ Cd-Tl	$\mu g/m^3$	<7	50
Σ As-Sn	$\mu g/m^3$	<65	500
PCDD/F	$ngTE/m^3$	<0,001	0,1

No significant differences between the reference measurement (operation without SRF) and SRF co-combustion were observed, the differences in the measured values being in the range of statistical variations. Furthermore there was no negative impact on boiler performance observed.

In the Weisweiler PP increased HCl concentrations were measured in the boiler exit, but not in the stack and it was concluded that the Cl is effectively captured during the desulphurization process. In addition was determined from the mass balances that for specific heavy metals and Cl the greatest quantity is captured in the ash and the gypsum.

After the measurement campaigns in April and November 2007 at Berrenrath PP and in combination with results of earlier measurements, several actions have been discussed and initiated to reduce corrosion risk and stabilise SRF co-firing at a high share:

- SRF co-firing by maximum sludge mass flow
- Avoidance of lime feeding during low SO2 concentration in the boiler
- SRF input by two ports to avoid high concentrations locally
- Homogeneous and quality controlled SRF quality
- Installation and testing of a corrosion monitoring (online HCl measurement, online corrosion

probe)

All of those actions resulted in a better co-combustion of the SRF regarding the operational behaviour and reduced the risk of corrosion at the super heaters.

5. CONCLUSIONS

Bringing all results of the project together the main conclusion is the general feasibility of co-combustion of SRF in lignite fired power plants and the measures support substantially a stable SRF co-firing at high mass flows. During the co-combustion of SBS®1 and low sulfur lignite, the sewage sludge can reduce the integration of chlorine into fly ash and deposits. Detailed investigation showed that the gettering of alkali components by silicates could be observed.

Modern treatment-technology and substantial material knowledge are the basis for the production of a high quality SRF. A quality management system according to CEN-TC 343 and the German RAL-GZ 724 can improve the relaiability of fuel properties and the fuel-quality itself substantially. The NIR- technology is a key tool to separate suitable HCF fractions with low Cl- values from MSM, bulky waste and mixed commercial wastes and it could be a promising approach to limit the Cl input into the boiler. Nevertheless high quality SRF can be compared to biomass based fuels such as used wood, straw etc.. Finaly it can be concluded that in a sustainable waste management system the SRF-production and MSW incineration can complement each other.

Nevertheles to integrate new fuels and enhance the fuel flexibility successfully the complete mixture of fuels should be investigated before starting cofiring and especially the secondary fuels should be quality ensured on a regular basis.

ACKNOWLEDGEMENTS

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REFERENCES (please list without numbers)

prCEN/TS 15357. Solid Recovered Fuels – Terminology, definitions and descriptions