File Copy

Department of
Environmental Protection

Twin Towers Office Building
2600 Blair Stone Road
Tallahassee, Florida 32399-2400

Lawton Chiles
Governor

Virginia B. Wetherell
Secretary

June 27, 1994

Mr. Daniel E. Strobridge
Camp Dresser & McKee
One Tampa City Center
Suite 1750
Tampa, Florida 33602

Dear Mr. Strobridge:

RE: PASCO COUNTY RESOURCE RECOVERY FACILITY
PSD-FL-127

We are in receipt of your June 8, 1994, documentation regarding the Sorbalit control technology. Approval of an air pollution control system or control technology is done on a case by case basis. We do not give a blanket approval of any new technology.

In accordance with F.A.C. Rule 17-04.080 (d) Modification of Permit Conditions, Pasco County Resource Recovery facility must install mercury control air pollution control equipment to comply with F.A.C. Rule 17-296.410 Waste to Energy Facilities requirements. They need to submit an application for a permit to construct/modify an air pollution source, DEP Form 17-1.202(1), which describes the mercury controls they propose to use.

If you have additional questions, please feel free to contact me.

Sincerely,

G. Preston Lewis, P.E.
Supervisor
Air Permitting and Standards

GPL/TH/bjb

cc: Mike Hewett, DEP
Bill Thomas S.W. District

DEP ROUTING AND TRANSMITTAL SLIP

TO: (NAME, OFFICE, LOCATION)

1. ~~PRESTON~~ [illegible]
2. ____
3. ____
4. ____
5. ____

PLEASE PREPARE REPLY FOR:

____ SECRETARY'S SIGNATURE

____ DIV/DIST DIR SIGNATURE

____ MY SIGNATURE

____ YOUR SIGNATURE

____ DUE DATE ____

ACTION/DISPOSITION

____ DISCUSS WITH ME

____ COMMENTS/ADVISE

____ REVIEW AND RETURN

____ SET UP MEETING

____ FOR YOUR INFORMATION

____ HANDLE APPROPRIATELY

____ INITIAL AND FORWARD

____ SHARE WITH STAFF

____ FOR YOUR FILES

COMMENTS:

INFO REGARDING PASCO CO. WTE FACILITY USING SORBALIT INSTEAD OF LIME.

PLEASE REVIEW & DETERMIN IF PERMIT AMENDMENT IS REQUIRED.

Please respond by 6/27 with Draft memo to CDM ~~[illegible]~~ FOR MY Secretary SIGN

THANKS

FROM: M. HEWETT DATE: 6/13 PHONE: ____

DEP 15-026 (12/93)

xc: Pat, John B.
Larry, Clair
orig. - return to
from: Howard
6/21

Florida Chemical Industry Council, Inc.
Suite 300 Barnett Bank Building 315 S. Calhoun Street
Tallahassee, Florida 32301-1837
(904) 224-8141 FAX (904) 224-5283

RECEIVED
JUN 16 1994
Division of Air
Resources Management

June 14, 1994

RECEIVED
JUN 21
Bureau of
Air Regulation

Mr. Howard Rhodes
Director
Division of Air Resources Management
Florida Department of Environmental
Protection
Twin Towers Office Building
2600 Blair Stone Road
Tallahassee, FL 32399-2400

Re: Section 112(g) of the Clean Air Act

Dear Howard:

On April 1, 1994, EPA released proposed regulations for section 112(g) of the Clean Air Act. The 112(g) regulation will establish a framework for how state permitting agencies must handle changes at modified, reconstructed or newly constructed major sources of hazardous air pollutants. As proposed, this regulation would restrict industry's ability to make the changes necessary to remain competitive in today's changing market. EPA's proposed regulation will also create additional burdens for DEP and local air environmental programs.

As you know, the rule comment period closes June 30, 1994. We are hopeful that DEP will be making comments. In the event that you will, we'd like you to have the benefit of some of our thoughts on the proposal. They are as follows.

- **The rule should allow a source to continue to conduct all operations authorized under state permit programs or by a Title V permit without triggering requirements applicable to modification or reconstruction.** (The proposed rule only recognizes <u>permit</u> authorizations and not other authorization types in the state programs.) This full range of exclusions is necessary so that states and sources can avoid reevaluating operations which have already been considered and approved during the permitting process.

- **When an applicable MACT standard has not been established, the rule should provide a streamlined process for making a case-by-case MACT determination.** States do not have the resources to perform the intensive analysis required to establish case-by-case MACT using all the procedures in the Act for development of source category MACT standards.

- **The rule should allow sources to proceed with a change without delay if offsets are provided.** More effort and innovation is needed to streamline 112(g) offset showings in order to develop a more effective and efficient program.

- **New source MACT should not be required for portions of facilities not actively being changed.** EPA has proposed two options for the definition of construction and reconstruction. Congress specifically avoided imposing new source MACT even when a process is being modified and does not even require existing source MACT under 112(g) if a source is not being changed. Regardless of which option is selected, new source MACT should not be required for portions of facilities not actively being changed.

Again, we encourage DEP to comment on this rule; also, we'd certainly like to get a copy of such comments, if possible. Should you have any questions, please contact Bill Van Duyn, Bush Boake Allen (904) 782-2180. Thank you for your consideration.

Sincerely,

Nancy Stephens

Nancy D. Stephens
Executive Director

ns
cc: Bill Van Duyn, BBA
Heather Keith, CMA

CDM
environmental engineers, scientists,
planners, & management consultants

CAMP DRESSER & McKEE INC.

One Tampa City Center
Suite 1750
Tampa, Florida 33602
813 221-2833

June 8, 1994

Mr. Michael Hewett
Division of Air
Florida Department of Environmental Protection
2600 Blairstone Road
Tallahassee, FL 32399-2400

Re: Pasco County Waste-to-Energy Facility, Mercury Compliance Transmittal of Sorbalit Information

Dear Mr. Hewett:

Transmitted under this cover are two articles that describe the Sorbalit reagent and test results. Also, included is a copy of some literature describing the product.

Please let me know if you need anything else. I appreciate the assistance you have provided thus far, thank you.

Sincerely,

CAMP DRESSER & McKEE INC.

Daniel E. Strobridge
Associate

DES:tmp

c: J. Gallagher, County Administrator
D. Bramlett, Assistant County Administrator
V. Mannella, Pasco County

C:dspasco.ep

MR STECBRIDGE

Post-it™ Fax Note 7671

Date 6/1/94	# of pages ▸ 15
To Vince Mannella	From Tony Licata
Co./Dept.	Co.
Phone #	Phone #
Fax # 813 856-6007	Fax #

Adsorbent B is Sorbalit

JUN - 7

MERCURY REMOVAL STUDIES AT A MUNICIPAL WASTE COMBUSTOR IN MARION COUNTY, OREGON

By:
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Ogden Martin Systems
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ABSTRACT

A program to study mercury removal from waste gases was completed at the Ogden Martin Systems of Marion #1 municipal waste combustor (MWC) in Brooks, Oregon. The testing determined the baseline mercury reduction capabilities of the existing semi-dry scrubber without supplemental adsorbents and then compared these with the mercury removal capabilities of several different adsorbents. Care was taken to control process variables so that mercury removal influencing factors could be clearly defined. Special test methods and procedures were used to isolate the types of mercury in the gas stream for each test in order to aid in the evaluation of the different adsorbents. The test results show significant mercury reduction levels could be achieved. Finally, comparison between mercury adsorbents is discussed.

Paper presented at the 1993 International Conference on Municipal Waste Combustion, (sponsored by the U. S. Environmental Protection Agency and the Air and Waste Management Association), Williamsburg, VA, March 30 to April 2, 1993.

INTRODUCTION

Mercury in municipal solid waste combustion flue gas streams can exist in both vapor and solid phases. Nearly all of the solid phase mercury is normally removed by the installed air pollution control system. The large majority of mercury emissions from the stacks of municipal waste combustors is in the vapor phase.[1]

Considerable success has been achieved in reducing emissions of mercury from effluent gas streams in municipal solid waste applications utilizing activated carbon (in the presence of HCl) in controlled concentrations as an adsorbent.[2] This study examines the effectiveness of activated carbon and two other adsorbents in the removal of mercury from the gas stream of an MWC in Brooks, Oregon.[3] Since the semi-dry scrubber/fabric filter removes a large percentage of the solid phase mercury without the aid of adsorbents, the laboratory analyses of these tests have been divided into vapor phase and solid phase (as functionally defined by the test method as pre-filter and post-filter) to illustrate the true effectiveness of adsorbents in controlling gaseous mercury from MSW combustors.

FACILITY DESCRIPTION

There are two R-C/Teller systems at the Marion County facility, one serving each of the two identical 275 ton per day combustors. The mercury removal test program was conducted on Unit #1. Figure 1 shows the general arrangement of the air quality control system including the injection locations for the test program. Combustion gases at or above 400°F containing particulate matter (including small quantities of solid phase mercury) and gaseous pollutants (including among others SO_2, HCl, NO_x and relatively low concentrations of vapor phase mercury) enter the quench reactor. There they are contacted by an atomized spray of lime slurry emitted from 5 spray nozzles. The quench reactor cools the flue gas to approximately 300°F and initiates the neutralization process to recover portions of acid gases. The quantity of lime slurry delivered to the quench reactor will be varied based upon baghouse outlet SO_2 concentration. As required by permit, a base flow of slurry to control HCl is fed to the quench reactor, even if the outlet SO_2 reading is less than 10 ppm. The secondary automatic control is based on temperature. Water is added as necessary to control quench reactor outlet temperature at the setpoint.

The cooled and partially neutralized flue gas exits the quench reactor and travels through the ductwork crossing the path of the dry venturi. The dry venturi serves as a feed system for activated carbon adsorbent and the two other adsorbents tested (Adsorbent A and Adsorbent B). The adsorbent is introduced through the dry venturi into the effluent gas stream in a counterflow direction. For the test program, the activated carbon, Adsorbent A and Adsorbent B were fed in metered quantities from a screw feeder to the 10-inch diameter transport duct leading to the dry venturi to enhance vapor phase mercury removal.

Ogden Martin Systems of Marion
Mercury Removal Test Program

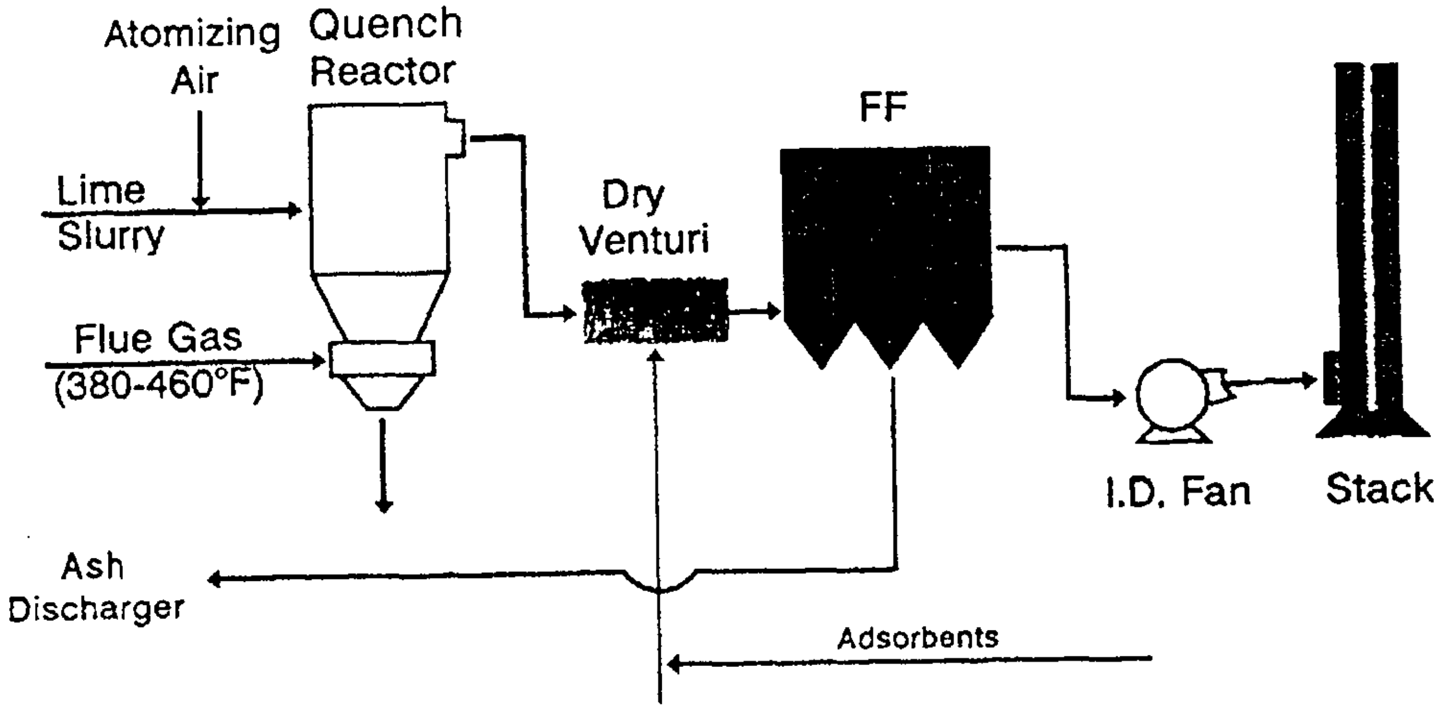

Fig. 1

The mixed gas then proceeds to the baghouse before exhausting through the stack. The baghouse serves as the final particulate collecting device as well as the fixed bed reactor for the removal of acid gases. The cleaned gas of 60,000 ACFM then leaves the stack at approximately 290°F.

Although the mercury removal test program was devised and segregated into four distinct test phases characterized by the type or lack of adsorbent injection into the R-C/Teller system, it was important from the beginning to establish a set of process operating conditions which could be run on Unit #1 throughout the entire test program. Establishment of the process conditions was based primarily on existing "normal" operating conditions. Plant management and operating personnel provided the majority of the input in optimizing the settings for balanced operation and in identifying the historical effects of varying conditions on the system. To minimize undue influence from changing process variables, the following parameters formed the basis of process operation during the test runs on Unit #1:

- normal quantity of refuse burned, > 200 tons/day at full load
- normal quantity of medical waste burned, 0-20 tons/weekday
- normal steam flow, approximately 67,000 #/hr
- quench reactor inlet temperature 380-450°F, normally around 420°F
- quench reactor outlet setpoint at 300°F
- slurry density 1.2-1.25 Baume based on plant measurement
- slurry feed to all 5 nozzles
- dry venturi feed duct blower discharge pressure 4" WC
- adsorbent feed through the dry venturi feed duct (when in operation)
- baghouse cleaning cycle: one compartment every 45 minutes (sooner if high ΔP setpoint is reached), 25 second reverse air clean period, 25 second null period

ANALYTICAL PROCEDURE

EPA Method 101A does not require a filter (which is optional and usually used when the particulate loading is expected to be high). For this test program, a particulate collection filter was used for each test at both the inlet and the outlet sampling locations. The analytical procedure adhered to by the analytical laboratory allows for separate preparation of the front half catch and back half catch per the EPA Method. Rather than combine them prior to analysis, however, the laboratory analyzed the front half separately from the back half, functionally separating the solid phase mercury from the vapor phase. We understand that some residual activated carbon on the particulate filter could skew partitioning from the vapor phase to the particulate phase.

A general description of the analytical procedure is as follows. The liquid in the back half of the sampling train, which includes glassware downstream of the filter holder and the liquid filled impingers, is placed into a container, and the glassware is rinsed with 4% potassium permanganate solution. The rinse is added to the impinger catch. If there were residual brown deposits in the glassware, it was rinsed with a minimum amount of 8 N HCl which was then added to the container. The contents of this container are filtered through a Whatman 40 filter, and the filter is rinsed with 4% permanganate solution and 8 N HCl. The filtrate is diluted to a known volume with deionized water and the sample analyzed using cold vapor atomic adsorption spectrophotometry (CVAA). The Whatman 40 filter from the back half preparation is archived.

The sampling probe up to the filter holder (but not including the filter) is rinsed with 4% potassium permanganate solution. The contents of this container are filtered through a Whatman 40 filter, and the filter is rinsed with 4% potassium permanganate and 8 N HCl. The filtrate is saved and constitutes a portion of the front half catch. The Whatman 40 filter from this preparation is archived.

The sample filter is placed into a container and 4% permanganate solution added. The sample filter is transferred to a beaker and evaporated on a steam bath to 25 ml. liquid. 20 ml. of nitric acid is then added to the beaker containing the sample filter and permanganate solution. The beaker is then covered and heated for 2 hours at 70°C. The beaker is then cooled and the solution filtered through Whatman 40 filter paper. The Whatman 40 filter paper is then rinsed with 4% potassium permanganate and 8 N HCl and the liquid added to the filtrate. The Whatman filter is then archived with the other front half Whatman filter from the probe rinse preparation. The filtrate is mixed with the filtrate from the probe wash preparation and diluted to a known volume with deionized water. The sample is then analyzed using CVAA. Unlike the EPA testing at Stanislaus[2], these laboratory filters were not digested and analyzed for mercury. Incorporation of the laboratory filters in the uncontrolled and controlled mercury values would lower the total mercury removal efficiency.

On a daily basis, a filter blank and a solution blank are taken. The filter blank is prepared and analyzed using the same procedure as the sample filter. The solution blank is prepared and analyzed using the same procedure as the impinger solution. The daily blank results are then used for correction of sample results for both of the mercury tests conducted that day.

TEST MATRIX

Four phases of mercury removal tests were successfully completed on the Ogden-Martin Systems of Marion #1 municipal waste combustor train. Phase 1 which lasted from March 18-27, 1992 consisted of testing for removal of mercury from the R-C/Teller air quality control system without the addition of adsorbent material. Phase 2 from March 31-April 10, 1992 characterized mercury removal using activated carbon as an adsorbent. Phase 3 testing consisted of mercury removal tests with a Research-Cottrell activated carbon-based proprietary product, Adsorbent A, being added to the system as the adsorbent material. The test period for Phase 3 was May 20-28, 1992. The test period for Phase 4 was from July 14-18, 1992. The fourth phase characterized mercury removal using Adsorbent B, another activated carbon-based proprietary product, as an adsorbent.

Table I indicates program test dates, assigned test run numbers, and test condition. For baseline testing, no mercury adsorbent was injected.

TABLE I. TEST MATRIX FOR MERCURY REMOVAL TEST PROGRAM

1992 DATE	TEST CONDITION	Hg RUNS
03-18	Baseline	MWC-1,-3
03-19	Baseline	MWC-5,-7
03-20	Baseline	MWC-9,-10
03-22	Baseline	MWC-13,-14
03-23	Baseline	MWC-17,-18
03-24	Baseline	MWC-21,-22
03-26	Baseline	MWC-25,-26
03-27	Baseline	MWC-29,-30
03-31	5#/hr Activated Carbon*	MWC-33,-34
04-01	5#/hr Activated Carbon	MWC-37,-38
04-02	5#/hr Activated Carbon	MWC-41,-42
04-04	5#/hr Activated Carbon	MWC-45,-46
04-05	5#/hr Activated Carbon	MWC-49,-50
04-06	5#/hr Activated Carbon	MWC-53,-54
04-09	10#/hr Activated Carbon**	MWC-57,-58
04-10	10#/hr Activated Carbon	MWC-61,-62
05-20	Baseline	MWC-65,-66
05-21	Baseline	MWC-69,-70
05-22	Adsorbent A***	MWC-74
05-23	Adsorbent A	MWC-77,-78
05-24	Adsorbent A	MWC-81,-82
05-25	Adsorbent A	MWC-85,-86
05-26	Adsorbent A	MWC-89,-90
05-27	Adsorbent A	MWC-93,-94
05-28	Adsorbent A	MWC-97,-98
07-14	Baseline	MWC-101,-102
07-15	Adsorbent B***	MWC-105,-106
07-16	Adsorbent B	MWC-110
07-17	Adsorbent B	MWC-113,-114
07-18	Adsorbent B	MWC-117,-118

* Equivalent to 51 mg activated carbon/DSCM, corrected to 12% CO_2

** Equivalent to 102 mg activated carbon/DSCM, corrected to 12% CO_2

*** 5#/hr equivalent activated carbon for all Adsorbent A and Adsorbent B tests

TEST RESULTS

Baseline Tests

The importance of the baseline tests to the mercury removal test program is in the characterization of pollutant removal by the air quality control system under "baseline" process operating conditions (as defined in the facility description, but without adsorbent injection). This would serve as a basis for comparison with improvements in mercury removal by addition of adsorbents in later test phases.

As shown for the baseline tests in Table II, the average mercury removal efficiency of the front half catch, which consists of solid phase mercury, is very high at 97.82%. Virtually all the mercury existing as particulate is removed by the semi-dry scrubber/baghouse. The back half catches, which functionally represent vapor phase mercury, have a much broader and generally lower range of collection efficiencies. Numerous test runs resulted in negative efficiencies for the vapor phase back half catch. Some sources have suggested this is due to release of mercury vapor when particulate mercurous chloride is oxidized to elemental mercury and chloride ions on the sampling train filter. Further study needs to be undertaken to examine this and other potential reaction mechanisms as well as deficiencies in executing the test method. The baseline tests averaged 20.0% vapor phase removal efficiency.

The total mercury removal efficiency averaged 37.6% for the baseline runs. Nearly 28% of the mercury entering the air pollution control system during the baseline tests has been identified as front half (solid phase) catch. The highly efficient solid phase removal by the semi-dry scrubber/baghouse raises the total mercury capture substantially from the vapor phase efficiency.

Activated Carbon Injection

The emphasis of Phase 2 testing (activated carbon injection) was to determine the effects of activated carbon on mercury removal in the R-C/Teller system. Baseline tests were not conducted during Phase 2, which began just four days after completion of the Phase 1 baseline tests. Activated carbon was fed to the air quality control system at a rate of 5 #/hr for a period of approximately two days prior to the first Phase 2 mercury removal test runs. A 5#/hr feed rate equated to 51 mg activated carbon/DSCM, corrected to 12% CO_2. After completion of the 5 #/hr activated carbon runs, a 10 #/hr injection rate was used for testing. 10 #/hr carbon feed rate equated to 102 mg activated carbon/DSCM at 12% CO_2.

Similar to the results in Phase 1, solid phase mercury removal was very high for both the 5 #/hr and 10 #/hr injection rates, which averaged 99.2% and 99.7% efficiency, respectively.

Vapor phase mercury removal emissions and corresponding removal efficiencies were greatly improved from the baseline condition with injection of activated carbon. Average vapor phase removal efficiency increased from approximately 20% to 75-77%. Another effect of activated carbon injection was to reduce variability in the outlet mercury emissions.

TABLE II
OGDEN MARTIN – MARION COUNTY
MERCURY REMOVAL TEST PROGRAM

MERCURY REMOVAL TEST RESULTS

Baseline

TEST	BK HALF (#/HR) INLET	OUT	BACK % EFF	FRONT HALF (#/HR) INLET	OUTLET	FRONT % EFF	TOTAL (#/HR) INLET	OUTLET	TOTAL % EFF
MWC-1	0.0243	0.0220	9.47	0.0152	0.0011	92.76	0.0395	0.0231	41.52
MWC-3	0.0350	0.0285	18.57	0.0103	0.0003	97.09	0.0453	0.0287	36.64
MWC-5	0.0329	0.0457	*0.00	0.0096	0.0001	98.96	0.0425	0.0457	*0.00
MWC-7	0.0296	0.0368	*0.00	0.0514	0.0001	99.81	0.0811	0.0369	54.50
MWC-9	0.0654	0.0174	73.39	0.0372	0.0001	99.73	0.1025	0.0175	82.93
MWC-10	0.0332	0.0184	44.58	0.0124	0.0001	99.19	0.0456	0.0184	59.65
MWC-13	0.0471	0.0713	*0.00	0.0281	0.0001	99.64	0.0752	0.0713	5.19
MWC-14	0.0697	0.0567	18.65	0.0085	0.0001	98.82	0.0783	0.0567	27.59
MWC-17	0.1712	0.1049	38.73	0.0150	0.0001	99.33	0.1862	0.1051	43.56
MWC-18	0.1588	0.0708	55.42	0.0282	0.0002	99.29	0.1870	0.0709	62.09
MWC-21	0.0209	0.0362	*0.00	0.0212	0.0001	99.53	0.0421	0.0363	13.78
MWC-22	0.0325	0.0278	14.46	0.0097	0.0001	98.97	0.0422	0.0279	33.89
MWC-25	0.0319	0.0359	*0.00	0.0226	0.0001	99.56	0.0545	0.0360	33.94
MWC-26	0.0307	0.0219	28.66	0.0124	0.0005	95.97	0.0431	0.0224	48.03
MWC-29	0.0266	0.0278	*0.00	0.0142	0.0001	99.30	0.0408	0.0279	31.62
MWC-30	0.1012	0.0211	79.15	0.0431	0.0001	99.77	0.1443	0.0212	85.31
MWC-65	0.0430	0.0339	21.16	0.0107	0.0002	98.13	0.0537	0.0341	36.50
MWC-66	0.0284	0.0245	13.73	0.0141	0.0002	98.58	0.0425	0.0247	41.88
MWC-69	0.1033	0.1506	*0.00	0.0338	0.0044	86.98	0.1371	0.1550	*0.00
MWC-70	0.0312	0.0438	*0.00	0.0130	0.0011	91.54	0.0442	0.0449	*0.00
MWC101	0.0347	0.0367	*0.00	0.0270	0.0001	99.63	0.0617	0.0368	40.36
MWC102	0.0337	0.0257	23.74	0.0166	0.0001	99.40	0.0502	0.0258	48.61
AVG	0.0539	0.0436	19.99	0.0206	0.0004	97.82	0.0745	0.0440	37.62

*Negative efficiencies, reported as 0.00

Note: Averages shown are columnar inlet, outlet and efficiency averages. Average efficiency is not calculated directly from inlet average and outlet average.

TABLE II

OGDEN MARTIN – MARION COUNTY

MERCURY REMOVAL TEST PROGRAM

MERCURY REMOVAL TEST RESULTS

5#/hr Activated Carbon Injected

(51 mg Activated/DSCM, corrected to 12% CO2)

	BK HALF (#/HR)		BACK	FRONT HALF (#/HR)		FRONT	TOTAL (#/HR)		TOTAL
TEST	INLET	OUT	% EFF	INLET	OUTLET	% EFF	INLET	OUTLET	% EFF
MWC-33	0.0272	0.0057	79.04	0.0106	0.0001	99.06	0.0378	0.0057	84.92
MWC-34	0.0328	0.0083	74.70	0.0061	0.0001	98.36	0.0390	0.0084	78.46
MWC-37	0.0321	0.0121	62.31	0.0195	0.0002	98.97	0.0516	0.0123	76.16
MWC-38	0.0355	0.0071	80.00	0.0160	0.0001	99.38	0.0515	0.0072	86.02
MWC-41	0.0336	0.0111	66.96	0.0169	0.0003	98.22	0.0505	0.0114	77.43
MWC-42	0.2064	0.0114	94.48	0.0932	0.0007	99.25	0.2996	0.0122	95.93
MWC-45	0.0477	0.0114	76.10	0.0173	0.0001	99.42	0.0651	0.0115	82.33
MWC-46	0.0516	0.0164	68.22	0.0213	0.0001	99.53	0.0729	0.0165	77.37
MWC-49	0.0376	0.0096	74.47	0.0187	0.0001	99.47	0.0563	0.0097	82.77
MWC-50	0.0593	0.0122	79.43	0.0095	0.0001	98.95	0.0687	0.0123	82.10
MWC-53	0.1085	0.0120	88.94	0.0752	0.0001	99.87	0.1837	0.0121	93.41
MWC-54	0.0992	0.0132	86.69	0.1687	0.0001	99.94	0.2678	0.0134	95.00
AVG	0.0643	0.0109	77.61	0.0394	0.0002	99.20	0.1037	0.0111	84.32

10#/hr Activated Carbon Injected

(102 mg Activated Carbon/DSCM, corrected to 12% CO2)

MWC-57	0.0274	0.0112	59.12	0.0676	0.0004	99.41	0.0950	0.0116	87.79
MWC-58	0.0659	0.0104	84.22	0.0230	0.0001	99.57	0.0890	0.0105	88.20
MWC-61	0.0407	0.0118	71.01	0.1108	0.0002	99.82	0.1515	0.0120	92.08
MWC-62	0.1126	0.0149	86.77	0.0522	0.0001	99.81	0.1648	0.0150	90.90
AVG	0.0617	0.0121	75.28	0.0634	0.0002	99.65	0.1251	0.0123	89.74

Note: Averages shown are columnar inlet, outlet and efficiency averages. Average efficiency is not calculated directly from inlet average and outlet average.

TABLE II
OGDEN MARTIN– MARION COUNTY
MERCURY REMOVAL TEST PROGRAM

MERCURY REMOVAL TEST RESULTS

Adsorbent A Injected

	BK HALF (#/HR)		BACK	FRONT HALF (#/HR)		FRONT	TOTAL (#/HR)		TOTAL
TEST	INLET	OUT	% EFF	INLET	OUTLET	% EFF	INLET	OUTLET	% EFF
MWC-74	0.0362	0.0047	87.02	0.0064	0.0002	96.88	0.0427	0.0049	88.52
MWC-77	0.0379	0.0097	74.41	0.0110	0.0002	98.18	0.0488	0.0099	79.71
MWC-78	0.0279	0.0097	65.23	0.0066	0.0002	96.97	0.0345	0.0100	71.01
MWC-81	0.0331	0.0036	89.12	0.0068	0.0002	97.06	0.0399	0.0038	90.48
MWC-82	0.0321	0.0029	90.97	0.0073	0.0006	91.78	0.0394	0.0035	91.12
MWC-85	0.0285	0.0055	80.70	0.0110	0.0002	98.18	0.0396	0.0057	85.61
MWC-86	0.0621	0.0071	88.57	0.0080	0.0002	97.50	0.0702	0.0074	89.46
MWC-89	0.2151	0.0050	97.68	0.0367	0.0002	99.46	0.2517	0.0052	97.93
MWC-90	0.0374	0.0052	86.10	0.0179	0.0003	98.32	0.0553	0.0054	90.24
MWC-93	0.0376	0.0022	94.15	0.0161	0.0002	98.76	0.0537	0.0024	95.53
MWC-94	0.0312	0.0020	93.59	0.0177	0.0002	98.87	0.0490	0.0022	95.51
MWC-97	0.0763	0.0015	98.03	0.0627	0.0002	99.68	0.1389	0.0017	98.78
MWC-98	0.0618	0.0028	95.47	0.0330	0.0002	99.39	0.0947	0.0030	96.83
AVG	0.0552	0.0048	87.77	0.0186	0.0002	97.77	0.0737	0.0050	90.06

Adsorbent B Injected

MWC105	0.0753	0.0117	84.46	0.0279	0.0001	99.64	0.1031	0.0118	88.55
MWC106	0.2217	0.0410	81.51	0.0287	0.0001	99.65	0.2504	0.0412	83.55
MWC110	0.0393	0.0079	79.90	0.0184	0.0001	99.46	0.0577	0.0079	86.31
MWC113	0.0709	0.0107	84.91	0.0156	0.0001	99.36	0.0866	0.0107	87.64
MWC114	0.0766	0.0101	86.81	0.0400	0.0001	99.75	0.1166	0.0101	91.34
MWC117	0.0351	0.0085	75.78	0.0073	0.0001	98.63	0.0424	0.0085	79.95
MWC118	0.0351	0.0038	89.17	0.0190	0.0001	99.47	0.0540	0.0039	92.78
AVG	0.0791	0.0134	83.22	0.0224	0.0001	99.42	0.1015	0.0134	87.16

Note: Averages shown are columnar inlet, outlet and efficiency averages. Average efficiency is not calculated directly from inlet average and outlet average.

An average vapor phase removal efficiency of 75.3% for the 10 #/hr activated carbon runs as well as average outlet emissions in the same range as the 5 #/hr injection runs indicate that the higher feed rates of activated carbon to the system through the dry venturi did not improve the vapor phase removal efficiency. It appears that there was an incremental increase in total efficiency for the 10 #/hr activated carbon injection over the 5 #/hr injection (respectively, 89.7% efficiency compared to 84.3%). This is due to the highly efficient relatively larger, average solid phase inlet catch during the 10 #/hr injection (50.7% solids as a percent of total mercury species) compared to the average of the 5 #/hr injections (38.0% solids as a percent of total mercury).

Injection of Adsorbents A and B

Two series of tests were run each with injection of a different activated carbon-based adsorbent. These adsorbents (designated A and B) which contained other materials in addition to activated carbon, were injected at overall larger mass rates. The active constituents (activated carbon) which directly affected mercury removal accounted for 5 #/hr feed rate.

Vapor and total mercury removal emissions and corresponding removal efficiencies were improved from the baseline condition with injection of Adsorbents A and B. There was also an improvement in vapor phase mercury removal efficiency with Adsorbents A and B as compared to 5 #/hr activated carbon (respectively, 87.8 and 83.2% removal versus 77.6% removal). Adsorbent B vapor phase emission rates were very close to the activated carbon injection emission rates. Total mercury removal efficiencies for the Adsorbent A and B tests were higher than for the 5 #/hr activated carbon runs (90.1 and 87.9% versus 84.3%, respectively), but were essentially equivalent when activated carbon was fed at 10 #/hr (90.1 and 87.2% versus 89.7%, respectively).

Metric Units

Mercury results are commonly reported in metric units. Table III presents inlet and outlet total mercury concentrations in mg/DSCM at 12% CO_2. The average efficiencies are approximately the same as those calculated from the mass pollutant rates in Table II.

TABLE III
OGDEN MARTIN– MARION COUNTY
MERCURY REMOVAL TEST PROGRAM

MERCURY REMOVAL TEST RESULTS

Mercury concentrations are mg/DSCM @ 12% CO2

Baseline

TEST	INLET TOTAL	OUTLET TOTAL	TOTAL %EFF
MWC–1	0.4277	0.2516	41.17
MWC–3	0.4841	0.3106	35.84
MWC–5	0.5145	0.4991	2.99
MWC–7	0.7407	0.3787	48.87
MWC–9	1.0801	0.1808	83.26
MWC–10	0.4898	0.1926	60.68
MWC–13	0.8121	0.6534	19.54
MWC–14	0.8577	0.5982	30.26
MWC–17	1.7905	1.1685	34.74
MWC–18	1.9662	0.8071	58.95
MWC–21	0.4361	0.3691	15.36
MWC–22	0.4230	0.3057	27.73
MWC–25	0.5633	0.4186	25.69
MWC–26	0.4469	0.2372	46.92
MWC–29	0.4408	0.2805	36.37
MWC–30	1.4921	0.2310	84.52
MWC–65	0.5333	0.3739	29.89
MWC–66	0.3950	0.2552	35.39
MWC–69	1.3082	1.7569	0.00
MWC–70	0.4534	0.4967	0.00
MWC–101	0.7128	0.4506	36.78
MWC–102	0.5425	0.2784	48.68
AVG	0.6947	0.3756	35.81

Note: Averages shown are columnar inlet, outlet and efficiency averages. Average efficiency is not directly calculated from average inlet and average outlet.

TABLE III
OGDEN MARTIN – MARION COUNTY
MERCURY REMOVAL TEST PROGRAM

MERCURY REMOVAL TEST RESULTS

Mercury concentrations are mg/DSCM @ 12% CO2

5 #/hr Activated Carbon Injected
(51 mg Activated Carbon/DCSM, corrected to 12% CO2)

TEST	INLET TOTAL	OUTLET TOTAL	TOTAL %EFF
MWC-33	0.4243	0.0564	86.71
MWC-34	0.4033	0.0810	79.92
MWC-37	0.5519	0.1259	77.19
MWC-38	0.4948	0.0691	86.03
MWC-41	0.5013	0.1101	78.04
MWC-42	2.8537	0.1315	95.39
MWC-45	0.7414	0.1402	81.09
MWC-46	0.7850	0.1859	76.32
MWC-49	0.6210	0.1185	80.92
MWC-50	0.6973	0.1342	80.75
MWC-53	1.8876	0.1140	93.96
MWC-54	2.5478	0.1471	94.23
AVG	1.0424	0.1178	84.21

10 #/hr Activated Carbon Injected
(102 mg Activated Carbon/DSCM, corrected to 12% CO2)

MWC-57	1.0127	0.1300	87.16
MWC-58	0.9676	0.1081	88.83
MWC-61	1.6252	0.1269	92.19
MWC-62	1.7619	0.1541	91.25
AVG	1.3419	0.1298	89.86

Note: Averages shown are columnar inlet, outlet and efficiency averages. Average efficiency is not directly calculated from average inlet and average outlet.

TABLE III
OGDEN MARTIN– MARION COUNTY
MERCURY REMOVAL TEST PROGRAM

MERCURY REMOVAL TEST RESULTS

Mercury concentrations are mg/DSCM @ 12% CO2

Adsorbent A Injected

TEST	INLET TOTAL	OUTLET TOTAL	TOTAL %EFF
MWC-74	0.4052	0.0504	87.56
MWC-77	0.4807	0.1002	79.16
MWC-78	0.3305	0.1023	69.05
MWC-81	0.3921	0.0382	90.26
MWC-82	0.3621	0.0384	89.40
MWC-85	0.3922	0.0582	85.16
MWC-86	0.7145	0.0875	87.75
MWC-89	2.7028	0.0572	97.88
MWC-90	0.5492	0.0545	90.08
MWC-93	0.5297	0.0267	94.96
MWC-94	0.4705	0.0239	94.92
MWC-97	1.3618	0.0165	98.79
MWC-98	0.9360	0.0318	96.60
AVG	0.7406	0.0528	89.35

Adsorbent B Injected

TEST	INLET TOTAL	OUTLET TOTAL	TOTAL %EFF
MWC-105	1.2462	0.1305	89.53
MWC-106	2.6951	0.4604	82.92
MWC-110	0.6148	0.0825	86.58
MWC-113	0.9345	0.0980	89.51
MWC-114	0.1166	0.0101	91.34
MWC-117	0.5080	0.0972	80.87
MWC-118	0.5591	0.0384	93.13
AVG	0.9535	0.1310	87.70

Note: Averages shown are columnar inlet, outlet and efficiency averages. Average efficiency is not directly calculated from average inlet and average outlet.

CONCLUSIONS

The following conclusions are supported by the test results in Table II:

1. The removal efficiency of total mercury species by a semi-dry scrubber and baghouse system increases substantially with the addition of activated carbon, Adsorbent A, or Adsorbent B. This enhancement is attributable to an increase in the vapor phase reduction.

2. Solid phase mercury removal efficiency is very high (average range of 97.8 to 99.7%) both with and without injection of adsorbents. This supports the premise that removal of solid phase mercury from the gas stream, as with other particulate, is a function of the capability of the semi-dry scrubber/baghouse.

3. Injection of either activated carbon, Adsorbent A or Adsorbent B into the air quality control system between the quench reactor and baghouse substantially increases removal of vapor phase mercury from the gas stream. This consistent result is not surprising due to the presence of activated carbon in both Adsorbent A and B.

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1. N.S. Bloom, "Mercury Speciation in Flue Gases: Overcoming the Difficulties," EPRI Conference, November, 1991.

2. K.L. Nebel, D.M. White, C.R. Parrish et al., Emission Test Report: Ogden Martin Systems of Stanislaus, Inc. Field Test on Carbon Injection for Mercury Control, EPA-600/R-92-192, U.S. Environmental Protection Agency, September, 1992.

3. D.B. Fickling, "Mercury Removal Test Program at Ogden Systems of Marion Unit 1, Brooks, Oregon," [illegible]

DRAVO LIME COMPANY

April 29, 1994

Reply to:
Licata Energy
345 Concord Rd.
Yonkers, NY 10710-1848

Mr. Vince Mannella
Pasco County Resource Recovery Facility
14230 Hays Road
Spring Hill, Fl 34610

Dear Vince:

As an owner of a Municipal Waste Combustor (MWC) you have a vested interest in controlling acid gases and air toxic emissions from your facility. My client, Dravo Lime, has a cost effective and proven emission control technology for these emissions. Dravo Lime has just completed an exclusive license agreement with Märker Umwelttechnik of Germany to manufacture and market Sorbalit®, a new technology for the U.S. market. We are very excited about this technology for it addresses the removal of mercury and dioxin that will meet the existing and anticipated new EPA standards.

Sorbalit is a patented air pollution control system that reduces eco-toxic pollutants such as volatile heavy metals (mercury), organics (dioxin and PCBs), and acid gases (SO_2 and HCl). The Sorbalit process produces a special sorbent comprised of a combination of lime, activated carbon and other proprietary sulfur components. This unique lime-based product will reduce several pollutants in a single application and, in most cases, without replacing or adding significantly to a plant's existing air pollution control equipment. The primary markets for Sorbalit are: waste-to-energy facilities; medical waste and hazardous waste incinerators; wood and coal fired boilers; and metal and glass smelting plants. Sorbalit applications for air pollution control systems are dry sorption, conditioned dry sorption, spray sorption, and wet scrubbing.

Sorbalit is currently being used in 25 fully operational projects in Germany and other European countries. Facility operators in Europe and the U.S. have obtained mercury reductions in the range of 70% to 99.9%, and dioxin reductions that exceed 90%. Test data has demonstrated that Sorbalit can meet the US EPA emission standards for acid gases for both coal and municipal waste fired boilers.

3600 One Oliver Plaza
Pittsburgh, PA 15222-2682
Phone: 412-566-5500
FAX: 412-566-5551

A Subsidiary of Dravo Corporation

Sorbalit is a technology not a product. The sorbent is custom blended for each client and source of emissions. Applications of Sorbalit range in carbon concentrations from 3 to 65% and it can be made with either hydrated lime or quick lime. In addition, we use special types of carbon based on the source of the mercury emissions. The amount of lime used is dictated by the amount of acid gases that need to be removed. The sulfur compounds enables the carbon to capture more of the vapor phase mercury. The actual adsorption capacity of Sorbalit for mercury is affected by:

- Gas temperature
- Flue gas moisture
- Inlet concentration of mercury
- Species of mercury
- Acid content of the flue gas
- Concentration of organics such as dioxin
- Type of carbon used and surface area
- Contact time

Dravo Lime is the leading producer of lime-based sorbents for air pollution control systems in the USA. They provide a complete service for their clients and have extensive research and development capabilities. The array of technical services provided include process design and/or evaluation, sample analyses, system start-up services and optimization.

Please find enclosed a Sorbalit brochure, a paper we recently presented, and other pertinent information for your review. Additional information can be obtained from either Lewis Benson at (502) 426-8355 or my office at (914) 779-3451. We look forward to the opportunity of working with you and possibly providing this new air pollution control system to your facility. We would be pleased to meet with you to make a technical presentation on Sorbalit at your earliest convenience.

Very truly yours,

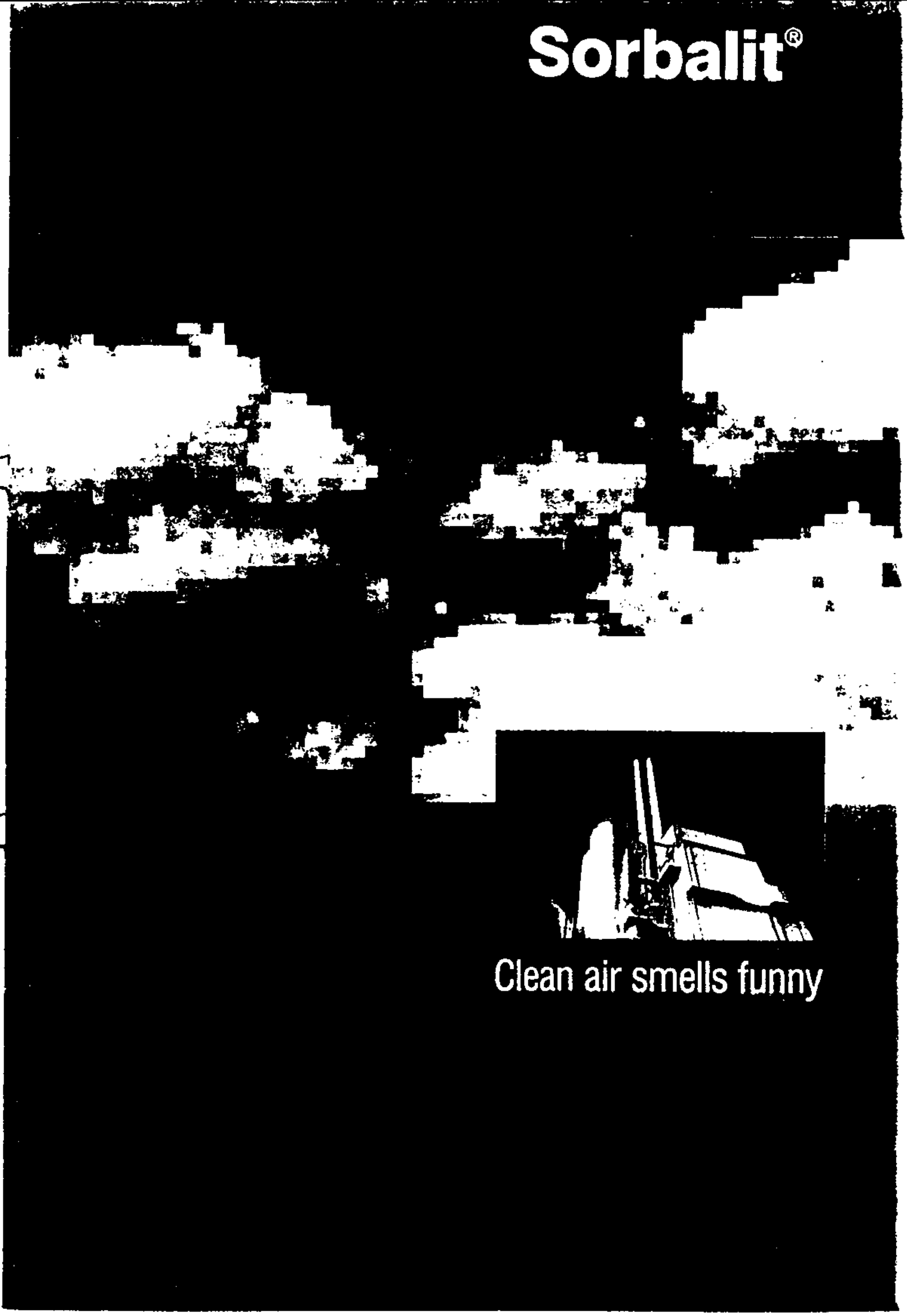
Tony

Anthony Licata
Technical Advisor

Enc.(s)

cc: L. Benson
M. Babu
R. Roden

Sorbalit®



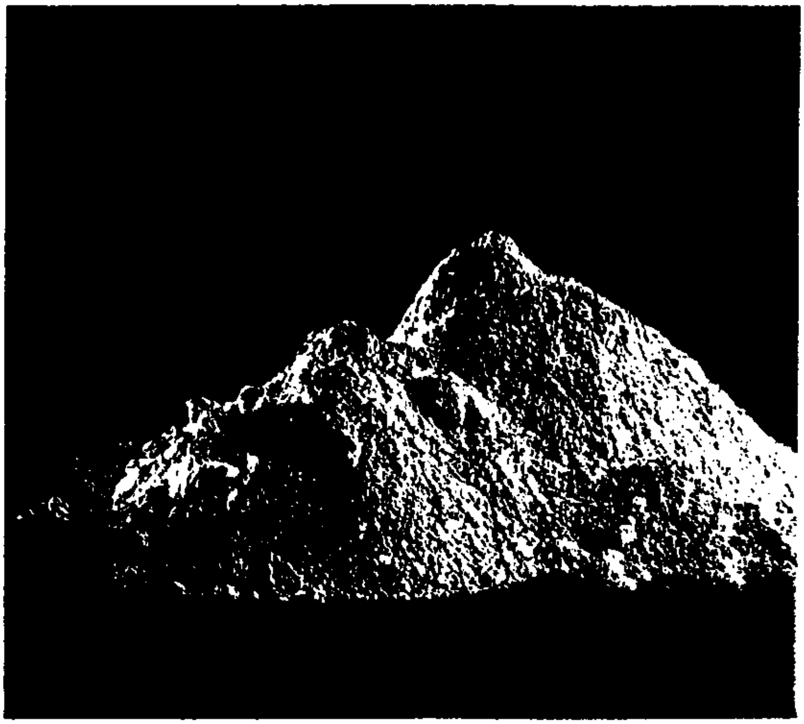
Clean air smells funny

The Märker Umwelttechnik team, each member a specialist in flue-gas purification.

3 years ago our team inaugurated our first development program for proprietary lime products used in flue-gas purification of power plants and incinerators. Extensive tests allowed us to constantly improve the performance of our special lime products resulting in **Sorbalit®** modified calcium hydroxide, a unique product patented.*

Märker Sorbalit® is produced with ultra-modern equipment by a process of dry-slaking fine, primary-ground, softburned calcium lime together with additives to improve flue-gas cleaning.

Märker Sorbalit® is highly effective against eco-toxic pollutants such as mercury, volatile heavy metals, dioxins, furans, polyaromatic hydrocarbons and chlorinated hydrocarbons. The rates of mercury reduction range from 70 to 99.9 % (Higher amounts of **Sorbalit®** can result in almost zero emission). In the case of dioxins and furans, the rates of removal exceed 90 %.



Composition

Märker Sorbalit® is composed of Märker calcium hydroxide and additives comprising organic and/or inorganic constituents, selection depends on the toxic substances to be removed.

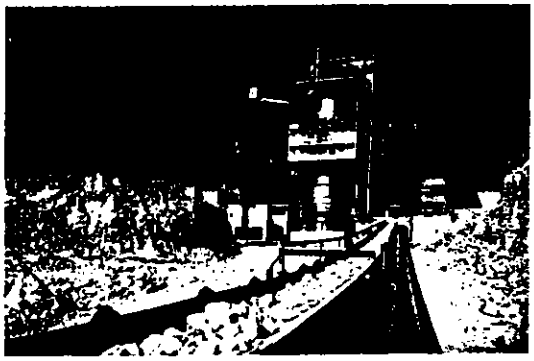
Technological parameters

Ca $(OH)_2$ – content in calcium hydroxide ca. 93 percent in weight %.
BET surface in calcium hydroxide > 20 sqm/g
Settled apparent density $< 0{,}39$ kg/l
Activated hydrate surface as a result of additives.

Sorbalit® will always reduce toxic emissions significantly, independent of an application, a certain process concept or air volume.

*) patents pending

Our latest state-of-the-art production equipment guarantees chemical and physical properties for each of our end-products.



Märker-Sorbalit® subject to constant quality control in the Märker laboratories.

Each single step of our process is monitored and if necessary corrected from our central (computerized) control station.

Flue-gas purification has undergone radical progress in the course of the past twenty years or so. Following the brilliant success obtained in the initial phase, the focus of attention now turned to organic pollutants above all dioxins and furans as well as heavy metals e.g. mercury.

Severe problems develop particularly in connection with dioxin reduction from incinerators. The conventional method of combining numerous units has simply not produced any results.

As a consequence an improved method promises the utilization of modified adsorbents.

Here, **Sorbalit®** serves to reduce volatile organic and inorganic substances. The combination of pulverized calcium hydroxide, acting as a basic material, with special substances caters for a wide variety of different applications with the aim to solve specific problems.

The modification of adsorbents was not aimed at the removal performance of acid constituents in the flue-gas currents but rather at reducing eco-toxic pollutants e.g.

- ○ volatile heavy metals, mercury, cadmium, thallium, selenium and arsenic
- ○ chlorinated dibenzodioxins and dibenzofurans (called dioxins and furans)
- ○ chlorinated hydrocarbons difficult to volatize, e.g. hexachlorobenzene and hexachlorcyclohexane
- ○ polychlorobiphenyls (abbreviated PCB)
- ○ polyaromatic hydrocarbons (abbreviated PAK)

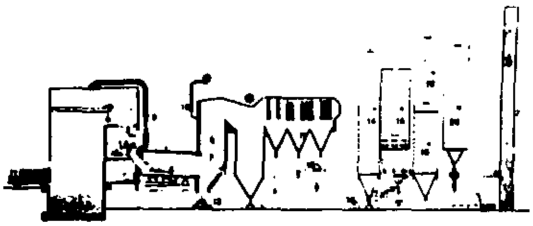
Because of the importance to reduce emission of organic substances – particularly those considered to be hazardous – the interest focused on a simple control system responsive to a wide range of toxic pollutants. **Sorbalit®** offers a system favored by inexpensive modification to address changing conditions in the control of eco-toxic substances.

Calcium hydroxide proved to be an ideal carrier for specific substances which as additives have a reduction or destructive effect on numerous substances specified above.

It is proven that **Sorbalit®** shows superior performance in a variety of different applications, including flue-gas purification, several of which have already been accomplished as described previously.

Numerous Applications

1 garbage bunker
2 charging crane for solid waste
3 loading chute
4 drum loading
5 kiln furnace head plate with burner and lances for pasty and liquid waste
6 combustion chamber
7 after-burner
8 burner and waste-water lances



9 primary air system
10 secondary air system
11 boiler
12 slag discharge
13 fly ash conveyor
14 reactor
15 fabric filter
16 flue gas fan
17 stack
18 recirculation silo
19 Sorbalit® silo
20 disposal storage bin

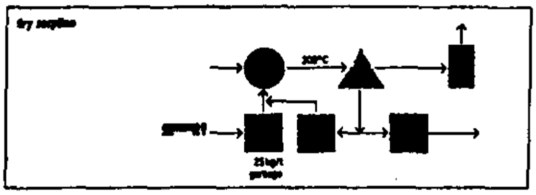
Sorbalit® can be employed for flue-gas purification in connection with the following incinerator systems:

- ○ Municipal incinerating plants, hazardous waste, sewage sludge and medical waste incinerators
- ○ Industrial coal-fired boilers
- ○ Power plants
- ○ Combustion systems of glass furnaces and in the ceramic industry.

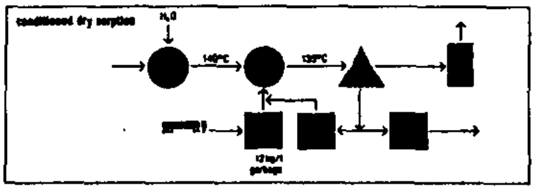
Other applications include:

- ○ Wood drying kilns especially for the reduction of water insoluble terpentines after wet scrubber
- ○ Chemical industry
- ○ Surface treatment plants in the metal coating industry.

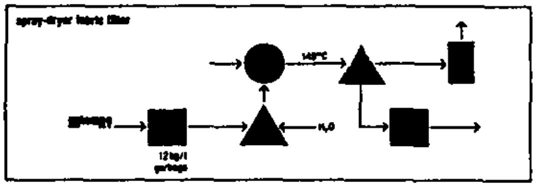
Dry Sorption
Injecting dry **Sorbalit®** into the flue-gas ahead of a fabric filter at inlet gas temperature of 240° C.



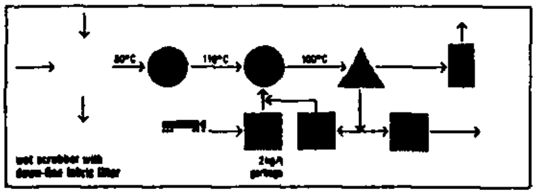
Conditioned Dry Sorption
Injecting dry **Sorbalit®** into the flue-gas after the evaporation cooler ahead of a fabric filter at a flue-gas temperature of 145° C.



Spray Sorption
Injecting a **Sorbalit®** suspension inside a spray dryer followed by a fabric filter at inlet gas temperature of 165° C.

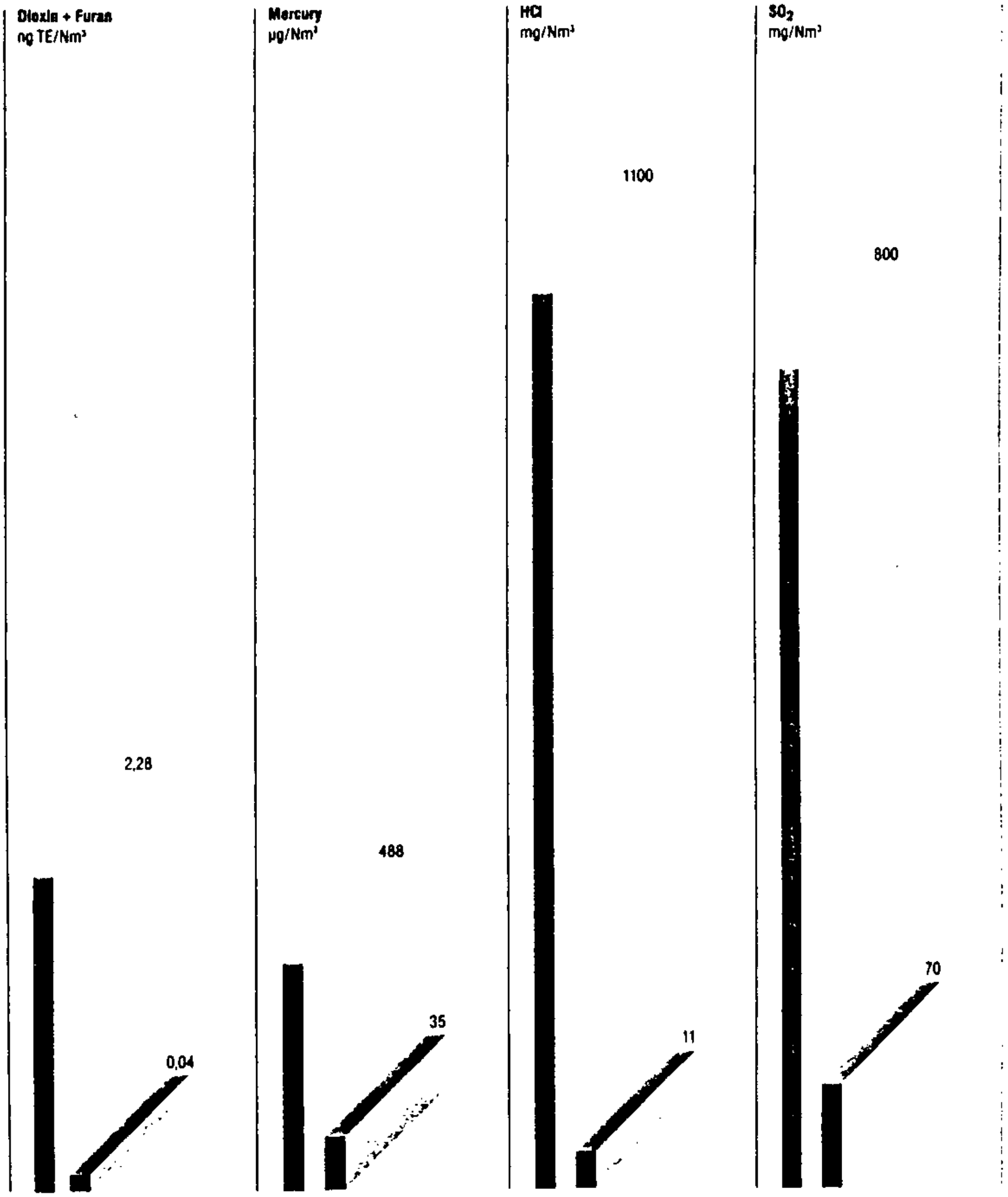


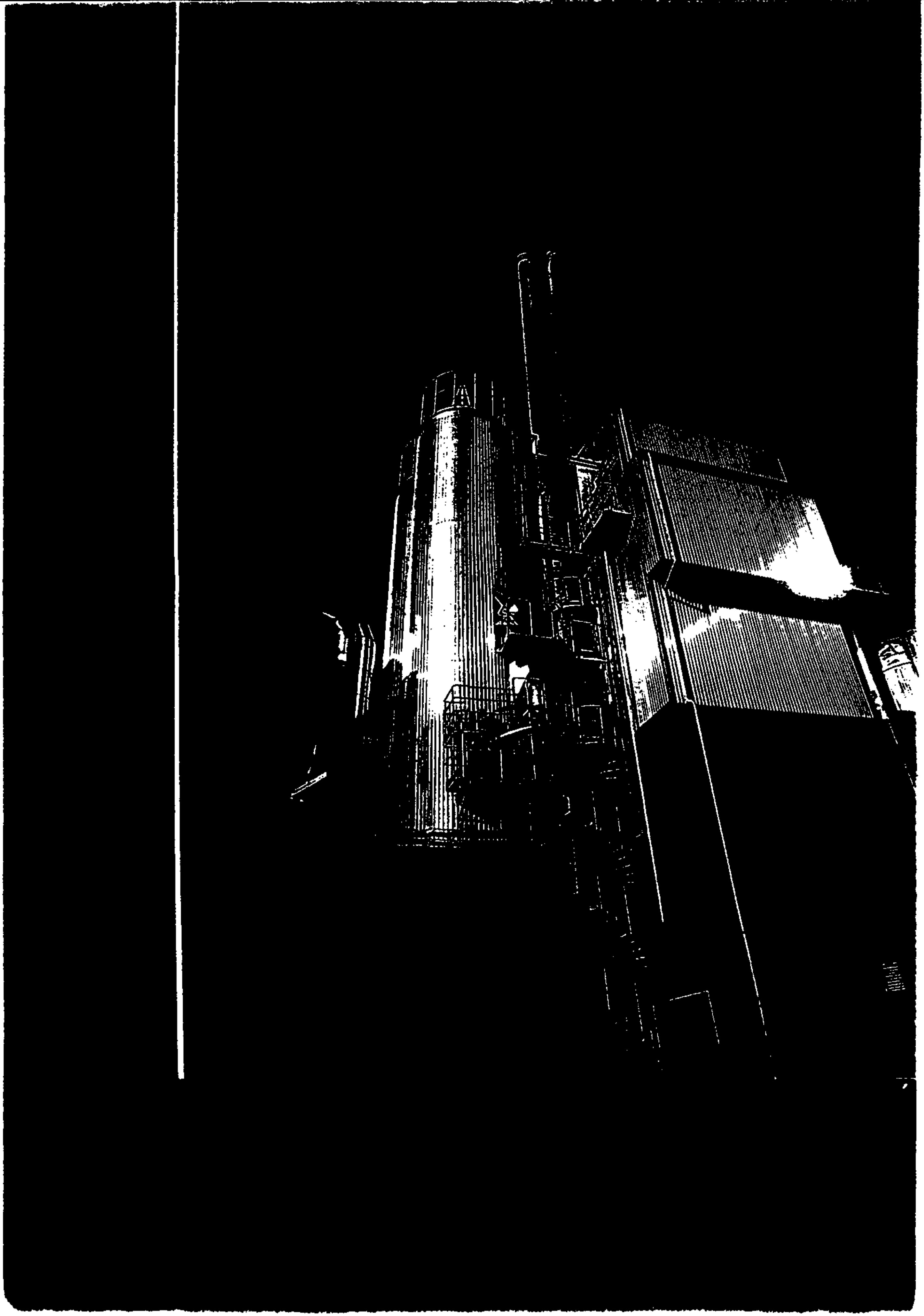
Wet Scrubber with Dry Sorption
Injection of **Sorbalit®** into the flue-gas between a wet scrubber and pre-heater into a fabric filter at inlet temperatures of 100° C.



■ recirculation silo
■ disposal storage bin
■ sorbalit silo
▲ fabric filter
● reactor
■ stack
▲ mixing tank
● cooler
● reheating
. scrubber

Emissions reduction





Top results in different plants

Waste-to-energy plant
GIA Geiselbullach/Munich

Capacity 3 x 144 tpd
Gas volume 3 x 35 000 Nm^3/h

Stoker

Flue-gas purification/Dry sorption
○ Injection of **Sorbalit®**
○ Reactor
○ Fabric filter
○ Recirculation system

Flue-gas temperature
205° C – 220° C
Quantity of Sorbalit®
25 kg/t of garbage

Outlet emission rate
SO_2 – 70 mg/Nm^3
HCl – 22 mg/Nm^3
Hg – < 0,05 mg/Nm^3
Dioxin/Furan – 0,019 ng TEQ/Nm^3

Hazardous waste incinerator
Schöneiche/Berlin

Capacity 55 tpd
Gas volume 31 000 Nm^3/h

Rotary kiln

Flue-gas purification/Conditioned dry sorption
○ Injection of **Sorbalit®**
○ Reactor
○ Fabric filter
○ Recirculation system

Flue-gas temperature 140° C
Quantity of Sorbalit®
12 kg/t of garbage

Outlet emission rate
SO_2 – 20 mg/Nm^3
HCl – 9 mg/Nm^3
Hg – 0,02 mg/Nm^3
Dioxin/Furan – 0,03 ng TEQ/Nm^3

Waste-to-energy plant
Würzburg

Capacity 2 x 300 tpd
Gas volume 2 x 70 000 Nm^3/h

Stoker

Flue-gas purification/Dry sorption
○ Injection of **Sorbalit®**
○ Reactor
○ Fabric filter

Flue-gas temperature
210° C – 240° C
Quantity of Sorbalit®
25 kg/t of garbage

Outlet emission rate
SO_2 – 3 mg/Nm^3
HCl – 5 mg/Nm^3
Hg – 0,037 mg/Nm^3
Dioxin/Furan – 0,03 ng TEQ/Nm^3

Hazardous waste incinerator
GSB Schweinfurt

Capacity 60 tpd
Gas volume 28 000 Nm^3/h

Stoker

Flue-gas purification/Spray dryer system
○ Slurry mixing station
○ Spray dryer
○ Fabric filter

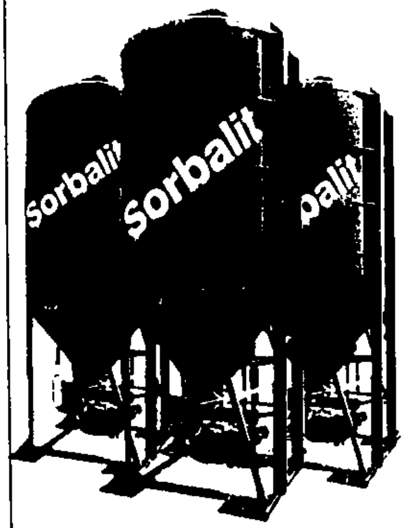
Flue-gas temperature 165° C
Quantity of Sorbalit®
12 kg/t of garbage

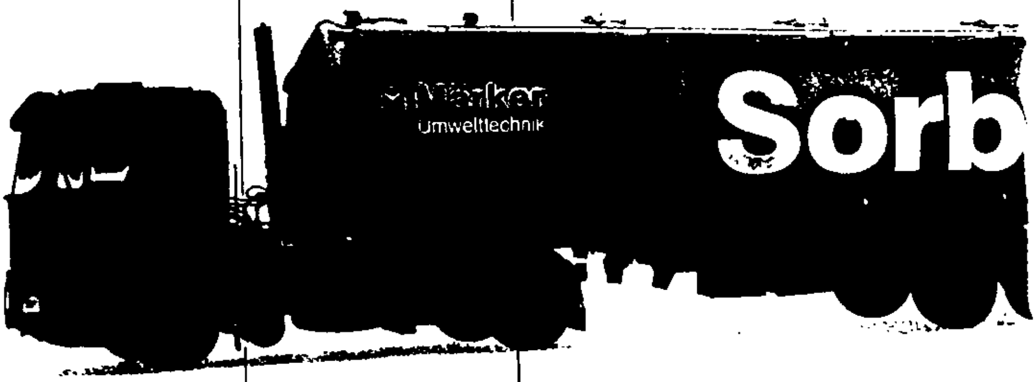
Outlet emission rate
SO_2 – 4 mg/Nm^3
HCl – 4 mg/Nm^3
Hg – 0,04 mg/Nm^3
Dioxin/Furan – 0,06 ng TEQ/Nm^3

Major Sorbalit® features

- ○ Suitable for virtually unlimited use in dry injection and spray dryer systems
- ○ Low initial capital investment
- ○ Simple process procedure
- ○ For targeted source emission limits, special Sorbalit® types are available

Our specialists will assist you and your plant personnel during introduction and application of our Sorbalit® process. Please contact us.





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Umwelttechn

92-41.09

SORBALIT - A New Economic Approach reducing Mercury and Dioxin Emissions

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Presented at
AWMA Conference
June 24, 1992
Kansas City, Missouri

1. Introduction

Dissatisfaction with the existing state of technology is at the root of technical progress - and dissatisfaction with the emission situation at waste incineration plants is widespread indeed. This dissatisfaction is not only expressed in public opinion; the engineers running incineration plants are just as dissatisfied.

What are the main reasons for their dissatisfaction?

- The high emissions of mercury (this being the index element for toxic heavy metals)

- The high emissions of dioxins and furans (these being the index compounds for toxic organic compounds).

The above-mentioned dissatisfaction has had several results. On the one hand, administrations all over the world have sought to reduce authorized emission rates by regulations (to take the German example, by the 17th Federal Regulation on Immission Protection) (1). On the other hand, processes have been developed to meet these requirements.

In this paper a process is presented that has already stood its test in Europe.

Basically, the process consists of two components:

1. a specially developed agent characterized by high adsorption material focussed on the toxic elements;

2. a reaction unit in the flue-gases of any incineration plant (that is, not a waste incineration plant only) ensuring a vortexing of the mixture of the adsorbing agent with the flue-gas, plus the separation of the adsorbing agent in a fabric filter.

The aim of this paper is not the discussion of theoretical background problems, but the presentation of results based on practical experience. The adsorbing agent will be briefly described and results concerning various types of flue-gas purification systems will be presented.

2. The Sorbalit System (2)

Patents for the Sorbalit^R System are pending (3). The Sorbalit agent is produced by mixing calcium hydroxide with surface-activated substances like activated carbon or lignite coke as well as other components in a special process. In this way a homogeneous powder is obtained that will not dissociate when used later, either. It is particularly important to avoid flotation or separation of the substances added to hyrated lime. In order to maintain product uniformity and effective levels of air pollution control, the components must stay in suspension.

The purification unit consists in its simplest form of an flue-gas pipe into which dosed Sorbalit is injected plus a fabric filter down-line.

This simple solution has the special advantage that it can be easily integrated into existing plants without have to expend significant capital for new equipment.

The following chapter deals with the Sorbalit solutions for the flue-gas treatments usually employed at waste incineration plants. It will also demonstrate the improvement in emission values.

3. Areas of Application

3.1 Dry sorption process
Waste-to-energy station Würzburg

The waste-to-energy station at Würzburg possesses two lines for incinerating municipal waste, each with a capacity of 12.5 Mg/h. The temperature of the flue-gas down-line of the boiler is reduced to a range of 180 to 200 °C by means of water cooling (4).

The hydrated lime used to be mixed with the flue-gas in a following fluidized bed reactor to reduce the emission of acid gases. The fluidized bed reactor also acts as a preliminary filter before the flue-gas gases are purified in a fabric filter, in accordance with the state of the art.

In the spring of 1989, tests were carried out with Sorbalit only by switching from hydrated lime to Sorbalit.

The dioxin and furan emissions were reduced from 9 - 10 ng TEQ/Nm^3 to 0.02 - 0.06 ng TEQ/Nm^3 (Figure 1). Sorbalit also displayed its effectiveness in reducing mercury emissions (Figure 2).

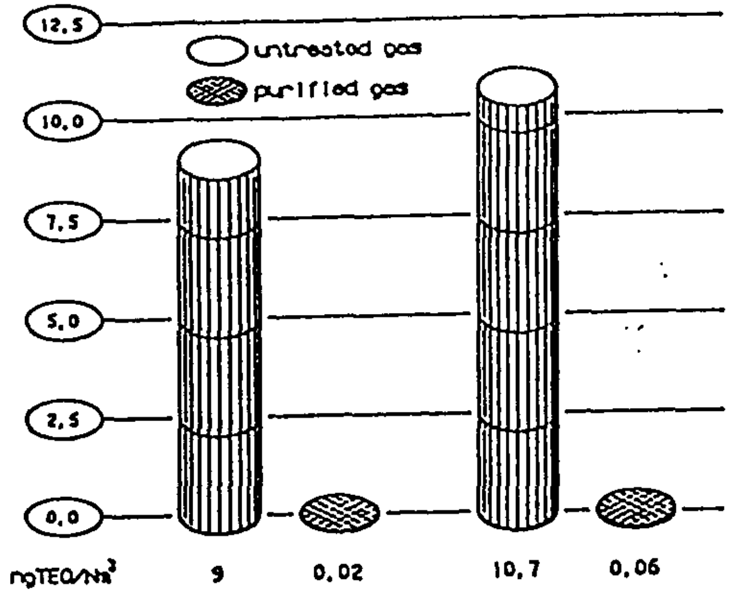

Figure 1: MHKW Würzburg: Dioxin-Reduction

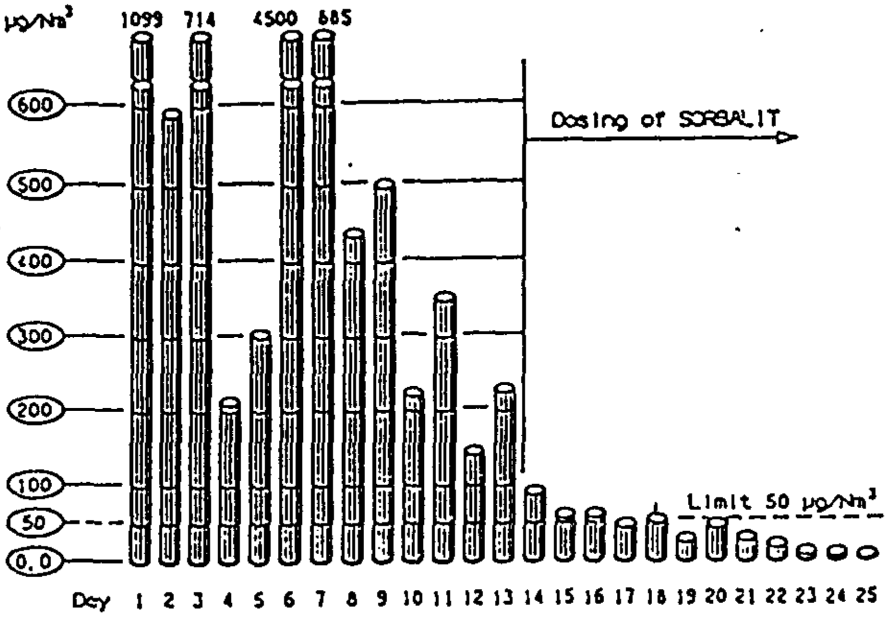

Figure 2: MHKW Würzburg: Mercury-Reduction

As can be seen from Figure 2, the use of Sorbalit reduces the emission of mercury to a level below the German limit of 50 ug/Nm^3. What is remarkable is the fact that this result was achieved without any modification of the plant configuration (5).

3.2 Conditioned dry sorption process
Hazardous waste incineration plant Schöneiche/Berlin

The hazardous waste incineration plant at Schöneiche in the former GDR is designed for a waste capacity of 2.3 Mg/h. The flue-gases down-line of the boiler are cooled to a temperature of 140 °C by the addition of water. The gas volume rate is then 31000 Nm^3/h. Prior to the use of Sorbalit, standard hydrated lime was employed as the adsorbing agent.

The operator of the plant decided to use Sorbalit, as this was the only way in which the approved limits for mercury could be complied with.

The tests were accompanied by measurements carried out by the Berlin Technical Control Association (TÜV) (6).

An overall summary of the most important results of the measuring work has been drawn up by Jungmann, Zürich (7).

Mercury measurements were carried out on the purified gas in January, 1990. The measurements are shown in Figure 3.

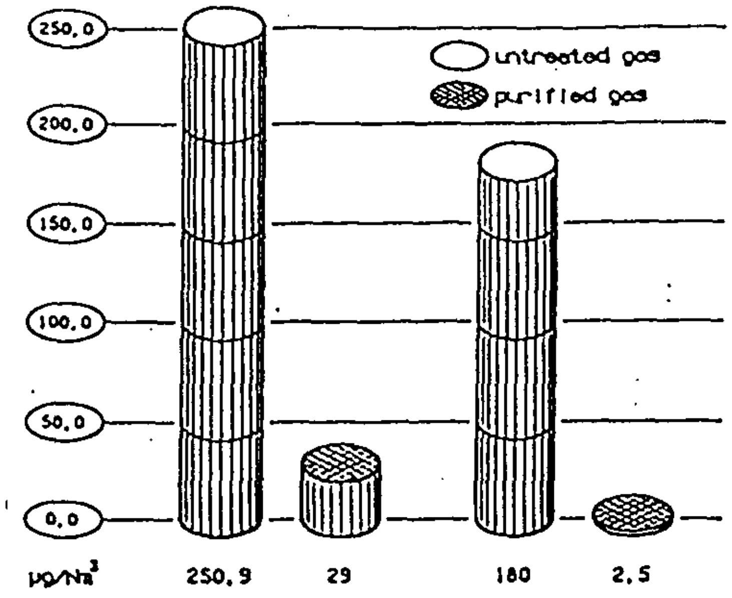

Figure 3: SVA Schöneiche: Mercury-Reduction

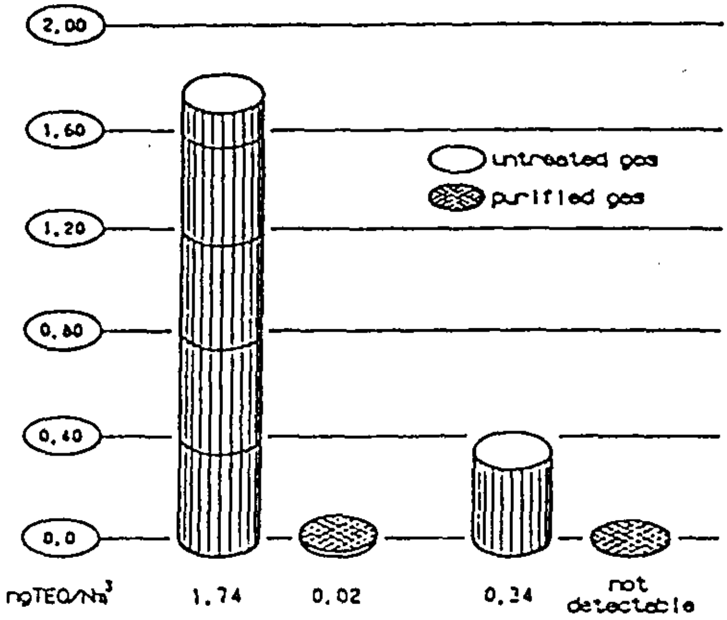

Figure 4: SVA Schöneiche: Dioxin-Reduction

Theses figures represent values well below the maximum limit for mercury in purified gas as stipulated in the 17th Federal Pollution Control Directive (17.BImSchV). Since this time, over 80 measurements have been carried out, each revealing barely detectable concentration levels.

It should be pointed out in particular that the operational tests with substantially lower levels of lignite coke content in the Sorbalit produced considerably better results than the laboratory experiments.

Figure 4 shows the respective levels of dioxin content in the untreated and in the purified gas. The level of dioxin concentration was in some cases even undetectable. The control levels fluctuate from 95.6 to 99,99 %.

The level of polychlorinated biphenyls in the untreated and in the purified gas was also measured. The values measured are shown in Table 1. The level of PCB content in the untreated gas was 130 ng/Nm^3, in the purified gas the various types of PCBs were no longer detectable (8).

PCB type	Content level in untreated gas ng/Nm^3	Content level in purified gas ng/Nm^3
Monochlorobiphenyls	< 1	< 1
Dichlorobiphenyls	< 1	< 1
Trichlorobiphenyls	10	< 2
Tetrachlorobiphenyls	18	< 3
Pentachlorobiphenyls	30	< 3
Hexachlorobiphenyls	38	< 2
Heptachlorobiphenyls	34	< 2
Octachlorobiphenyls	30	< 1
Nonachlorobiphenyls	24	< 1
Decachlorobiphenyls	14	< 1
Total PCBs	130	

Table 1: PCB-Reduction: SVA Schöneiche

The excellent rate of separation for the polychlorinated biphenyls also justifies the assumption that additional heavy superchlorinated compounds such as hexachlorobenzene and hexachlorocyclohexane can be removed from the flue-gas flow. The separation rates for the polyaromatic hydrocarbons cannot be established until the relevant measurements are available. A high level of separation is expected, however (9).

It should in particular be emphasized again that these outstanding levels for the purified gases were attained without any modifications to the plant or modification to the flue-gas purification system.
The viability of the concept of improving flue-gas purification via the use of modified calcium hydroxide is thus confirmed.
The flue-gas gas purification system at the Schöneiche hazardous waste incineration plant has been operating with Sorbalit since December, 1989. About 50 dioxin measurements have been taken since; at no time the limits have been exceeded.

3.3 Spray dryer system:
Hazardous waste incineration plant Schweinfurt

At the hazardous waste incineration plant Schweinfurt 2.5 Mg/h of hazardous waste are incinerated. The gas volume rate is 28000 Nm^3/h. The plant consists of a lime slurry preparation station with the spray dryer and a fabric filter down-line. Instead of the lime slurry traditionally used a Sorbalit suspension was employed, with no further modifications to the plant being necessary (10).
The results are shown in Figure 5 for dioxins and in Figure 6 for mercury.

What appears remarkable is the fact that on account of the convincing results the test run was immediately followed by continuous operation.

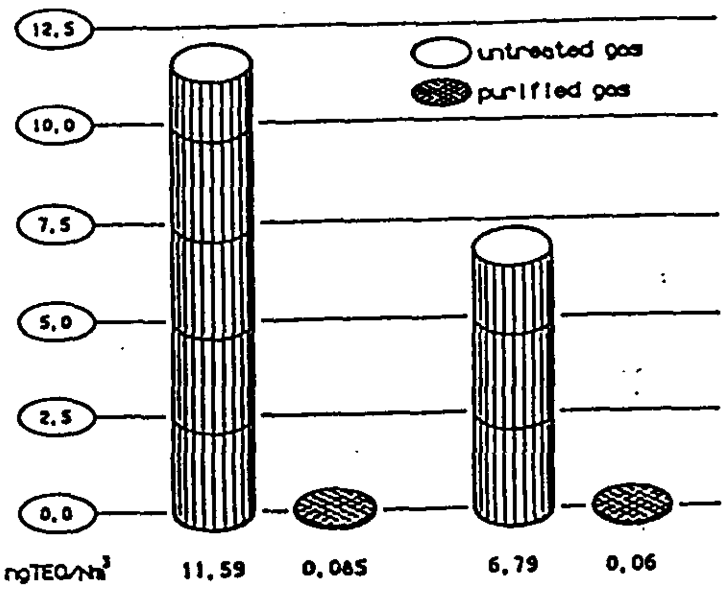

Figure 5: GSB Schweinfurt: Dioxin-Reduction

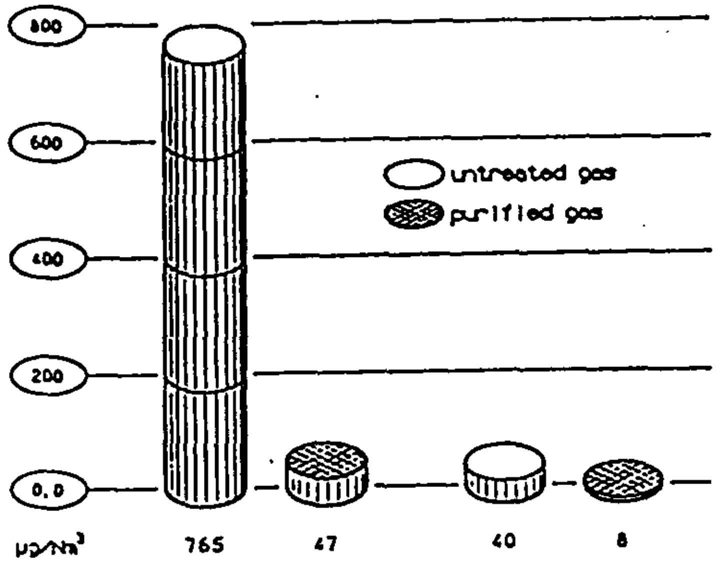

Figure 6: GSB Schweinfurt: Mercury-Reduction

3.4 "Police filter" down-line
Low temperature incineration plant KWU Siemens, Ulm

This plant constitutes a pilot project having a flue-gas volume rate of 13000 Nm^3/h only. The flue-gas purification system consists of an ESP, a spray dryer, a cyclone and a wet scrubber.

This configuration makes it possible to separate the acid components and the heavy metals, but not the organic pollutants. For that reason, a Sorbalit stage was added down-line as a "police filter" consisting of a Sorbalit dosage device and a fabric filter. The separation rates are shown in the Figures 7 - 10. The measurement results for mercury demonstrate that even extremely high concentrations of mercury can be mastered through this two-stage system. The Sorbalit stage acts as an additional safeguard against excessive concentrations in wet scrubbing - that is why the term "police filter" was introduced (11).

It was with this process in mind that the municipal waste incineration plant Bonn (18 Mg/h, 90000 Nm^3/h) was planned and built, and that the existing municipal waste incineration plant Zirndorf (8 Mg/h, 80000 Nm^3/h) was modified.

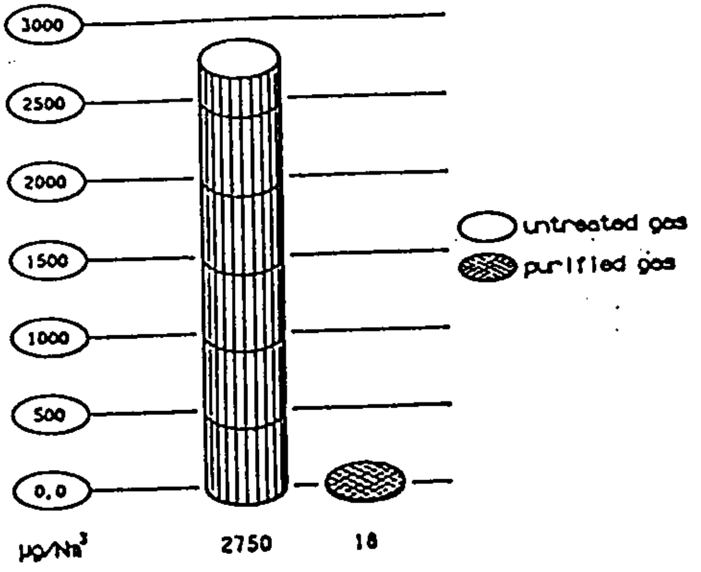

Figure 7: KWU/Siemens Ulm: Mercury-Reduction

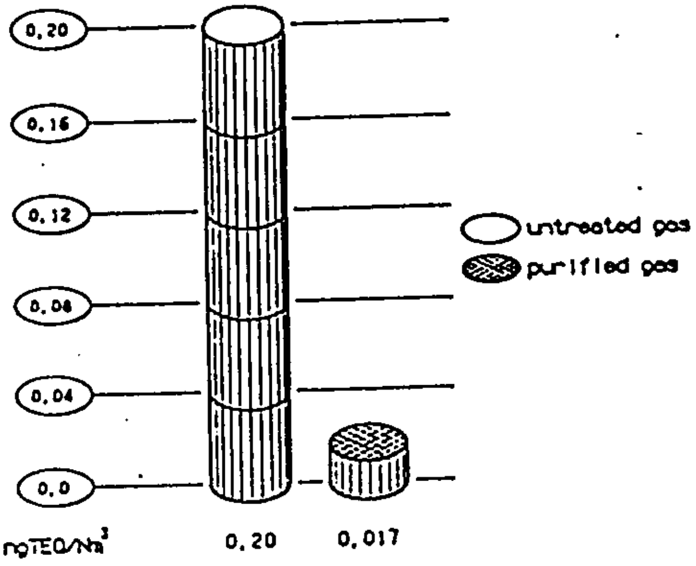

Figure 8: KWU/Siemens Ulm: Dioxin-Reduction

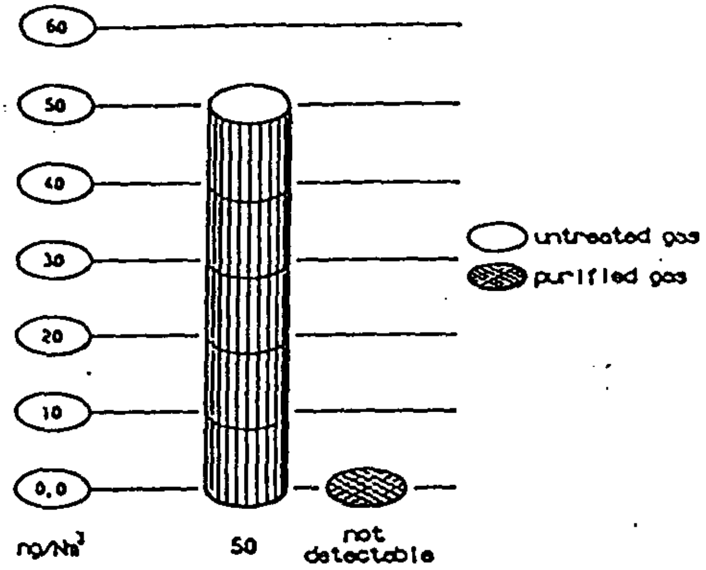

Figure 9: KWU/Siemens Ulm: PCB-Reduction

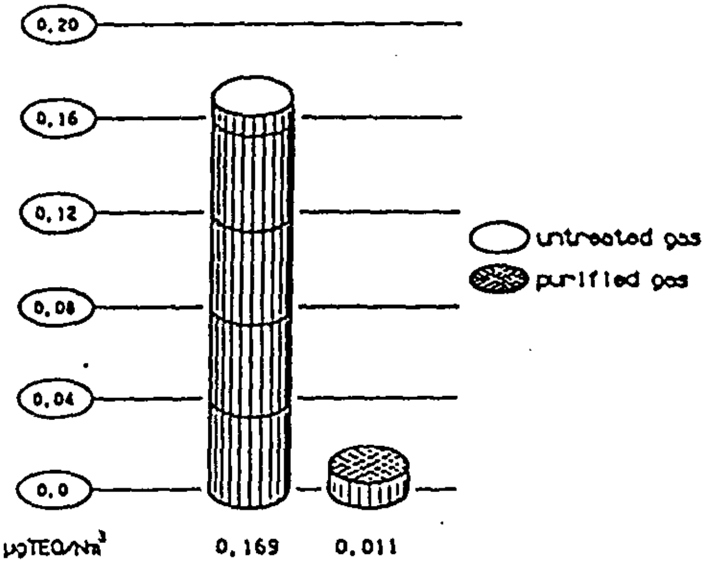

Figure 10: KWU/Siemens Ulm: PAH-Reduction

4. Safety aspects

The use of combustible substances like activated carbon, even though in small quantities only, requires consideration with regard to the risk of fire and explosion (12).

No problems relating to the combustibility of Sorbalit are known with regard to the operation of flue-gas gas purification plants whose temperatures are reliably maintained in the range of 140 °C.

Problems are to be expected at temperatures above 200 °C, however, unless precautionary measures are taken.

Overheating may occur at two points in the plants under unfavourable conditions, in each case involving used, and not fresh Sorbalit:

- discharge from the fabric filter
- discharge from the silo for used Sorbalit ("used lime silo").

These problems can be solved via relatively simple measures: any blocking in the discharge of used Sorbalit must be avoided. Blocking during discharge of the hot used Sorbalit from the fabric filter chamber can be detected via level indicators. Temperature indicators have to be installed as well. In the event of a blocking actually occurring the chamber can be rendered inert by nitrogen (13).

Overheating in the silo is similarly prevented by carrying out discharge operations under nitrogen and ensuring that no inlet of air is possible.

These measures have proven highly successful and are the only additional measures recommendable in the use of Sorbalit.

5. Summary and Outlook

The objective of the development concept for Sorbalit was to modify the calcium hydroxide previously employed at waste incineration plants in such a manner as to make it suitable as a carrier for absorption materials and in this way to minimize the emissions of ecotoxic substances. This paper has described and presented the initial results.

When Sorbalit is employed, emission values of

- < 0.05 mg Hg/Nm^3 for mercury
- < 0.1 ng TEQ/Nm^3 for dioxins and furans
- below the detectable limit for PCBs
- below the limit emission for PAHC

are reliably attained.

The use of Sorbalit in waste incineration processes furthermore entails considerable advantages with regard to the process engineering involved. Tried and tested facilities which are already available, from the supply silo through conveyance and dosing facilities to the mixing lines, filters and checking facilities, all remain in use.

The use of fabric filters is particularly effective. Residual dust levels of < 10 mg/Nm^3 can be attained, and values of 1 mg/Nm^3 are quite realistic (14).

This good separating capacity is also of importance with regard to the use of Sorbalit, as it means that Sorbalit to which the separated pollutants are attached is not emitted.

The flow-treatment process, that is, the injection of Sorbalit into the flue-gas flow, followed by vortexing of the flow and subsequent separation on the fabric filter, can be installed as a "Sorbalit stage" down-line of any incineration plant (15).

This is therefore a universally applicable process. Consequently, numerous areas of application are envisaged for Sorbalit in the field of flue-gas purification, some of which have already been put into practice.

The Sorbalit stage for separating volatile inorganic and organic substances can be integrated into the flue-gas purification systems of the most diverse processes:

- waste incineration plants and sewage sludge incineration plants
- large-scale furnaces
- power stations
- furnaces in the glass-manufacturing and ceramic industries
- wood-drying plants
- steelmills
- aluminium melting plants

Some results are shown in Table 2.

Name of the plant	Outlet Emissions Mercury µg/Nm³	 Dioxin ngTEQ/Nm³
Waste to energy station Geiselbullach	23	0,019
Waste incenerator Berlin-Ruhleben	40	0,06
Waste to energy station Würzburg	37	0,03
Hazardous waste inceneration plant Schöneiche	20	0,03
Hazardous waste inceneration plant Schweinfurt	40	0,06
Waste inceneration plant Marktoberndorf	27	0,06
Waste inceneration plant Zirndorf	< 50	0,05
Low temperature inceneration plant Ulm/Wieblingen	18	0,017
Low temperature inceneration plant Burgau	< 50	0,09
Aluminium work Stockach		0,013
Crematory Düsseldorf		0,03
Copper melting plant Hamburg	23	0,06

Table 2: Use of Sorbalit
Results of measurement of Mercury and Dioxin

Reports have been completed on test measurements for six plants not referenced in this report and will be published shortly.
Actual test results from four additional plants will be available in the next few weeks.

The use of Sorbalit is therefore only in its beginnings. The modification of calcium hydroxide has opened up totally new areas of application for lime in the field of high technology.

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Waste incinerator plant Berlin-Ruhleben

Capacity	7 x 7 t/h
Gas volume	7 x 35 000 Nm^3/h
Incinerator	Stoker
Flue-gas purification	Conditioned dry sorption -Dosing of SORBALIT -Reactor -Fabric filter
Flue-gas temperatur (before fabric filter)	165 ° C
Quantity of SORBALIT	12 kg / t of garbage
Emission rate	SO_2 - 4 mg/Nm^3 HCl - 4 mg/Nm^3 Hg - 0,04 mg/Nm^3 Dioxon/Furan - 0,06 ng TEQ/Nm^3

Waste incineration plant Marktoberndorf

Capacity	3	t/h
Gas volume	18 000	Nm^3/h
Incinerator	Stoker	
Flue-gas purification	-Dosing of SORBALIT -Fabric filter -Wet scrubber	
Flue-gas temperatur (before fabric filter)	160	°C
Quantity of SORBALIT	15	kg / t of garbage
Emission rate	SO_2 - 62	mg/Nm^3
	HCl - 6	mg/Nm^3
	Hg - 0,027	mg/Nm^3
	Dioxon/Furan - 0,06	ng TEQ/Nm^3

Sorbalit®

Hazardous waste incineration plant

Schweinfurt

Capacity	2,5 t/h	
Gas volume	28 000 Nm^3/h	
Incinerator	Stoker	
Flue-gas purification	Spray dryer -Slorry mixing station -Spray dryer -Fabric Filter	
Flue-gas temperatur (before fabric filter)	165 ° C	
Quantity of SORBALIT	12 kg / t of garbage	
Emission rate	SO_2	- 4 mg/Nm^3
	HCl	- 4 mg/Nm^3
	Hg	- 0,04 mg/Nm^3
	Dioxon/Furan	- 0,06 ng TEQ/Nm^3

Sorbalit®

Waste incineration plant Zirndorf

Capacity	2 x 4 t/h
Gas volume	2 x 40 000 Nm^3/h
Incinerator	Stoker
Flue-gas purification system	-ESP -Wet scrubber -Dosing of **SORBALIT** -Fabric filter
Flue-gas temperature (before fabric filter)	110 ° C
Quantity of SORBALIT	2 kg / t of garbage
Emission rate	SO$_2$ - 50 mg/Nm^3 HCl - 10 mg/Nm^3 Hg - <0,05 mg/Nm^3 Dioxon/Furan - 0,1 ng TEQ/Nm^3

Sorbalit®

Waste to energy station Bonn

Capacity	3 x 6 t/h
Gas volume	3 x 30 000 Nm^3/h
Incinerator	Stoker
Flue-gas purification	-Spray dryer -ESP -Wet scrubber -Dosing of SORBALIT -Fabric filter
Flue-gas temperatur (before fabric filter)	110 °C
Quantity of SORBALIT	2 kg / t of garbage
Emission rate (guaranteed max.rate)	SO_2 - 30 mg/Nm^3 HCl - 10 mg/Nm^3 Hg - < 0,05 mg/Nm^3

Low temperatre incineration plant

KWU-SIEMENS Ulm-Bieblingen

Capacity	0,25	t/h	(Pilot plant)
Gas volume	13 000	Nm^3/h	
Incinerator	Rotary kiln		
Flue-gas purification system	- ESP -Spray dryer -Cyclon -Wet scrubber -Fabric filter		
Flue-gas temperature (before fabric filter)	110	°C	
Quantity of SORBALIT	2	kg / t of garbage	

Emission rate	SO_2	- 45	mg/Nm^3
	HCl	- 10	mg/Nm^3
	Hg	- 0,018	mg/Nm^3
	Dioxon/Furan	- 0,017	ng TEQ/Nm^3

Sorbalit®

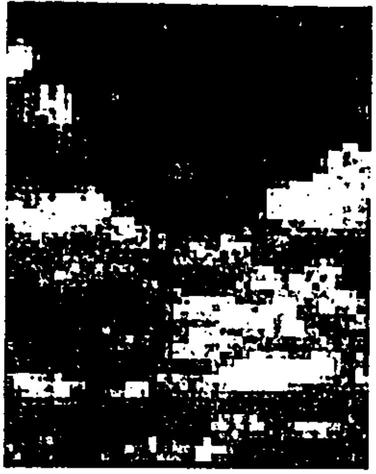
Low temperatur incineration plant Burgau

Capacity	2 x 3,5 t/h
Gas volume	2 x 18 000 Nm^3/h
Incinerator	Rotary kiln
Flue-gas purification system	-Cyclon -Dosing of **SORBALIT** -Fabric filter
Flue-gas temperatur (before fabric filter)	190 °C
Quantity of SORBALIT	12 kg / t of garbage
Emission rate	SO_2 - 17 mg/Nm^3 HCl - 2 mg/Nm^3 Hg - < 0,05 mg/Nm^3 Dioxon/Furan - 0,09 ng TEQ/Nm^3

Sorbalit®

Waste to energy station GSB Geiselbullach

Capacity	3 x 6 t/h		
Gas volume	3 x 35 000 Nm^3/h		
Incinerator	Stoker		
Flue-gas purification	Dry sorption -Dosing of **SORBALIT** -Reactor -Fabric filter -Recirculation system		
Flue-gas temperatur (before fabric filter)	205-220 °C		
Quantity of SORBALIT	25 kg / t of garbage		
Emission rate	SO_2	-	70 mg/Nm^3
	HCl	-	22 mg/Nm^3
	Hg	-	< 0,05 mg/Nm^3
	Dioxon/Furan	-	0,019 ng TEQ/Nm^3



Sorbalit®

Hazardous waste incineration plant

Schöneiche

Capacity	2,3 t/h
Gas volume	31 000 Nm^3/h
Incinerator	Rotary kiln
Flue-gas purification	Conditioned dry sorption -Dosing of **SORBALIT** -Reactor -Fabric Filter -Recirculation system
Flue-gas temperatur (before fabric filter)	140 °C
Quantity of SORBALIT	12 kg / t of garbage
Emission rate	SO_2 - 20 mg/N^{m3}
	HCl - 9 mg/Nm^3
	Hg - 0,02 mg/Nm^3
	Dioxon/Furan - 0,03 ng TEQ/Nm^3

Sorbalit®

Waste to energy station Würzburg

Capacity	2 x 12,5 t/h
Gas volume	2 x 70 000 Nm^3/h
Incinerator	Stoker
Flue-gas purification	Dry sorption -Dosing of **SORBALIT** -Reactor -Fabric filter -Recirculation system
Flue-gas temperatur	210-240 °C
Quantity of SORBALIT	20-25 kg / t garbage
Emission rate	SO_2 - 3 mg/Nm^3 HCl - 5 mg/Nm^3 Hg - 0,037 mg/Nm^3 Dioxon/Furan - 0,03 ng TE/Nm^3

Sorbalit - modified calcium hydroxide for flue-gas purification

Jochen Blumbach, Lutz-Peter Nethe

1. Introduction

Refuse incineration plants have - unjustly - acquired an exceedingly bad reputation. There is barely another type of large-scale technical facility in which exhaust gas purification has experienced such a rapid course of development.

The initial requirement to retain visible impurities, such as dust, was quickly followed by the need to neutralise the acidic pollutants, such as hydrogen chloride, hydrogen fluoride and sulphur oxides.

Today, the public quite justifiably demands that exhaust gases should be purified as extensively as technical capabilities allow. This means that heavy metals, particularly mercury, must also be removed and, of course, "horror compounds" such as dioxins and furans.

The technology required for this purpose is available. This talk is intended to describe a new development in this field, and it will reveal this development to be optimal in both ecological and economic terms.

2. Dry sorption in refuse incineration plants

The "classical" purification processes which have been employed up to now are:

- wet cleaning
- spray sorption
- dry sorption
- conditioned dry sorption

A common feature of all these processes is that, although they adequately neutralise the exhaust gases, they nevertheless have problems with heavy metals and other ecotoxic substances.

This talk is concerned primarily with dry sorption, quite simply because the most comprehensive experience is available in this area.

In the dry sorption process, calcium hydroxide is injected into and mixed with the exhaust gas flow, in the course of which the neutralisation reactions take place and the solids are separated in filters. This process takes place at temperatures of between 180°C and 200°C.

Conditioned dry sorption refers to the practice of reducing this temperature to approximately 140°C by the addition of water.

The advantage of dry sorption is that it does not produce any waste water and guarantees simple and, subsequently, safe and reliable operation. It can be operated at a high temperature level, which is beneficial for subsequent denitration. Extremely low levels of dust emission can be attained by the use of fabric filters.

The otherwise excellent economic efficiency is limited by a high level of calcium hydroxide consumption, which is greater for pure dry sorption than for conditioned dry sorption. A further drawback, this time a technical one, has also applied to both processes up to now: the high level of mercury emission.

D. Holl from the Bavarian State Pollution Control Office has published data on this area from various flue-gas purification plants employed for refuse incineration operations (1):

On the basis of this information, the expected emissions are roughly as follows:

- 0.27 mg/m^3 for dry sorption with E filter
- 0.12 mg/m^3 for dry sorption with fabric filter (although more recent measurements have also revealed values of 0.2 mg/m^3 here)

And other processes are no better, either:
For spray sorption with fabric filter, a level of 0.18 mg/m^3 has been measured.

This data shows that it is not even possible to maintain a limit reliably below 0.2 mg Hg/m^3, let alone to comply with the requirements of the 17th Federal Pollution Control Directive (BImSchV) for Hg concentrations of < 0.05 mg/m^3. Additional emission minimisation measures are therefore necessary.

Such measures may involve the complete modification of plant configurations - the most obvious solution - or the use of modified calcium hydroxide - the intelligent and economical solution.

Why?

3. The modification of calcium hydroxide to minimise emissions

The basic material of calcium hydroxide is a substance with which mankind has been involved for thousands of years, above all as a building material. The earth's lime resources are quite inexhaustible, and processing capacities exist in all countries. This is not least of all the reason why hydrated lime is the most widespread lye in technical use. Hydrate is non-combustible and non-toxic. It reacts with carbon dioxide to form calcium carbonate - limestone. Limestone is relatively insoluble, which prevents it from being spread via the medium of water.

Hydrated lime is easy to handle for technical purposes, including in refuse incineration plants. It can be added to the exhaust gas flow in controlled doses in well tested conveyor systems, in which tried and tested facilities are available for mixing gases and solids. Separation by retention in filters, particularly fabric filters, can be carried out without any problems whatsoever.

It was therefore an obvious measure to make use of this tried and tested technology, whereby the objective was to employ the calcium hydroxide not only as a reagent, but also as a carrier for an adsorbing agent. This would ensure both the neutralisation and separation of acidic constituents from the exhaust gas flow and the adsorption of heavy metals and other ecotoxic constituents.

It appeared conceivable to select such adsorbent substances for separating individual substances on the one hand, and for a broad-ranging effect on the other hand.

Calcium hydroxide did actually prove to be the ideal carrier when certain processes were employed, above all because these adsorbent substances often require to be added reliably to the exhaust gas flow in only the most minute amounts and evenly distributed.

4. Laboratory experiments

For the experiments a plant was employed which could be operated with synthetically produced exhaust gas of typical composition in a temperature range of 100°C to 200°C. This enables a large number of substances to be checked for their suitability in the stated temperature range. In this way, the modification of calcium hydroxide was optimised and experience was acquired regarding the quantities required and the separating capacity of the adsorbent substance. This talk is concerned with open-hearth furnace coke as an adsorbing agent. The results of experiments with other substances will be provided on a separate occasion.

Table 1 shows the most important chemical and physical properties of open-hearth furnace coke in the form of coke dust (2).

Table 1

Analysis values for lignite coke

Brief analysis:		
Water content	% by weight	1.0
Ash content	% by weight	9.0
Volatile constituents	% by weight	3.5
Fixed carbon	% by weight	86.5
Calorific value (Hz)	kJ/kg	29 700
	kcal/kg	7 100
Oxide analysis of coke ash:		
SiO_2	% by weight	6
Al_2O_3	% by weight	4
Fe_2O_3	% by weight	10
SO_3	% by weight	11
CaO	% by weight	55
MgO	% by weight	12
$Na_2 + K_2O$	% by weight	2
Physical characteristics:		
Density	g/cm^3	1.90
Bulk density	g/cm^3	0.95
Specific surface	m^2/g	250
Spontaneous ignition temperature	°C	300
Sulphur (wf)	% by weight	0.45

Table 2 shows the test results for the separation of mercury from a synthetic exhaust gas. The degree of separation was investigated in relation to the proportion of open-hearth furnace coke in the modified calcium hydroxide, for two different admixing processes.

These results clearly show that a good level of mercury separation is possible at the relatively high temperatures, whereby the degree of separation increases together with the proportion of open-hearth furnace coke.

Table 2

Mercury-separating capacity of open-hearth furnace coke (OHFC) - Laboratory experiments at 180 to 200 °C

Manner of adding OHFC to $Ca(OH)_2$	Proportion of OHFC %	Degree of separation %
OHFC suspended in slaking water for quick lime	2.5	68
	5.0	75
	10.0	88
OHFC added separately to the $Ca(OH)_2$	2.5	66
	5.0	75
	10.0	95

On the basis of similar experiments relating to other pollutants, it was concluded that substantial reductions could also be expected in the emissions of

- volatile heavy metals - cadmium, thallium, selenium and arsenic, in addition to mercury,
- chlorinated dibenzodioxins and dibenzofurans,
- other heavy chlorinated hydrocarbons, e.g. hexachlorobenzene and hexachlorocyclohexane,
- polychlorinated biphenyls - PCB,
- polyaromatic hydrocarbons.

On the basis of the extremely satisfactory laboratory results, it appeared justifiable to test modified calcium hydroxide on an operational scale, without any intermediate pilot phase, particularly as the required national and international patents for this process had by this time been filed.

5. Operational-scale experiments

The modified calcium hydroxide which had, in the meantime, been produced by means of a special process, was employed under the trade name of Sorbalit(R)*. OHFC is employed as the primary adsorbing agent.

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* Sorbalit(R) is a registered trademark of the company Märker Zementwerk GmbH, Harburg.

5.1 Using Sorbalit in dry sorption

5.1.1 Waste-fuelled heating and power station of the GfA at Geiselbullach

The waste-fuelled heating and power station of the GfA waste disposal company disposes of the waste in the districts of Dachau and Fürstenfeldbruck, in the direct vicinity of Munich.

The waste is subjected to thermal processing on two lines with a capacity of 6 Mg/h and the resulting exhaust gases are purified in a dry sorption process. The exhaust gas purification plant is equipped with a cyclone dust separator, a mixing stage for thoroughly mixing the hydrated lime and the exhaust gas, and a fabric filter for separating the solid matter.

Sorbalit was tested in operation for the first time in this waste-fuelled heating and power station in January, 1989. Only the active substance was changed: instead of the customary hydrated white lime which was previously used, Sorbalit was employed, without any other changes.

In spite of the high temperatures, which occasionally reached 240 °C, it was immediately confirmed that the mercury emission level, which is normally in the range of 0.2 to 0.25 mg/m^3, can be reduced to well below 0.1 mg/m^3.

The operator of the plant subsequently commissioned dioxin measurements to be carried out. The results of the measurements, which were carried out by the Bavarian Technical Control Association (TÜV Bayern) and Prof. Hutzinger, University of Bayreuth, were presented to the public at a press conference on 18th May, 1990.

These results revealed that the dioxin concentration is 2.2 $\overset{n}{\text{mg}}$ TEQ/Nm^3 in the untreated gas and markedly less than 0.1 $\overset{n}{\text{mg}}$ TEQ/Nm^3 in the purified gas. The calculations were carried out in accordance with the international toxicity equivalence factors.

These experiments showed that Sorbalit is suitable for separating dioxins and furans, even in the high temperature range of 180 to 220°C.

Due to the good separating results for mercury and dioxins, Sorbalit has been in continuous use at this plant since May, 1990.

5.1.2 Würzburg heating and power station

The heating and power station at Würzburg possesses two lines for incinerating domestic refuse, each with a capacity of 12.5 Mg/h. The temperature of the exhaust gases down-line of the boiler is reduced to a range of 180 to 200°C by means of water cooling.

The calcium hydroxide is mixed with the exhaust gas in a following fluidized bed reactor. The fluidized bed reactor also acts as a preliminary filter, before the exhaust gases are purified in a fabric filter, in accordance with the state of the art.

In the spring of 1989, tests were carried out with Sorbalit of varying composition at this plant; here again, only the active substance was changed.

The dioxin and furan emissions were reduced from 9 - 10 ng TEQ/Nm^3 to 0.02 - 0.06 ng TEQ/Nm^3. Sorbalit also displayed its effectiveness in reducing mercury emissions: the levels were reduced from 3 mg/Nm^3 to $<$ 0.05 mg/Nm^3.

5.2 The use of Sorbalit in conditioned dry sorption

Pollutive waste incineration plant at Schöneiche

The pollutive waste incineration plant at Schöneiche in the former GDR is designed for a waste throughput rate of 2.3 Mg/h. The exhaust gases down-line of the boiler are cooled to a temperature of 140°C by the addition of water. The volumetric flow rate is then 25,000 m^3/h. Prior to the use of Sorbalit, standard hydrated lime was employed as the adsorbing agent.

The operator of the plant decided to use Sorbalit, as this was the only way in which the approved limits for mercury could be complied with.

The tests were accompanied by measurements carried out by the Berlin Technical Control Association (TÜV) (3).

An overall summary of the most important results of the measuring work has been drawn up by Jungmann, Zürich (4).

Mercury measurements were carried out on the purified gas on 5th Jan., 1990 and 9th Jan., 1990. The measurements revealed values of 0.012, 0.033, 0.043 and 0.053 mg/m^3. These figures represent values well below the maximum limit for mercury in purified gas as stipulated in the 17th Federal Pollution Control Directive (BImSchV). Since this time, over 80 measurements have been carried out, each revealing barely detectable concentration levels.

It should be pointed out in particular that the operational tests with substantially lower levels of OHFC content in the Sorbalit produced considerably better results than the laboratory experiments.

Further tests were carried out regarding the separation of special organic pollutants, in particular dioxins and polychlorinated biphenyls.

Table 3 shows the respective levels of dioxin content in the untreated and purified gas as measured in the test run from 20th Dec., 1989 to 6th Feb., 1990. The table reveals that in four out of six measurements the dioxin content level was no more than 0.03 ng TEQ/Nm³ in the purified gas. Only when the untreated gas contained 5.4 ng TEQ/Nm³ was a level of 0.12 ng TEQ/Nm³ measured in the purified gas. In two cases, the level dioxin concentration was even undetectable. The separation levels fluctuate from 95.6 to 100 %.

Table 3

Dioxin content levels in the untreated and purified gas at the Schöneiche pollutive waste incineration plant, measurements carried out from 20th Dec., 1989 to 6th Feb., 1990

Date	Untreated gas	Purified gas	Separation level
20.12.89	1,73 ng TEQ/Nm³	0,03 ng TEQ/Nm³	98,3 %
21.12.89	5,44 ng TEQ/Nm³	0,12 ng TEQ/Nm³	93,8 %
26.01.90	1,26 ng TEQ/Nm³	0,022 ng TEQ/Nm³	98,3 %
31.01.90	0,34 ng TEQ/Nm³	0,015 ng TEQ/Nm³	95,6 %
02.02.90	1,05 ng TEQ/Nm³	undetectable	100,0 %
06.02.90	1,74 ng TEQ/Nm³	undetectable	100,0 %

On 11th Feb., 1990, the level of polychlorinated biphenyls in the untreated and purified gas was also measured. The measured values are shown in Table 4. The level of PCB content in the untreated gas was 130 ng/m³, in the purified gas the various types of PCBs were no longer detectable.

Table 4

PCB content levels in the untreated and purified gas at the Schöneiche pollutive waste incineration plant when using Sorbalit, measurements on 11th Dec., 1990

PCB type	Content level in untreated gas ng/m^3	Content level in purified gas ng/m^3
Monochlorobiphenyls	< 1	< 1
Dichlorobiphenyls	< 1	< 1
Trichlorobiphenyls	10	< 2
Tetrachlorobiphenyls	18	< 3
Pentachlorobiphenyls	30	< 3
Hexachlorobiphenyls	38	< 2
Heptachlorobiphenyls	34	< 2
Octachlorobiphenyls	30	< 1
Nonachlorobiphenyls	24	< 1
Decachlorobiphenyls	14	< 1
Total PCBs	130	

The excellent rate of separation for the polychlorinated biphenyls also justifies the assumption that additional heavy superchlorinated compounds, such as hexachlorobenzene and hexachlorocyclohexane, can be removed from the exhaust gas flow. The separation rates for the polyaromatic hydrocarbons cannot be established until the relevant measurements are available. A high level of separation is expected, however.

The company Ingenieurgemeinschaft Technischer Umweltschutz GmbH accompanied and verified the measurements carried out on the Schöneiche pollutive waste incineration plant by TÜV Berlin in the capacity of a neutral specialist organisation. The companies findings with regard to dioxin emission include the following statement, contained in (5), page 4:

"After modification of the flue-gas purification process, measured values have also been established for

these emissions which indicate that the proposed limit of 0.1 ng TEQ/Nm^3 can be attained under the test conditions.
The Schöneiche pollutive waste incineration plant is therefore the first plant in Germany to demonstrate this standard."

It should be emphasized in particular that these outstanding levels for the purified gases were attained without any modifications to the plant and modification of the exhaust gas purification system.
The viability of the concept of improving flue-gas purification via the use of modified calcium hydroxide is thus confirmed. The exhaust gas purification system at the Schöneiche pollutive waste incineration plant has been operating with Sorbalit since December, 1989. No problems have occurred as yet.

5.2.2 Refuse incineration plant at Berlin-Ruhleben

The Berlin-Ruhleben refuse incineration plant possesses 7 incineration lines.
Down-line of the boiler, the exhaust gas temperature is reduced to 140°C, after which hydrated lime is added for the purpose of neutralisation. Dust removal is carried out by means of a fabric filter.

Due to the outstanding results obtained with Sorbalit at the Schöneiche pollutive waste incineration plant, large-scale trials were also carried out here. Although the measurement results have yet to be published, it can be concluded that the problem of mercury emission has been solved in convincing manner and that the level of dioxin emissions is also well below the stipulated limit of 0.1 ng TEQ/Nm^3. This is the only way in which the operator's decision to refit the plant for operation with Sorbalit can be interpreted (cf. also Table 5).

5.3 Summary of measured values

Table 5 shows the results of the tests carried out on the above-stated plants. It also demonstrates that the use of Sorbalit is not restricted to dry sorption and conditioned dry sorption. Values for a low-temperature incineration plant with wet washing system and down-line fabric filter are also included. Here again, the mercury and dioxin absorption rates are in the same range as those for the other plants. The proportion of polyaromatic hydrocarbons and polychlorinated biphenyls in the untreated and purified gas were additionally measured here. The excellent adsorbent capacity of Sorbalit is confirmed here by the reduction from 0.169 ng/m^3 to 0.011 ng/m^3 of polyaromatic hydrocarbons and polychlorinated biphenyls, a level which is barely detectable.

6. Safety aspects

As Table 1 showed, open-hearth furnace coke is a combustible material. Safety aspects therefore require consideration with regard to the risk of fire and explosion.

Tests carried out by the Bergbauinstitut (Mining Institute) in Dortmund have revealed that Sorbalit is not subject to a danger of explosion up to an OHFC content level of 35%. This means that Sorbalit can be treated in the same manner as standard hydrated lime up to this limit. No modifications to the transportation vehicles, silo facilities and dosing facilities are therefore required.

No problems relating to the combustibility of Sorbalit are known with regard to the operation of exhaust gas purification plants whose temperatures are reliable maintained in the range of 140 °C.

[redacted]n.

Overheating may occur at two points in the plants under unfavourable conditions, in each case involving used, and not fresh Sorbalit:

- discharge from the fabric filter
- discharge from the silo for used Sorbalit ("used lime silo")

Problems occurred during discharge from the fabric filter at Geiselbullach waste-fuelled heating and power station, while malfunctions relating to discharge operations from the "used lime silo" applied at the waste-fuelled heating and power station at Würzburg.

Analysis of the malfunctions revealed the following:

In each case, overheating of the material was preceded by discharging problems.

The static layers of used material become increasingly hotter, as the carbon is combusted when oxygen is present. The resultant heat cannot be discharged in the static material, and in this way the spontaneous ignition temperature of the used Sorbalit is reached, which for a 5% HOK concentration, for example, is around 340°C.

Although no fire results, the hydrated lime contained in the Sorbalit reacts with the CO2 which is produced, to form calcium carbonate. This calcium carbonate becomes caked together and renders discharge of the material difficult or impossible.

These problems can be solved via relatively simple measures on the basis of this explanation: blockages in the discharge of used Sorbalit must be avoided.

Measures for identifying transportation difficulties were therefore carried out at the waste-fuelled heating and power stations of the GfA at Würzburg and Berlin-Ruhleben. Blockages during discharge of the hot, used Sorbalit from the fabric filter chamber can be detected via level indicators. Temperature indicators were also installed. In the event of a blockage actually occurring now, the chamber or the silo can be rendered inert with nitrogen.

Overheating in the silo is similarly prevented by carrying out discharge operations under nitrogen and ensuring that no inlet of air is possible.

These measures have proven highly successful at Geiselbullach since May, 1990.

7. Treatment of residual substances

In accordance with the technical directive for waste subject to particularly stringent control requirements, which came into effect on 1st October, 1990, the reaction products from the exhaust gas purification process are classified as substances which are either to be disposed of at a landfill site for pollutive waste or deposited underground. This is necessary on account of the high proportion of salt, heavy metal and dioxin content involved. The use of Sorbalit does not result in any fundamental change with regard to this assessment. The reaction products from the exhaust gas purification process are already polluted with heavy metals and dioxins, prior to adding any adsorbing substances.

In the case of the plants currently in operation, the residual substances are disposed of at monitored landfills belonging to the operators.

It is planned, however, to transport the reaction products from the plants at Geiselbullach and Würzburg to the mining landfill at Heilbronn. This is the most effective manner of solving the problem of the reaction products from the exhaust gas purification process which are classified toxic. An additional alternative would involve solidifying the substances with the aid of cement, a process which is also already employed.

When Sorbalit is employed down-line of wet washing systems, the situation is incomparably more favourable. First of all, the specific consumption rate for Sorbalit is much lower, amounting to only around 10 % of the consumption rate for dry sorption. Furthermore, the used Sorbalit contains a lower level of mercury contamination.
In these cases, disposal thus represents no problem - the used Sorbalit can be reinjected into the combustion chamber, to destroy any dioxins which may still be present.

Reference should be made to the level of dioxin content in the used Sorbalit. The dioxin balance revealed an expected concentration of 93000 ppt TE for used Sorbalit from the Schöneich plant. However, in actual fact, a value of only 238 ppt TE was established (7). Assuming that the dioxin is desorbable, this means that 97.5% of the absorbed dioxins and furans were no longer detectable.

8. Summary and outlook

The objective of the development concept for Sorbalit was to modify the calcium hydroxide previously employed in waste incineration plants in such a manner as to make it suitable as a carrier for absorption materials and in this way to minimise the emissions of ecotoxic substances. This paper has described the modification of open hearth furnace coke and presented the initial results.

When Sorbalit is employed with an OHFC content level of 2 - 3 %, emission values of

- < 0,05 mg Hg/Nm^3 for mercury
- < 0.1 ng TEQ/Nm^3 for dioxins and furans
- below the detectable limit for PCBs
- below the limit emission for PAHC

are reliably attained.

The use of Sorbalit in dry sorption and conditioned dry sorption processes furthermore entails considerable advantages with regard to the process engineering involved. Tried and tested facilities which are already available, from the supply silo, through conveyance and dosing facilities to the mixing lines, filters and checking facilities, all remain in use. The use of fabric filters is particularly effective. Residual dust levels of < 10 mg/m^3 can be attained, and values of 1 mg/m^3 are quite realistic.

This good separating capacity is also of importance with regard to the use of Sorbalit, as it means that Sorbalit to which the separated pollutants are attached is not emitted.

The flow-treatment process, that is, the introduction of Sorbalit into the exhaust gas flow, followed by vortexing of the flow and subsequent separation on the fabric filter, can be installed as a "Sorbalit stage" down-line of any incineration plant.

This is therefore a universally applicable process. Consequently, numerous areas of application are envisaged for Sorbalit in the field of exhaust gas purification, some of which have already been put into practice.

In dry sorption processes, Sorbalit is employed to separate the acidic pollutants and, at the same time, to minimise other ecotoxic pollutants. After washers which do not require neutralisation, limestone powder or other fine-ground materials could be used as the carrier for the adsorbing agent.

The Sorbalit stage for separating volatile inorganic and organic substances can be integrated into the exhaust gas purification systems of the most diverse processes:

- refuse incineration plants, pollutive waste incineration plants and sewage sludge incineration plants
- large-scale furnaces
- power stations
- furnaces in the glass-manufacturing and ceramic industries
- wood-drying plants
- steelworks
- aluminium works

The combination of fine-powdered calcium hydroxide as an alkaline carrier with additives of adsorbing substances is thus suitable for diverse applications, whereby the precise adsorbent additives and dosages can be selected for the specific case of application concerned.

The use of Sorbalit with the described plants is therefore only in its beginnings. The modification of calcium hydroxide has opened up totally new areas of applications for lime in the field of high technology.

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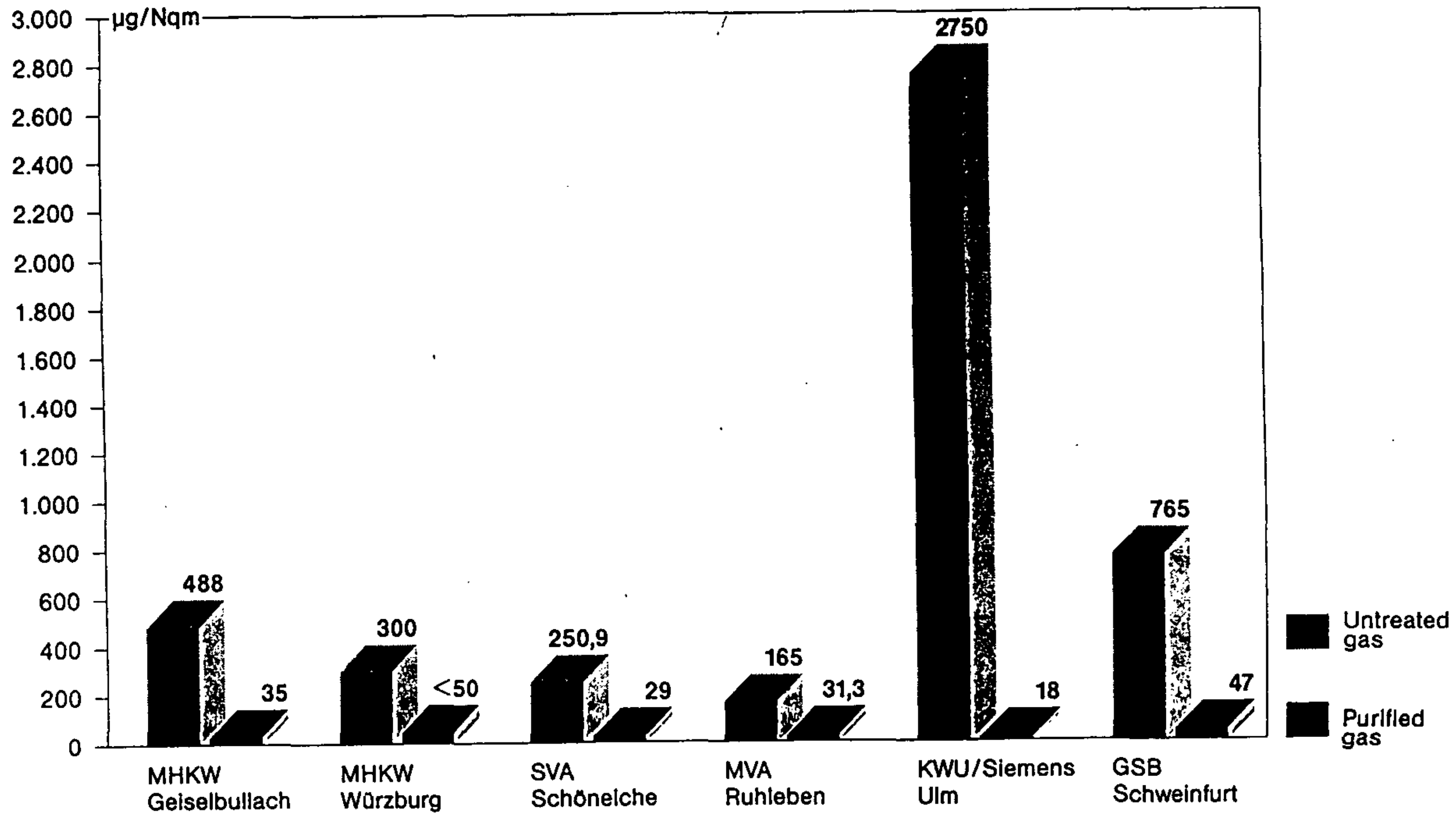
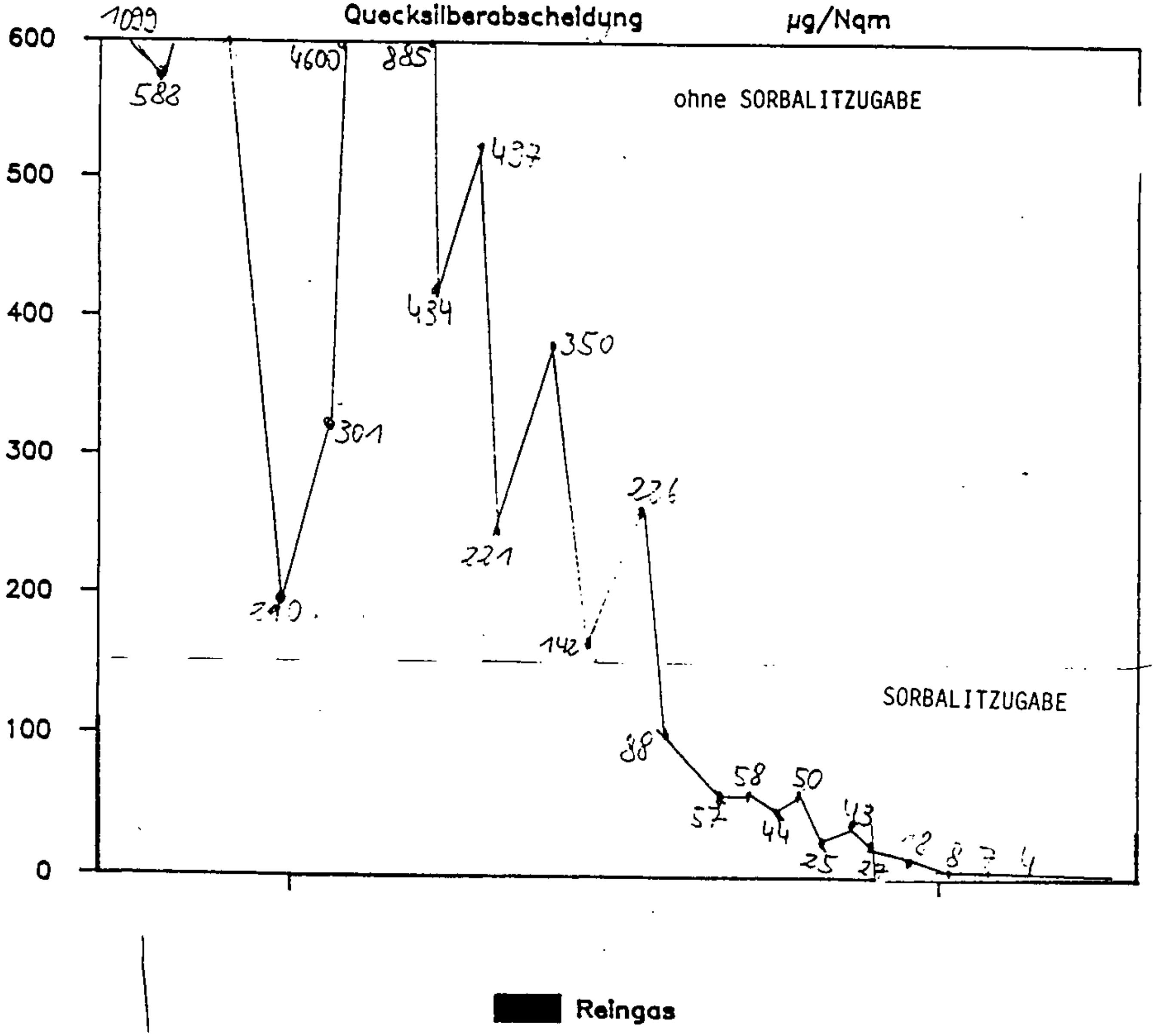
Mercury reduction by Sorbalit®



MHKW Geiselbullach Sorbalit



Sorbalit®

Quecksilber-Gehalte des Roh- und Reingases
einer Müllverbrennungsanlage mit Trockensorption
mit und ohne SORBALIT
mit und ohne Abgas temperatur senkung

Rohgas Hg $\mu g/m^3$	Abgastemperatur °C	Reingas Hg $\mu g/m^3$	Abgastemperatur °C
	190	1099	190
		588	
		714	
		210	
573		301	
4590		4500	
964		885	
615		434	
541		497	
260		221	
316		350	
180		142	
278		226	
		SORBALIT	
245	190	88	190
188		57	
308		58	
396		44	
350	190	50	175
597		25	
250		43	
594	190	27	165
465		18	
253		8	
198		7	
164		4	

An Alternative Economic Approach to Mercury and Dioxin Control for MWCs

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1. INTRODUCTION

The endeavor to improve the existing state of technology, and the widespread concern with certain emissions at solid and hazardous waste-treatment facilities is at the root of technical progress. This concern is not only expressed in public opinion and regulations, but also by the owners and operators of MWC facilities who also desire reduced emissions.

The main reasons for their concern are:

- The higher than desired emission of mercury, an index element for volatile heavy metals.
- The higher than desired emission of dioxins and furans, an index for various organic compounds.

The above mentioned concerns have had several results. On the one hand, environmental control agencies all over the world have sought to reduce emission rates by the implementation of new regulations; for example, Germany's 17th Federal Regulation on Emission Protection (1), the Clean Air Act Amendments of 1990 in the united States, and recent regulatory action in New Jersey and Florida. In other cases, concern and regulatory uncertainty has delayed the implementation and permitting of projects.

A process is presented in this paper that has already stood its test in Europe and has been demonstrated in the U.S.

Basically, the process consists of two components:

1. A specially developed agent characterized by a high adsorption material focusing on the toxic elements, and
2. Air pollution control systems used by various types of combustion sources including MWCs, which provide through agitation, a vortexing of the adsorbing agent mixture in a collection devise, usually a fabric filter or ESP.

The aim of this paper is not the discussion of theoretical background problems but the presentation of field test results which illustrate applications that reduce the concerns related to mercury and dioxins based on practical experience. The adsorbing agent will be briefly described and results concerning various types of air pollution control systems will be presented.

2. THE SORBALIT® SYSTEM

Sorbalit is a patented system not a product. The Sorbalit agent (sorbent) is produced by mixing lime, either calcium hydroxide ($Ca(OH)_2$) or quick lime (CaO), with surface-activated substances such as activated carbon or lignite, coke and sulfur-based components in a special process.

In the Sorbalit process, a homogeneous powder is produced that will not dissociate (demix) when used in air pollution control systems. It is particularly important to avoid flotation or separation of the carbon and sulfur substances which have been added to the lime. In order to maintain product uniformity and effective levels of air pollution control, the components must stay in suspension from the manufacturing process through transportation and the air pollution control system. The basis for the Sorbalit System is their proprietary mixing technology.

In its simplest form, the air pollution control system consists of a pipe, into which dosed Sorbalit is injected into the flue gas, plus a fabric filter or ESP which is located down stream. This simple solution has an economic advantage in that it can easily be integrated in existing plants without have to expend significant capital for new equipment.

The following Sections deal with the Sorbalit application for the air pollution control systems usually employed in various waste treatment plants. These systems include dry, dry/water conditioning, and spray dryer technologies. They also demonstrate the improved reduction in emission values obtained with this process. Typical application of Sorbalit using these three technologies are illustrated in Drawings 1, 2 and 3.

3. AREAS OF APPLICATION

3.1 Dry Sorption Process

Würzburg Waste-to-Energy Plant

The waste-to-energy plant at Würzburg has two process lines for converting municipal solid waste to energy. Each line has a capacity of 12.5 Mg/h (330 T/D). The temperature of the flue gas down stream of the boiler is reduced to 180 to 200°C (356 to 392°F) by means of water cooling.

Prior to the application of the Sorbalit System, hydrated lime was injected into the flue gas, in a fluidized bed reactor to control, the emission of acid gases. The fluidized bed reactor acts as a preliminary filter before the flue gases are cleaned in a pulse jet fabric filter.

In the spring of 1989, tests were conducted to evaluate switching from hydrated lime to Sorbalit. The dioxin and furan emissions were reduced from 9 - 10 ng TEQ/Nm^3 when normal lime was used, to 0.02 - 0.06 ng TEQ/Nm^3, a 200 time reduction, when Sorbalit was used (Figure 1). Sorbalit also displayed its effectiveness in reducing mercury emissions (Figure 2).

As can be seen from Figure 2, the use of Sorbalit reduces the emission of mercury to a level below the German limit of 50 $\mu g/Nm^3$ at 11% O_2. What is remarkable is the fact that this result was achieved without any modification of the plant configuration. The overall reduction of Hg is limited by the relatively high flue gas temperature of the facility. Unfortunately, due to the design limitations of this plant, the flue gas temperature can not be lowered, which would reduce the emission of mercury and thereby lower their consumption rate of Sorbalit.

3.2 Dry/Wet Conditioned Sorption Process

Hazardous Waste Incineration Plant Schöneiche/Berlin

The hazardous waste incineration plant at Schöneiche, in the former GDR, is designed for a waste capacity of 2.3 Mg/h (60 T/D). The flue gases down stream of the boiler are cooled to a temperature of 140°C (284°F) by the injection of water. The gas volume rate during the test was 31,000 Nm^3/h (19,657 scfm).

The operator of this plant decided to use Sorbalit, as this was the only way in which the approved limits for mercury could be achieved without the addition of new control equipment. Prior to the use of Sorbalit, standard hydrated lime was employed as the adsorbing agent.

The tests were accompanied by measurements carried out by the Berlin Technical Control Association (TUV). An overall summary of the most important results of the measuring work have been prepared by Jungmann of Zurich.

In January, 1990, mercury measurements were carried out on the untreated flue gases before and after the injection of Sorbalit. The measurements are shown in Figure 3.

These figures represent values well below the maximum emission limit for mercury as stipulated in the 17th Federal Pollution Control Directive (17.BimSchV). Since that time, over 80 measurements for mercury have been carried out, each revealing barely detectable concentration levels.

It should be pointed out that these operational tests were conducted with a substantially lower carbon content (3% C) in the Sorbalit than in the original laboratory experiments (10% C). The field tests with 3% carbon demonstrated better results than the laboratory tests conducted with 10% carbon.

Figure 4 shows the respective levels of the dioxin concentration in the untreated and in the cleaned flue gases. The dioxin concentration in the Sorbalit treated flue gas was in some cases undetectable. The removal levels fluctuate from 95.6 to 100%.

The concentration of polychlorinated biphenyls (PCBs) in the untreated and in the cleaned flue gas was also measured. The values measured are shown in Table 1. The level of PCB content in the untreated flue gas was 130 ng/Nm^3; in the cleaned flue gas the various types of PCBs were no longer detectable.

The excellent rate of removal of the polychlorinated biphenyls also justified the assumption that additional heavy superchlorinated compounds such as hexachlorobenzene and hexachlorocyclohexane can be removed from the flue gases. The separation rates for the polyaromatic hydrocarbons cannot be established until the relevant measurements are available, however, high levels of removal are expected.

It should be emphasized again that these outstanding levels for the treated cleaned flue gases were attained without any modifications to the plant or the air pollution control system.

The viability of the concept of improving a flue gas cleaning system via the use of modified calcium hydroxide is thus confirmed. The air pollution control system at the Schöneiche hazardous waste incineration plant has been operating with Sorbalit since December, 1989. About 50 dioxin measurements have been taken since; at no time have the limits been exceeded.

3.3 Spray Dryer System

Hazardous Waste Incineration Plant Schweinfurt

At the hazardous waste plant at Schweinfurt 2.5 Mg/h (66 T/D) of hazardous waste are converted to energy. The flue gas volume rate is 28,000 Nm^3/h (17,755 scfm). The original plant consists of a pebble lime slurry preparation station with a spray dryer and a fabric filter. In the retrofit, instead of the traditional lime slurry, a Sorbalit suspension was employed, with no further modifications to the plant being employed. The results are shown in Figure 5 for dioxins and in Figure 6 for mercury.

What appears remarkable is the fact that based on these convincing results, the test run was immediately followed by continuous operation.

4. Safety Aspects

The use of any technology which utilizes carbon injection requires consideration with regards to the risk of fire and explosion, even when used in small quantities. However, since Sorbalit is a mixture of lime and a carbon material, the smoldering and flash point of the carbon are raised beyond any anticipated temperatures that can be expected with normal handling procedures.

No problems relating to the combustibility of Sorbalit are known with regard to the operations of air pollution control systems whose gas temperatures are maintained in the range of 140°C (284°F). Problems may occur at facilities where the flue gas temperature exceeds 200°C (392°F) unless operating and design precautionary measures are taken. The exothermic reaction of lime can add 90°C (194°F) to the gas temperature of 200°C which brings the total temperature close to the smoldering temperature of carbon.

Overheating of the carbon may occur at two points in operating plants under unfavorable conditions. These conditions involve only used and not fresh Sorbalit:

- Discharge from the fabric filter or ESP hoppers
- Discharge from the storage silo for used Sorbalit and flyash

It is important to note that in a retrofit application, if the project is not experiencing problems with the plugging of hoppers under present operating conditions, they should will not have any problems when Sorbalit is used. If the plant is having hopper plugging, the potential problems can be solved via relatively simple measures:

- Any blockage in the discharge hoppers of used Sorbalit must be avoided (use extra rappers and/or change the discharge valve).
- Blockages during discharge of the hot, used Sorbalit from the fabric filter hopper can be detected via level indicators (install level detectors).
- Temperature indicators have to be installed.
- In the event of a blockage actually occurring, the hopper can be rendered inert by a simple (manual) injection of nitrogen or CO_2.

Overheating in a discharge storage silo, if used, is similarly prevented by carrying out discharge operations under a nitrogen blanket to prevent infiltration of air. These measures have proven highly successful and are the only additional measures recommended in the use of Sorbalit. **More substantial safety measures will have to be utilized when employing other carbon based technologies.**

5. Summary and Outlook

The objective of the development concept for Sorbalit was to modify the lime based sorbents previously employed at various sources of combustion in such a manner as to make it suitable as a carrier for absorption materials and; in this way, to minimize the emissions of ecotoxic substances. This paper has described and presented the initial operating results from various combustion facilities.

When Sorbalit is employed, the following emission values are reliably attained:

- < 50 μg mg Hg/Nm^3 for mercury at 11% O_2 (70 μg at 7% O_2)
- < 0.1 ng TEQ/Nm^3 for dioxins and furans at 11% O_2
- Below the detectable limit for PCBs
- Below the emission limit for PAHC

Furthermore, the use of Sorbalit in waste combustion processes entails considerable advantages with regard to the process engineering involved. Tried and tested facilities which are already available, from the supply silo through conveyance and dosing equipment to the mixing lines, filters, and flow controllers, all remain in use.

The use of fabric filters is particularly effective. Residual dust levels of < 10 mg/Nm^3 (0.004 grs/scf) at 11% O_2 can be attained and; values of 1 mg/Nm^3 (0.0004 grs/scf) are quite realistic. This good separating capacity is also of importance with regard to the use of Sorbalit, as it means that Sorbalit, to which the separation pollutants are attached, is not emitted and the sorbent usage is reduced.

As a rule of thumb, if an ESP is utilized instead of a fabric filter, it requires approximately twice the amount of Sorbalit to achieve the same results. An economic comparison can be made in a retrofit application on the trade-off of increased operating cost versus the capital cost for installing a fabric filter and its associated down time.

The gas cleaning process, that is, the injection of Sorbalit into the flue gas flow, followed by vortexing of the flow and subsequent separation on the fabric filter or ESP, can be installed as a "Sorbalit System" down stream of any combustion plant.

This is, therefore, a universally applicable process. Consequently, numerous areas of application are envisioned for Sorbalit in the field of flue gas cleaning, some of which have already been put in to practice.

The Sorbalit sysytem for separating volatile inorganic and organic substances can be integrated into the flue gas cleaning systems of the most diverse processes:

- solid and hazardous waste incineration plants
- sewage/sludge incineration plants
- coal fired power plants
- wood fired boilers

- furnaces in the glass manufacturing and ceramic industries
- wood drying plants
- steel mills
- aluminum melting plants (primary and secondary)

Some test results are shown in Table 2.

Reports have been completed on test measurements for six plants not referenced in this report and they will be published shortly. Actual test results from four additional plants will be available in the next few weeks.

In general terms, Sorbalit is effective in removing mercury over a wide range of operating conditions and applications. Figure 7 presents a graphic summation of test data from European facilities and an American test program. This summary includes dry, dry/wet conditioned and spray dryer equipped plants. This data clearly indicates the effectiveness of the Sorbalit System. Our test data has found that two of the key parameters in determining the overall removal efficiency of mercury are the inlet concentration and the temperature of the flue gas. Figure 8 illustrates the impact flue gas temperature has on mercury emissions.

The development of applications for Sorbalit is continuing in many new areas. The modification of lime products, both quick lime and calcium hydroxide, has opened up totally new areas of opportunities for lime in the field of high technology air pollution control.

Drawings 4 and 5 show two recent developments in the Sorbalit System that are specific for the U.s. retrofit spray dryer applications. Drawing 4 illustrates the application with Sorbalit manufactured with quick lime. Drawing 5 shows the application of adding a concentrated form of Sorbalit to an existing facility. This was accomplished by simply adding one storage silo and one mixing tank to the system.

We believe that this brief summation has demonstrated that Sorbalit has the flexibility to be integrated into many existing applications and systems.

TABLE 1

PCB REDUCTION

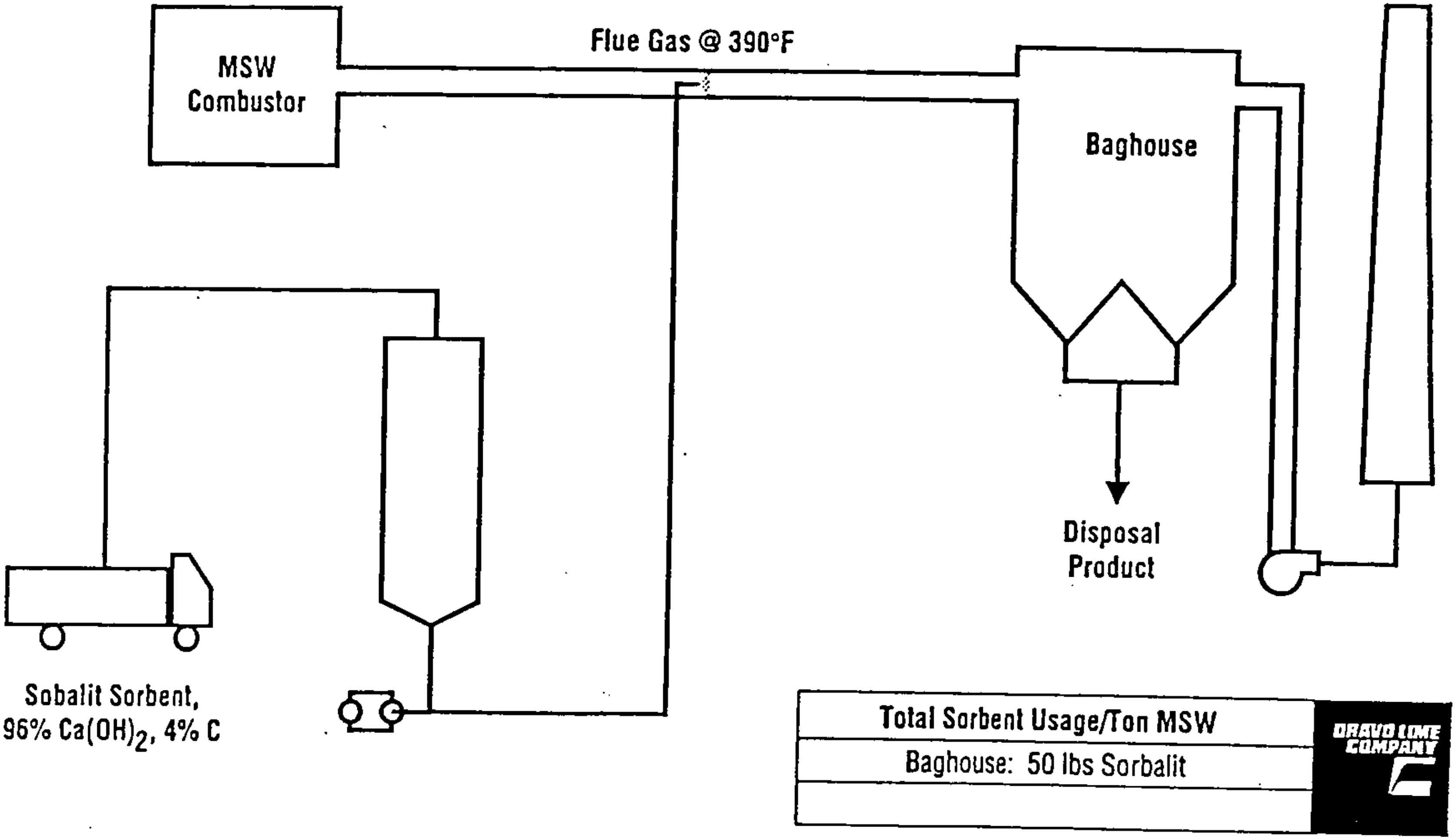
SVA SCHÖNEICHE/BERLIN

PCB Type	Concentration in untreated gas ng/Nm³	Concentration in cleaned gas ng/Nm³
Monochlorobiphenyls	< 1	< 1
Dichiorobiphenyls	< 1	< 1
Trichiorobiphenyls	10	< 2
Tetrachiorobiphenyls	18	< 3
Pentachiorobiphenyls	30	< 3
Hexachiorobiphenyls	38	< 2
Heptachiorobiphenyls	34	< 2
Octachiorobiphenyls	30	< 1
Nonachiorobiphenyls	24	< 1
Decachiorobiphenyls	14	< 1
TOTAL PCBs	130	

Drawing 1.

SORBALIT Technology

Hydrated Lime/Carbon/Sulfur Blend, Duct Injection Application



Total Sorbent Usage/Ton MSW
Baghouse: 50 lbs Sorbalit

DRAVO LIME COMPANY

TABLE 2

MERCURY AND DIXOIN

EMISSION DATA

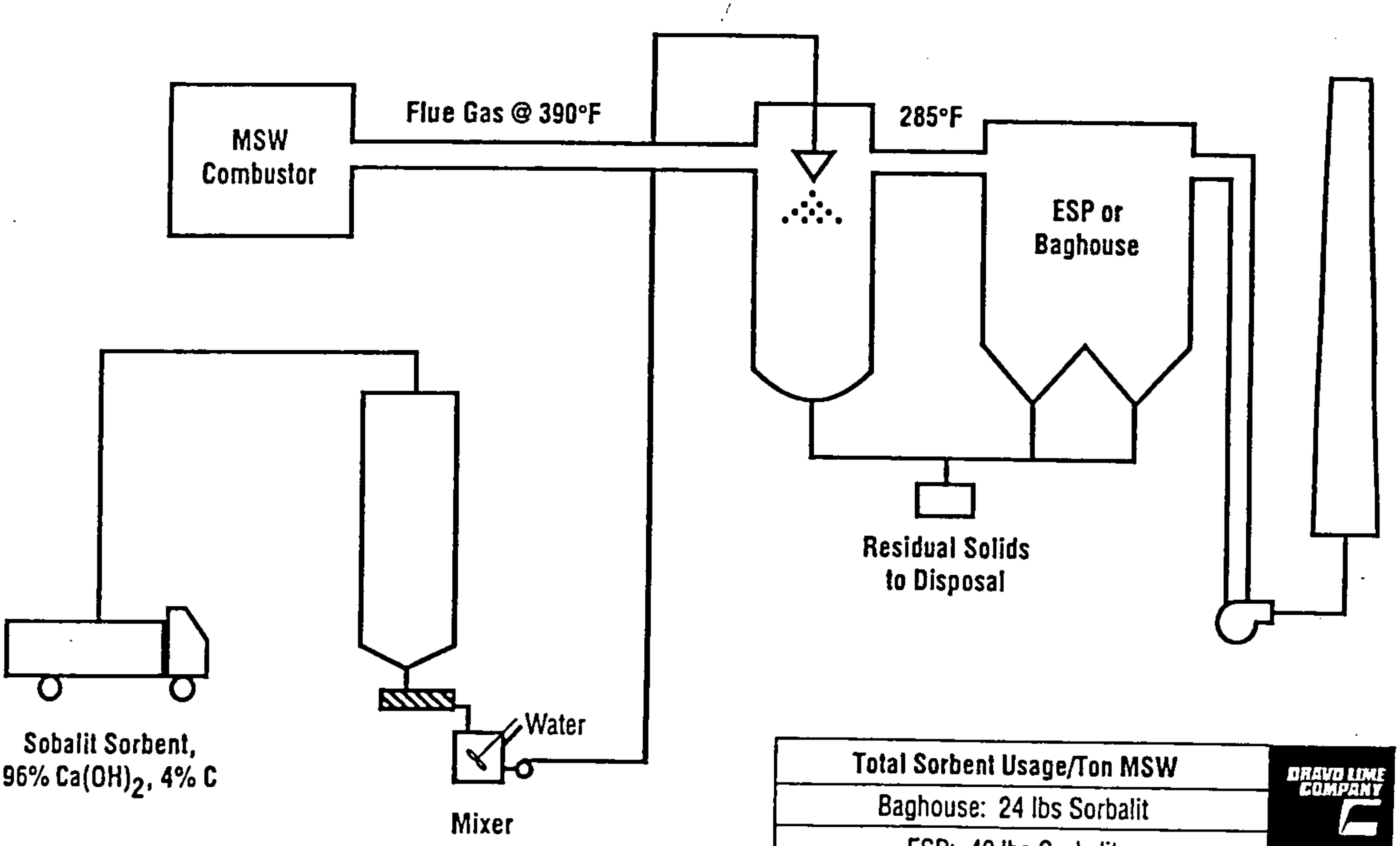
Name of Plant		Outlet Emissions [1]	
		Mercury μg/Nm^3	Dioxin ng/Nm^3
Waste-to-energy plant Gelselbullach	32.2	23	0.019
Waste incinerator Berlin-Ruhieban	56	40	0.06
Waste-to-energy plant Würtzburg	51.8	37	0.03
Hazardous waste incinerator Schöneiche	28	20	0.03
Hazardous waste incinerator Schweinfurt	56	40	0.06
MSW incinerator Marktoberndorf	37.8	27	0.06
MSW incinerator Zirndorf	<70	<50	0.05
Low temperature incinerator Ulm/Wieblingen	25.2	18	0.017
Low temperature incinerator Burgau	<70	<50	0.09
Aluminium plant Stockach	—		0.013
Cremetory Düsseldorf	—		0.03
Copper melting plant Hamburg	32.2	23	0.06

Note 1: Corrected to 11% O_2

Drawing 3.

SORBALIT Technology

Hydrated Lime/Carbon/Sulfur Blend, Spray Dryer Application

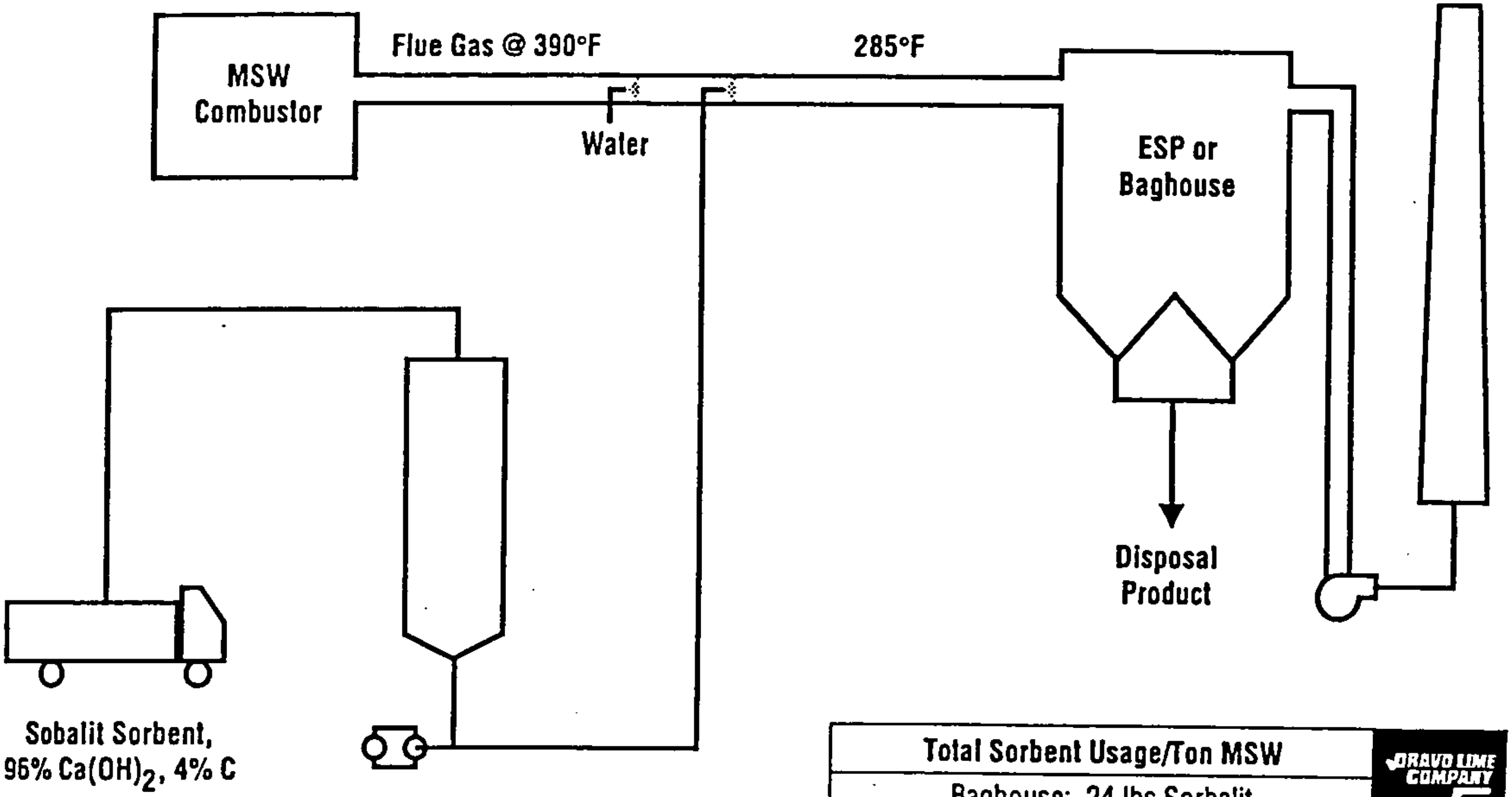


Total Sorbent Usage/Ton MSW
Baghouse: 24 lbs Sorbalit
ESP: 40 lbs Sorbalit

DRAVO LIME COMPANY

Drawing 2.

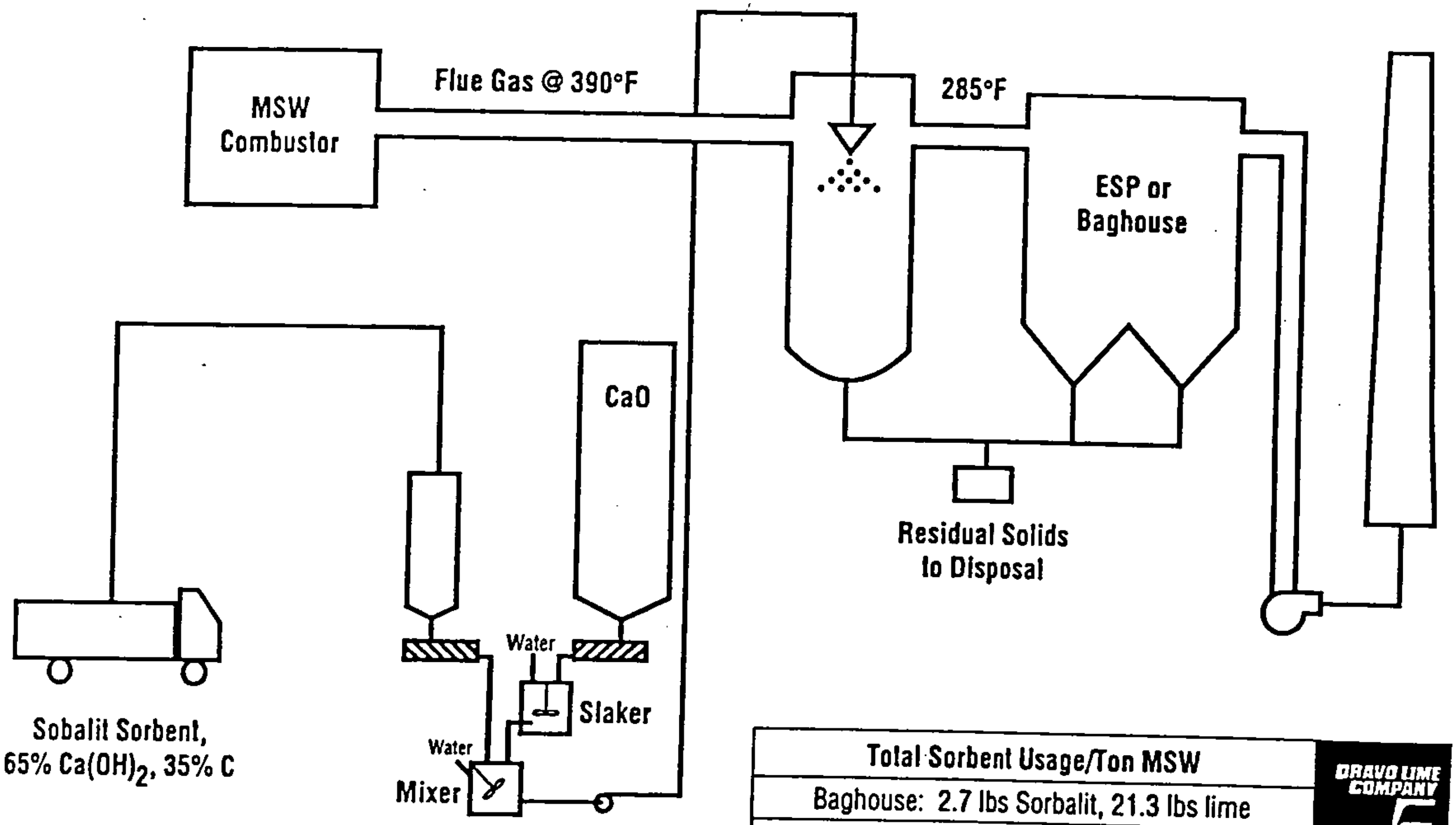
SORBALIT Technology Hydrated Lime/Carbon/Sulfur Blend, Conditioned Duct Injection Application



Total Sorbent Usage/Ton MSW
Baghouse: 24 lbs Sorbalit
ESP: 40-50 lbs Sorbalit

Drawing 5.

SORBALIT Technology 35% Carbon Concentrate/Sulfur Blend, Spray Dryer Application



Total Sorbent Usage/Ton MSW
Baghouse: 2.7 lbs Sorbalit, 21.3 lbs lime
ESP: 4.5 lbs Sorbalit, 35.5 lbs lime

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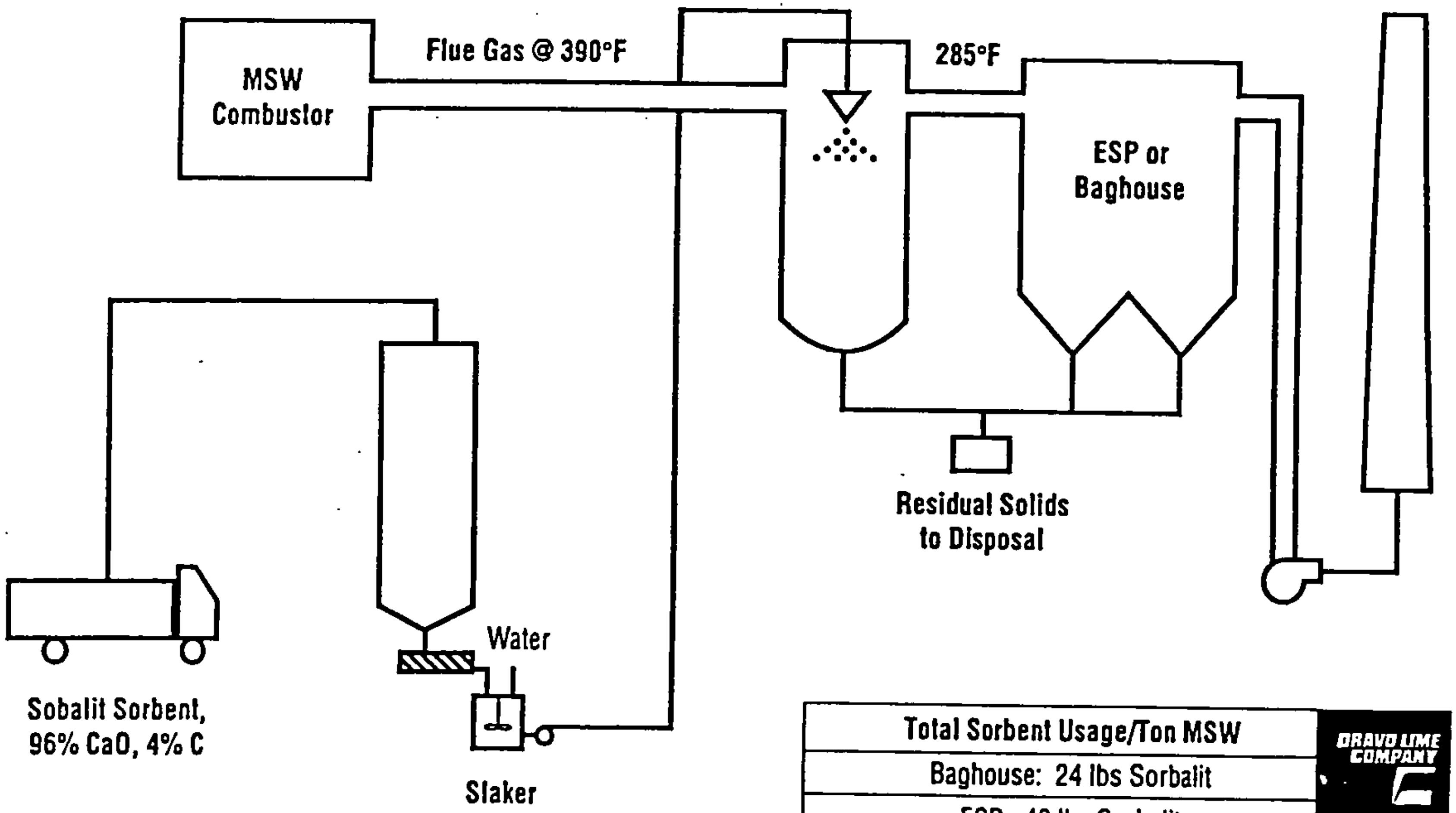
Drawing 4.

SORBALIT Technology

Quicklime/Carbon/Sulfur Blend, Spray Dryer Application



Total Sorbent Usage/Ton MSW
Baghouse: 24 lbs Sorbalit
ESP: 40 lbs Sorbalit

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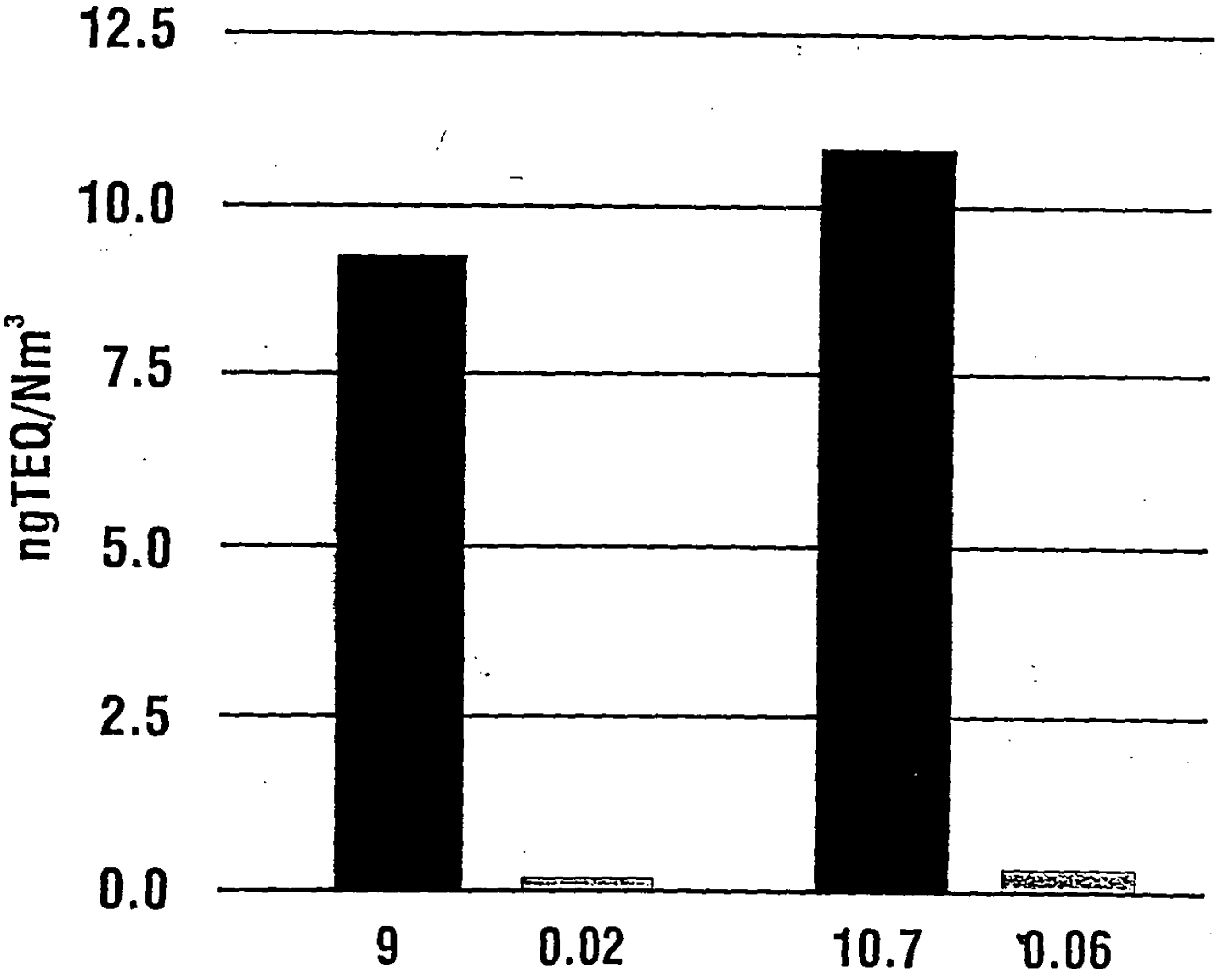
Figure 1: Würzburg

Dioxin Reduction



Untreated Gas ■

Post-Sorbalit Treatment ▨

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Figure 2: Würzburg

Mercury Reduction

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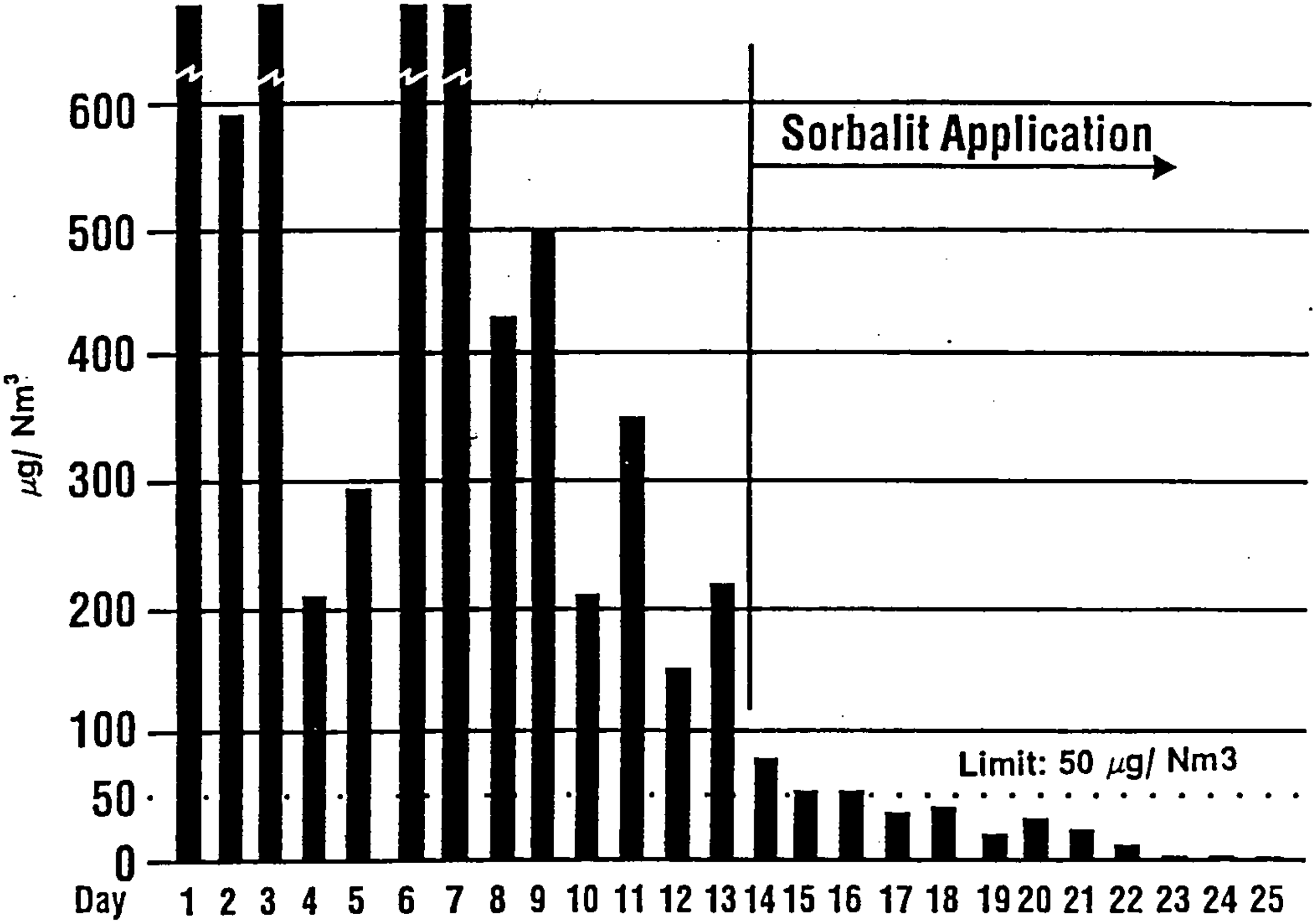

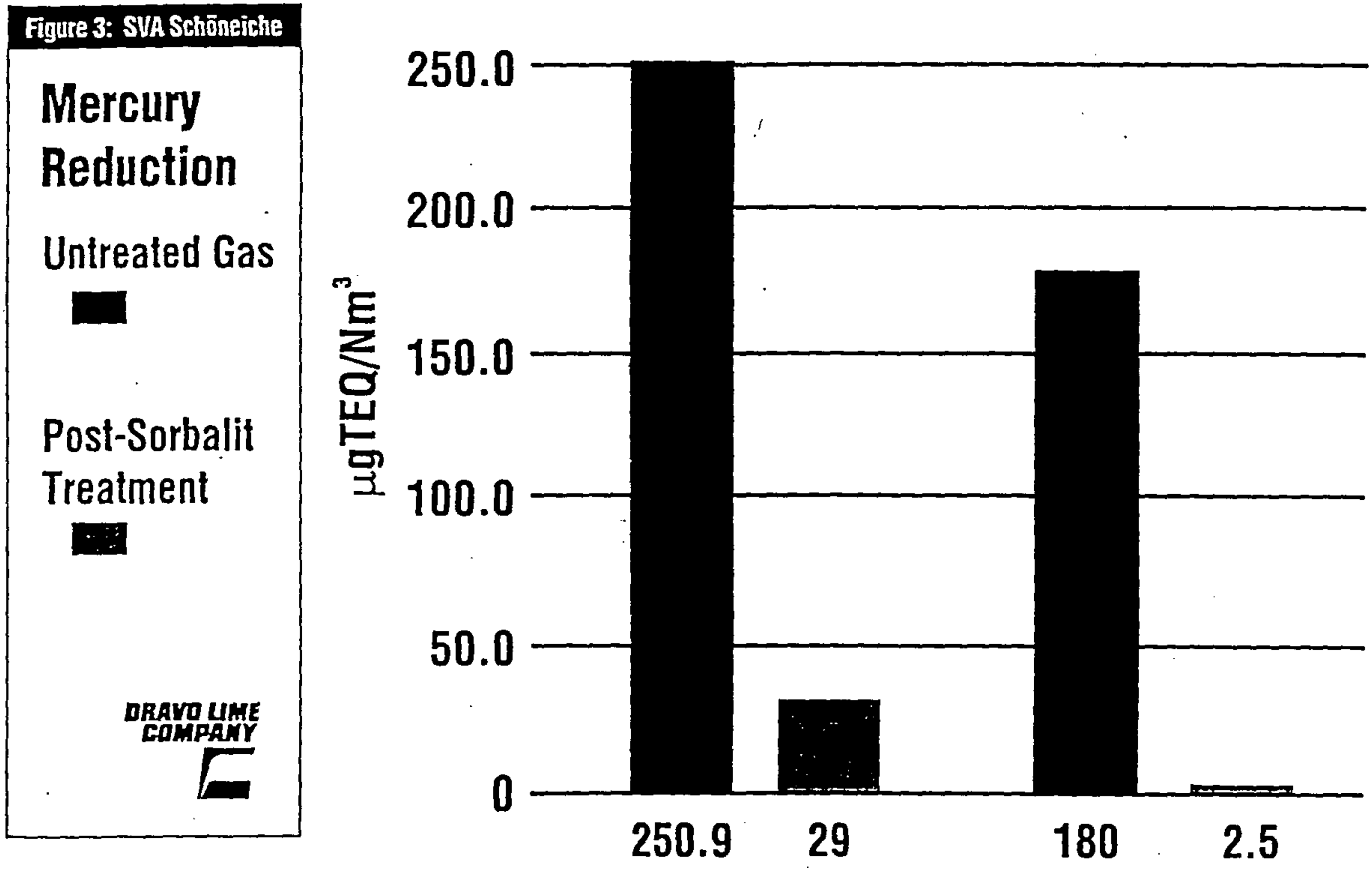
Figure 3: SVA Schöneiche

Mercury Reduction

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Figure 4: SVA Schöneiche

Dioxin Reduction

Untreated Gas
■

Post-Sorbalit Treatment
▨

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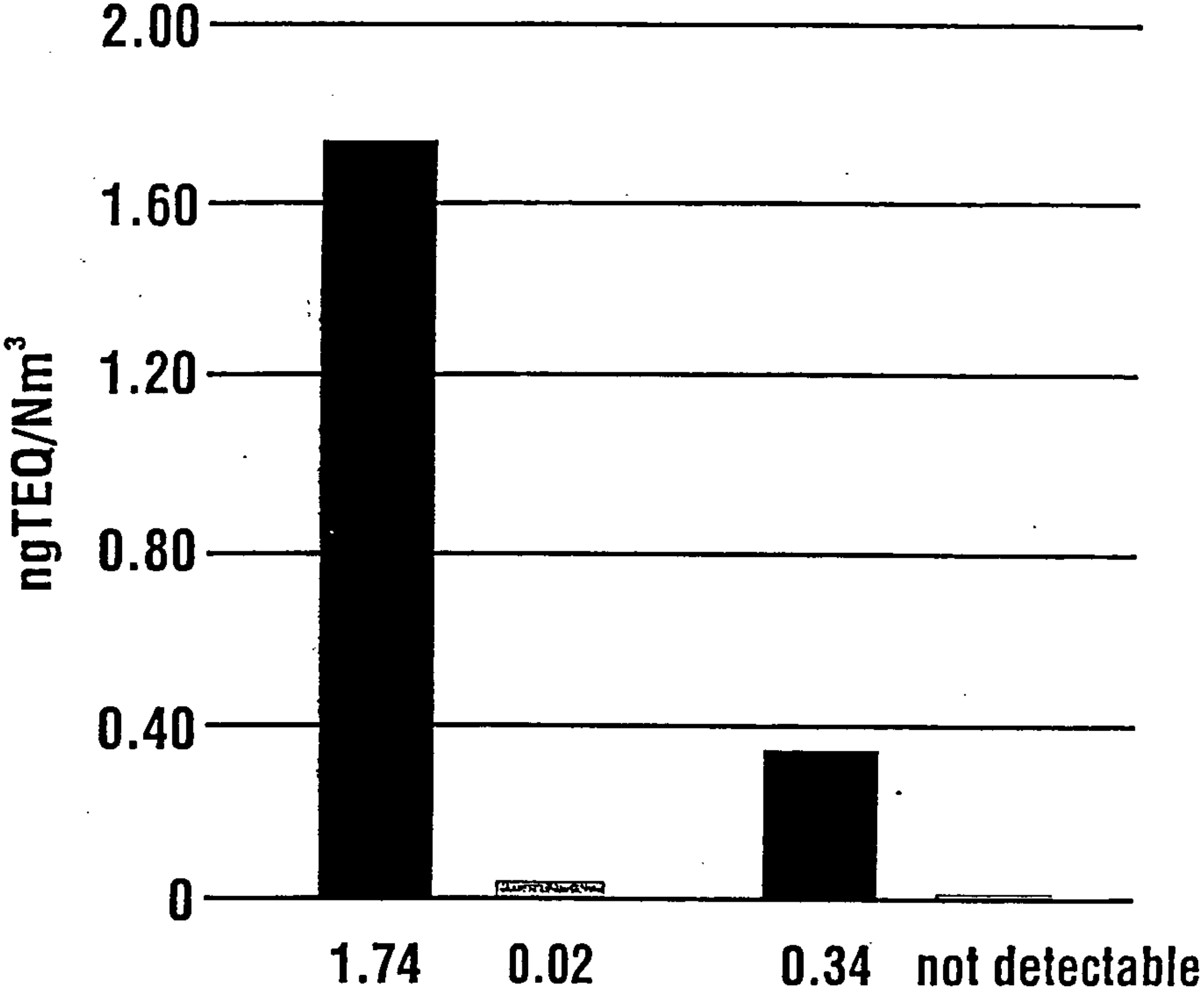

Figure 5: GSB Schweinfurt

Dioxin Reduction

Untreated Gas ■

Post-Sorbalit Treatment ▨

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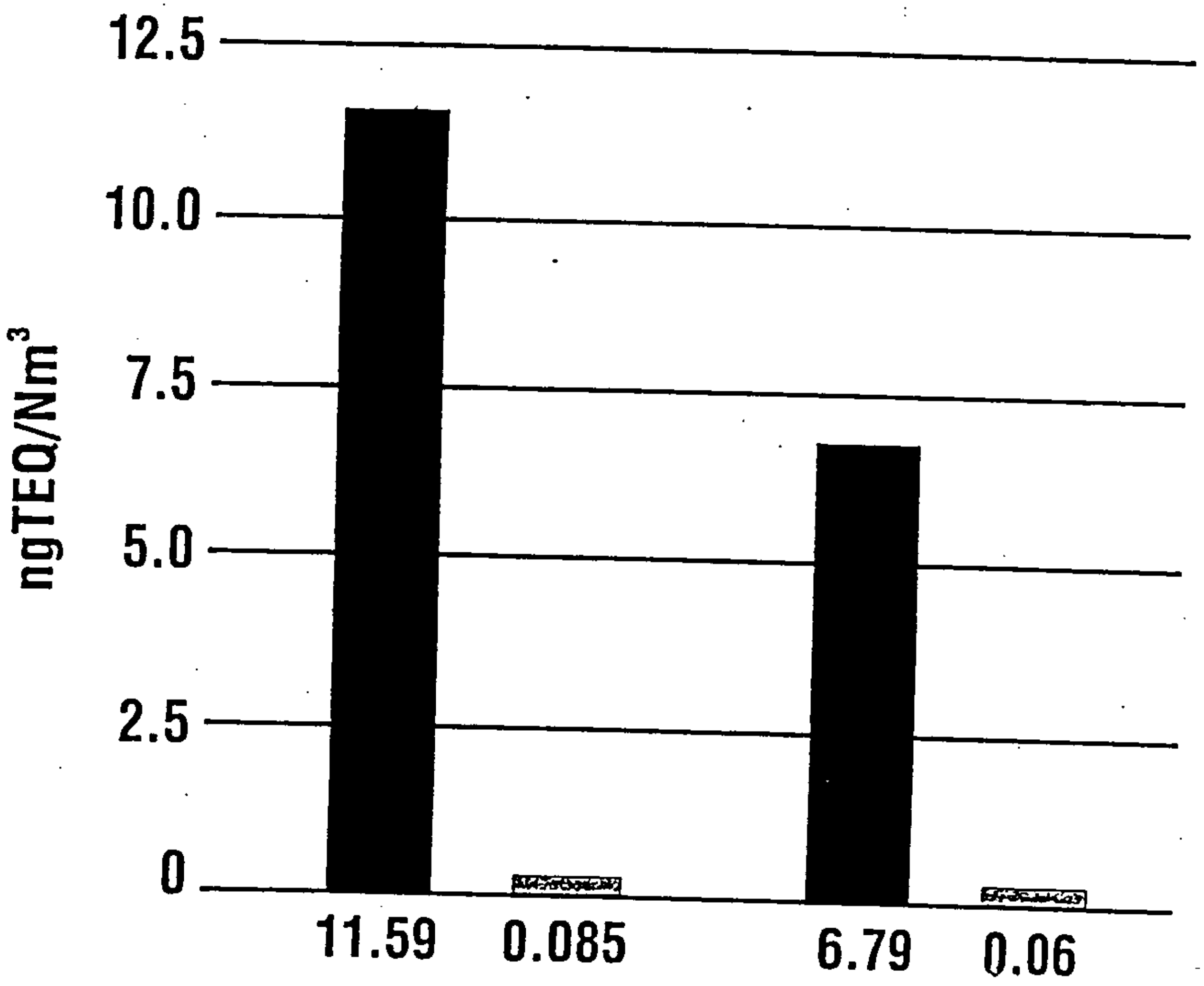

Figure 6: GSB Schweinfurt

Mercury Reduction

Untreated Gas

■

Post-Sorbalit Treatment

■

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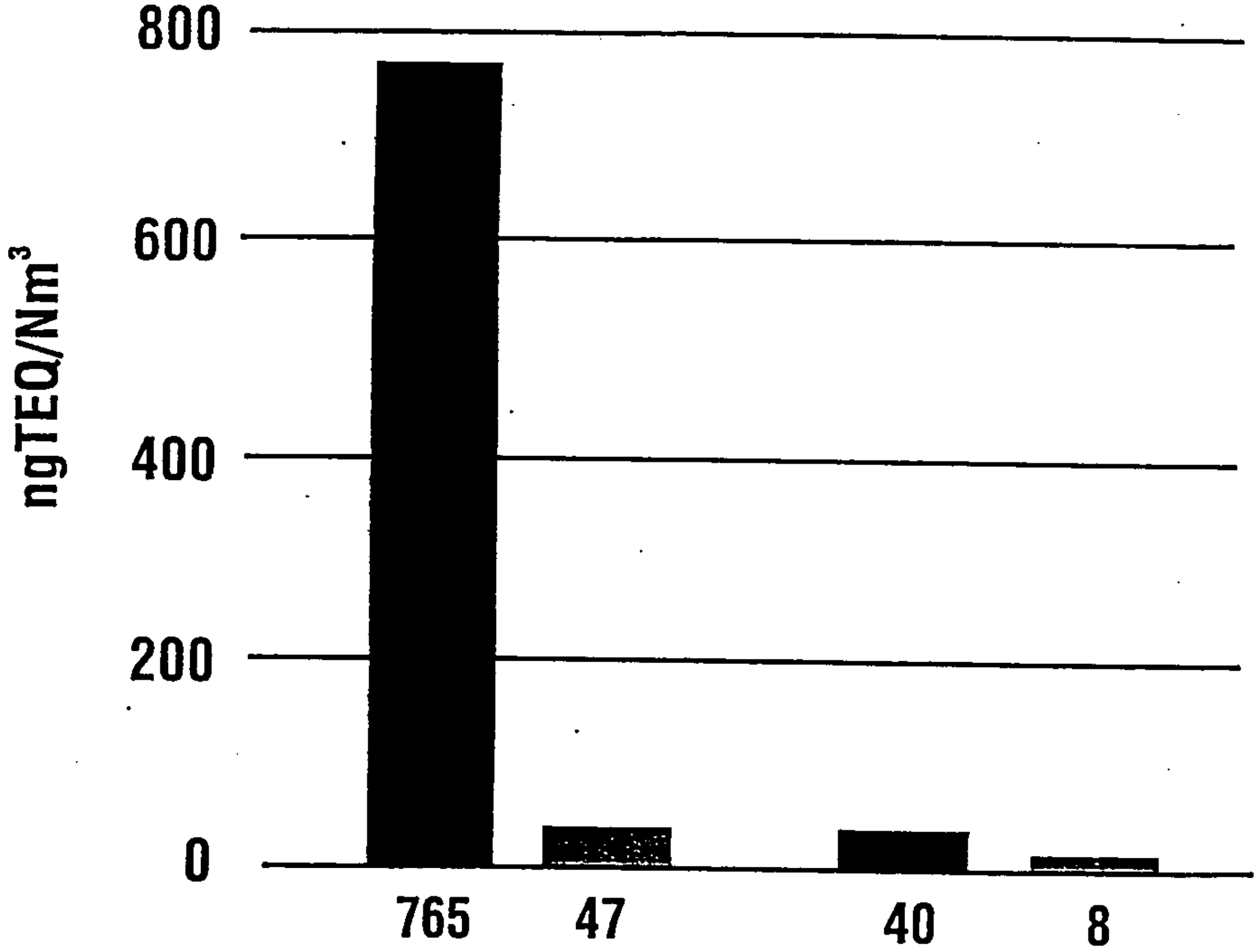


Figure 7

Mercury Removal (All Sorbalit Data)

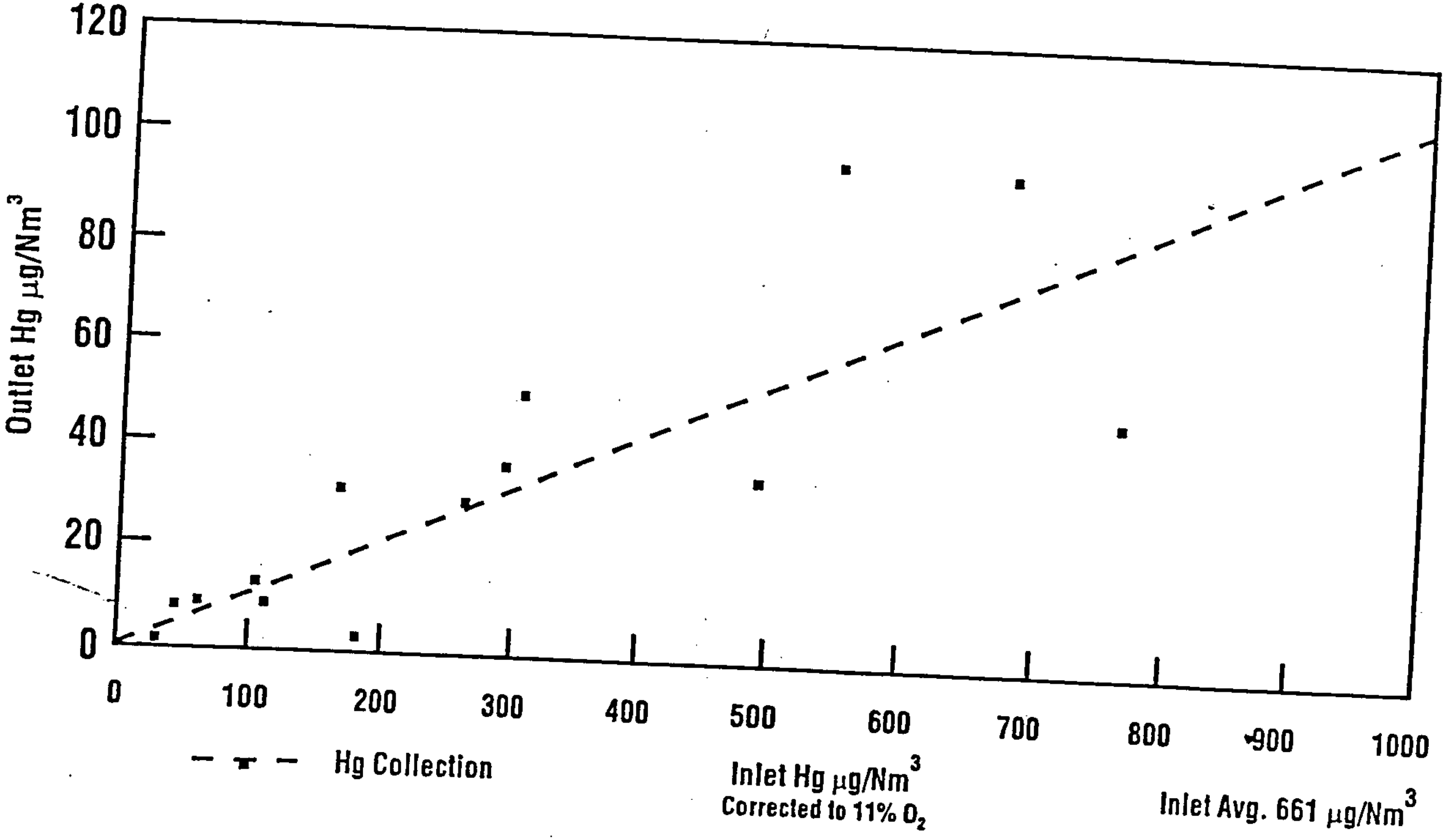
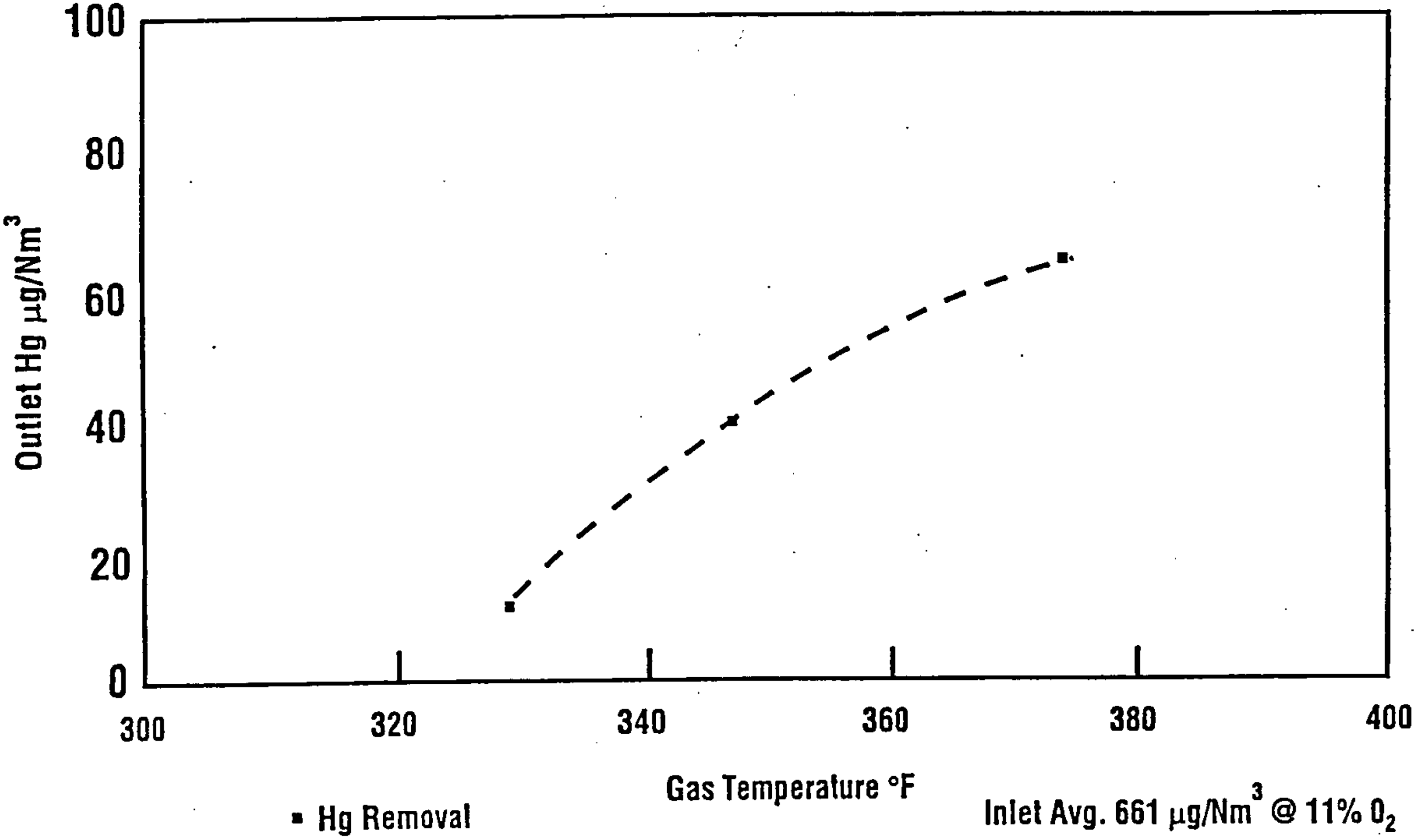


Figure 8

Effect of Temperature on Hg Removal (Sobalit — Dry Injection)



For Routing To Other Than The Addressee

To: ______________ Location: ______________
To: ______________ Location: ______________
To: ______________ Location: ______________
From: ______________ Date: ______________

State of Florida
DEPARTMENT OF ENVIRONMENTAL REGULATION

Interoffice Memorandum

FILE - PASCO RRF

TO: Preston Lewis

FROM: Bill Thomas

DATE: July 31, 1992

RE: **Pasco County Resource Recovery Facility Complaint**

The District has received and investigated numerous complaints from ~~Wayne~~ NATHAN & Susan Elko, 13623 Treaty Road, Spring Hill, FL 34610, telephone (813) 862-8193, regarding the Pasco facility. To date, no air pollution violations have been found. The facility is in compliance with the specific air emission limits and permit conditions. A stack test recently performed demonstrated compliance with the specific emission limits. The District performs inspections of the facility on a quarterly basis per the state's commitment.

For your information, the District has investigated complaints concerning health effects, reports of excessive visible emissions, odors, and medical and hazardous waste burning at the facility. The Division of Forestry and Pasco County have found and cited several illegal open burning activities in the area. The open burning of copper wire, garbage, and trash is frequently found in the area.

Our staff has had <u>lengthy</u> discussions with the Elkos. The county owned facility routinely offers tours to interested citizens and groups. Interested citizens or groups can contact the facility at (813) 856-2917.

SS/vsa

Elko

- Called MS. ELKO
And read letter to her
Inversion in past two weeks
- no air moving before 9:00 am different colors
early morning explosion - area

For Routing To Other Than The Addressee

To: ____________ Location: ____________
To: ____________ Location: ____________
To: ____________ Location: ____________
From: ____________ Date: ____________

State of Florida
DEPARTMENT OF ENVIRONMENTAL REGULATION

Interoffice Memorandum

RECEIVED
MAY 18 1992
Division of Air
Resources Management

TO: Barry D. Andrews, AIR BAR, Tallahassee

FROM: J. Harry Kerns, S.W. District Air, Tampa

DATE: May 13, 1992

SUBJECT: NOx Control at Waste to Energy Facilities

A citizen specifically asked the S.W. District Office to refer her question to the appropriate person in Tallahassee. The question is:

> Why does the Pasco County Resource Recovery Facility (waste-to-energy incinerator) not have NOx control (de-NOx) according to the Clean Air Act? Also, please answer the same question for the Hillsborough, Pinellas, and Lake County facilities.

This request is forwarded to you because your office handled the BACT analysis during the Site Certification process.

The citizen's name, address, and phone number are:

Ms. Susan Elko
13632 Treaty Road
Spring Hill, FL 34610

Phone (813) 862-8193

Barry, thank you for handling this citizen request.