DOE/MC/31160 - 5221
(DE96004496)

Particulate Hot Gas Stream Cleanup Technical Issues

Quarterly Report
January - March 1996

DISCLAIMER

May 1996

Work Performed Under Contract No.: DE-AC21-94MC31160

For
U.S. Department of Energy
Office of Fossil Energy
Morgantown Energy Technology Center
Morgantown, West Virginia

By
Southern Research Institute
2000 Ninth Avenue South
Birmingham, AL 35225-5305

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Morgantown Energy Technology Center
P.O. Box 880
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2000 Ninth Avenue South
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TABLE OF CONTENTS

EXECUTIVE SUMMARY

This is the sixth in a series of quarterly reports describing the activities performed under Contract No. DE-AC21-94MC31160. Our analyses of Hot Gas Stream Cleanup (HGCU) ashes and descriptions of filter performance address aspects of filter operation that are apparently linked to the characteristics of the collected ash or the performance of the ceramic barrier filter elements. Task 1 is designed to generate a data base of the key characteristics of ashes collected from operating advanced particle filters (APFs) and to relate these ash properties to the operation and performance of these filters. Task 2 concerns testing and failure analysis of ceramic filter elements.

Under Task 1 during the past quarter, we conducted tests to determine if small amounts of activated carbon or fumed silica powders could be used to condition PFBC or gasifier ashes. For some powders, it has been demonstrated that fine particles can be applied to the surface of the source powder so that the relatively large powder particles become coated with a layer of the fine conditioning particles. Fine conditioning particles present on the surfaces of the larger base line particles cause these larger particles to be farther apart from each other, decreasing the van der Waals attraction between them. If a layer of fine particles could be effectively deposited on the surface of highly cohesive PFBC and gasifier ashes, these ashes might become more free-flowing. Improved flowability would tend to make these ashes easier to remove from the filter vessel. The results we obtained in these experiments indicate that, depending on the particular characteristics of the ash and the additive, it is possible to use small amounts of a conditioning powder to reduce the apparent cohesivity of the ash. The degree to which this type of conditioning is effective is dependent on the physical characteristics of the conditioning powder and the source ash.

We also characterized the response of PFBC and gasification hopper ashes to mechanical compacting forces. As we have observed for other samples, compacting forces can significantly reduce the porosity of loosely deposited ashes. During filtration compacting forces equal to the pressure drop across the filter cake are applied to the ash layer collected on the surface of the barrier filter. Our permeability data indicate that the degree of compaction we noted in these tests would result in significantly increased pressure drop across the cake. This increased pressure drop would in turn cause further compaction.

During the past quarter we have designed the primary structure of the HGCU data base we are constructing in Microsoft Access®. The data base will contain a variety of information, including numerical values, short or long text entries, and photographs. Once this information has been entered, Access® will allow the user to compose various graphs and data presentations based on filtered and sorted groups of data. We have scanned in SEM photographs of the ashes in the data base and still images taken from the videotapes we made during our four site visits to the Tidd PFBC. In addition to measured ash characteristics, we intend to include background information related to the various facilities included in the data base, such as the participating organizations, the key operating personnel, process descriptions, photographs of the facility, and literature citations describing the work performed at the facility. This information will be assembled from various sources and entered in the Access® data base over the next few months. We plan to issue the HGCU data base as a run-time version of Microsoft Access® stored in a CD-ROM format. This format will be required since the final data base will contain quite a large number of photographic images that require significant storage space.

Task 2 efforts during the past quarter focused on the preparation of test specimens and tensile tests of two shipments of alumina-mullite material received from Blasch Precision Ceramics. Even with the utmost care, specimen breakage during machining and test fixture assembly was frequent for this material - an indication of low tensile strength. The material from both shipments contained regions of hard "beads" that often tore out during machining.

INTRODUCTION

This is the sixth quarterly report describing the activities performed under Contract No. DE-AC21-94MC31160. Task 1 of this contract concerns analyses of HGCU ashes and descriptions of filter performance that are designed to address the problems with filter operation linked to the characteristics of the collected ash. Task 2 of this contract includes characterization of new and used filter elements. Some of the problems observed at the Tidd and Karhula PFBC facilities include excessive filtering pressure drop, the formation of large, tenacious ash deposits within the filter vessel, and bent or broken candle filter elements. These problems have been attributed to ash characteristics, durability of the ceramic filter elements, and specific limitations of the filter design. In addition to these problems related to the characteristics of PFBC ashes, our laboratory characterizations of gasifier and carbonizer ashes have shown that these ashes also have characteristics that might negatively affect filtration. Problems with the durability of the filter elements are being addressed by the development and evaluation of elements constructed from alternative ceramic materials.

To identify which ash characteristics can lead to problems with filtration, we have assembled 235 ash samples from eleven facilities involved in METC's HGCU program. We have analyzed many of these ashes with a variety of laboratory tests. Physical attributes of the particles that we have examined include size distribution, specific surface area, particle morphology, and bulk ash cohesivity and permeability. We have also performed a range of chemical analyses on these ashes, as well as characterizations of agglomerates of ash removed from filter vessels at Tidd and Karhula. We are in the process of assembling the data obtained in these studies into an interactive data base which will help the manufacturers and operators of high-temperature barrier filters tailor their designs and operations to the specific characteristics of the ashes they are collecting.

In order to understand the thermal and mechanical behavior of the various types of ceramic materials used in hot gas filtration, we have been performing hoop and axial tensile tests, thermal expansion, compression, and creep evaluations of these materials at temperatures up to 1800 °F. Nondestructive testing methods we perform on filter specimens include density and ultrasonic velocity. To date we have evaluated various characteristics of Dupont/Lanxide PRD-66, Dupont composite, 3M composite, IF and P Fibrosics, Refractron, Schumacher, and Blasch alumina mullite materials.

OBJECTIVES

Task 1 has two primary objectives. The first is to generate a readily accessible data base of the key characteristics of ashes collected from operating advanced particle filters. The second objective is to relate these ash properties and the contents of the data base to the operation and performance of the advanced particle filters and filter components. The first objective includes formatting the data base and collecting, analyzing, and maintaining ashes from operating HGCU facilities. The second objective of this task involves the collection of operating histories from advanced particle filters, correlating these histories with ash characteristics, interpreting these correlations, and communicating our conclusions in the various venues prescribed by the U.S. Department of Energy's Morgantown Energy Technology Center (DOE/METC).

The objective of Task 2 is to develop an overall understanding of the thermal and mechanical behavior of hot gas filter materials. This objective includes the creation of a materials property data base which will allow the prediction of the behavior of these materials in hot gas cleanup environments. Pertinent tests will be carried out on specimens of unused filter material and also on filter elements that have been exposed in actual operating environments. Nondestructive test techniques will be applied to filter elements to characterize the strength and durability of these elements without rendering them unusable. This task will also evaluate the adequacy and completeness of manufacturers' quality assurance/quality control plans for manufactured filter elements.

TASK 1 RESEARCH ACTIVITIES

During the past quarter we performed a variety of analyses on the samples described in Table 1 and also began developing the detailed structure of the HGCU data base in Microsoft Access®.

Table 1
Ash Samples from the HGCU Data Base Characterized during the Past Quarter

ID #	Source	Brief description
4049	Tidd	Advanced Particulate Filter (APF) hopper ash
4170	DOE/METC	modular gas cleanup rig (MGCR) pilot-scale gasifier hopper ash
2562	KRW	TP-037-9: C-121 hopper ash (4/28/88)

ADDITIVE CONDITIONING TESTS

Our first tests during this past quarter were designed to determine if small amounts of powders with very fine size distributions could be used to condition PFBC or gasifier ashes. For some powders, it has been demonstrated that the addition of less than 5 % by weight of very fine particles to the powder can cause the relatively large powder particles to become coated with a layer of the fine conditioning particles. Fine conditioning particles present on the surfaces of the larger base line particles cause these larger particles to be farther apart from each other, decreasing the van der Waals attraction between them. If a layer of fine particles could be effectively deposited on the surface of highly cohesive PFBC and gasifier ashes, these ashes might become more free-flowing. Improved flowability would tend to make these ashes easier to remove from the filter vessel.

Tidd APF hopper ash (ID # 4049) and DOE/METC MGCR hopper ash (ID # 4170) were mixed with two additives (activated carbon and fumed silica). The activated carbon powder we tested is a lignite-based commercial product known by the trade name Darco FGD, and was manufactured by Norit Americas, Inc. The amorphous fumed silica we used in these tests was manufactured by the Cabot Corporation, and goes by the trade name Cab-O-Sil grade EH-5. The basic properties of these additives are summarized in Table 2. To prepare the mixtures for testing, small amounts of additive were added to a container of hopper ash and the container was shaken thoroughly for two minutes. Mixtures were produced with 2.0 and 5.0 % by weight of additive. The results of the uncompacted bulk porosity (UBP) and tensile strength tests we performed on these mixtures are presented in Table 3. (Measurements of uncompacted bulk porosity and tensile strength indicate relative cohesivity, but they do not provide a direct measurement of ash cohesivity.)

Table 2
Characteristics of Additives Used to Condition HGCU Hopper Ashes

quantity	fumed silica	activated carbon
specific surface area, m^2/g	380*	395
uncompacted bulk porosity, %	NM	86.8
Stokes' MMD, µm	0.007**	19
drag-equivalent diameter, µm	NM	0.588
specific gas flow resistance, in $H_2O\cdot min\cdot ft/lb$	NM	15
tensile strength, N/m^2	NM	4.5
true particle density, g/cm^3	2.2	2.06

* value reported by Cabot Corporation

** value reported by Cabot Corporation (calculated from specific surface area data assuming monodisperse, smooth, spherical particles)

NM = not measured

Table 3
Uncompacted Bulk Porosities of Mixtures of Hopper Ashes and Conditioning Additives

Source hopper ash	additive	% wt. additive	UBP, %	tensile strength, N/m^2
DOE/METC (ID # 4170)	none	0.0	97.0*	0.2**
DOE/METC (ID # 4170)	fumed silica	2.0	97.3	0.1
DOE/METC (ID # 4170)	fumed silica	5.0	97.4	0.3
DOE/METC (ID # 4170)	activated carbon	2.0	97.6	0.3
DOE/METC (ID # 4170)	activated carbon	5.0	96.9	0.4
Tidd APF (ID # 4049)	none	0.0	89.6	5.1
Tidd APF (ID # 4049)	fumed silica	2.0	88.4	4.9
Tidd APF (ID # 4049)	fumed silica	5.0	90.1	3.4
Tidd APF (ID # 4049)	activated carbon	2.0	89.0	8.0
Tidd APF (ID # 4049)	activated carbon	5.0	87.3	9.0

* This value replaces the value of 94 %, which was reported in our last quarterly report.

** This value replaces the value of 0.6 N/m^2, which was reported in our last quarterly report.

The results shown in Table 3 indicate that the only significant effect of these conditioning agents was for the Tidd hopper ash (ID # 4049) mixed with the activated carbon. Although the addition of fumed silica to the Tidd hopper ash (ID # 4049) and the DOE/METC gasification char (ID # 4170) resulted in somewhat different values of tensile strength for these mixtures, these differences can probably be attributed to uncertainties in the measurement procedure. The addition of activated carbon to the DOE/METC gasification char (ID # 4170) also modified the tensile strength of the char, although measurement uncertainties probably also make these small measured changes unreliable.

We attribute the apparent reduction in cohesivity of the Tidd APF hopper ash (ID # 4049) after the addition of the activated carbon to the increased separation distance between the hopper ash particles according to the mechanism described at the beginning of this discussion. The effectiveness of this type of conditioning may be limited by the proportion of submicron particles already present in the ash to be conditioned. Conditioning may also be limited by the basic morphology of the particles in the ash to be conditioned. Either the presence of a large proportion of submicron particles or rough, irregular particle surfaces may serve to separate the primary ash particles prior to the addition of any conditioning agent. The results we obtained in these experiments indicate that, depending on the particular characteristics of the ash and the additive, it is possible to use small amounts of a conditioning powder to reduce the apparent cohesivity of the ash. The degree to which this type of conditioning is effective is dependent on the physical characteristics of the conditioning powder and the source ash. These experiments, which were conducted at ambient conditions, should not be extrapolated to typical HGCU conditions because it has been shown that HGCU filter vessel temperatures can alter the physical characteristics of the ash particles (e.g. eutectic formation in the Tidd PFBC).

UPDATED ANALYSES OF DOE/METC MGCR HOPPER ASH

In the conditioning tests described above, we repeated our measurement of the uncompacted bulk porosity of the sample of ash from the MGCR facility located at DOE/METC. This new value of uncompacted bulk porosity (97 %) also affects the specific gas flow resistance associated with this ash. Based on the measurements we performed this quarter, the specific flow resistance of this ash is 18 in $H_2O \cdot min \cdot ft/lb$. This value is much lower than the value we reported earlier of 101 in $H_2O \cdot min \cdot ft/lb$ associated with a estimated dustcake porosity (or uncompacted bulk porosity) of 94 %. This apparent reduction in specific gas flow resistance does not affect the ability of this ash to cause extremely high filtering pressure drops. If a filter cake composed of this ash is allowed to compact to around 90 % porosity, specific gas flow resistances around 400 in $H_2O \cdot min \cdot ft/lb$ could be expected.

ASH COMPACTION TESTS

We also characterized the response of the Tidd APF hopper ash (ID # 4049) and KRW hopper ash (ID # 2562) to compacting forces. The compaction data, which we measured at room temperature for these two ashes, are presented in Figures 1 and 2. These data were obtained with a compaction device marketed by Jenike and Johansen Inc. The test procedure involves filling an open-topped cylinder with uncompacted ash and then gradually applying load to the top surface of the ash by adding weights to a circular plate placed on top of the ash sample. The circular plate acts as a loose fitting piston to transfer the applied load directly to the ash sample. A depth gauge is used to measure the height of

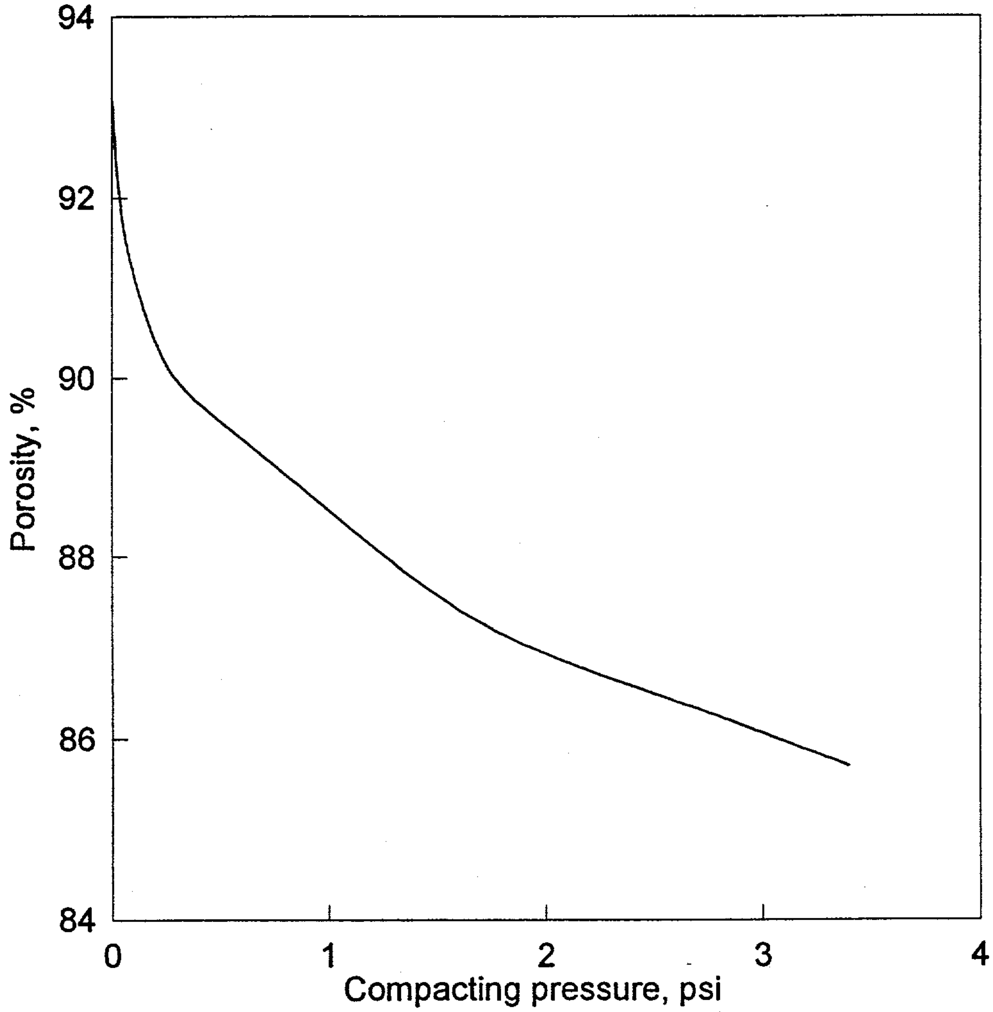

Figure 1. Data measured for the KRW gasification hopper ash (ID # 2562) showing the dependence of cake porosity on mechanical pressure applied across the cake.

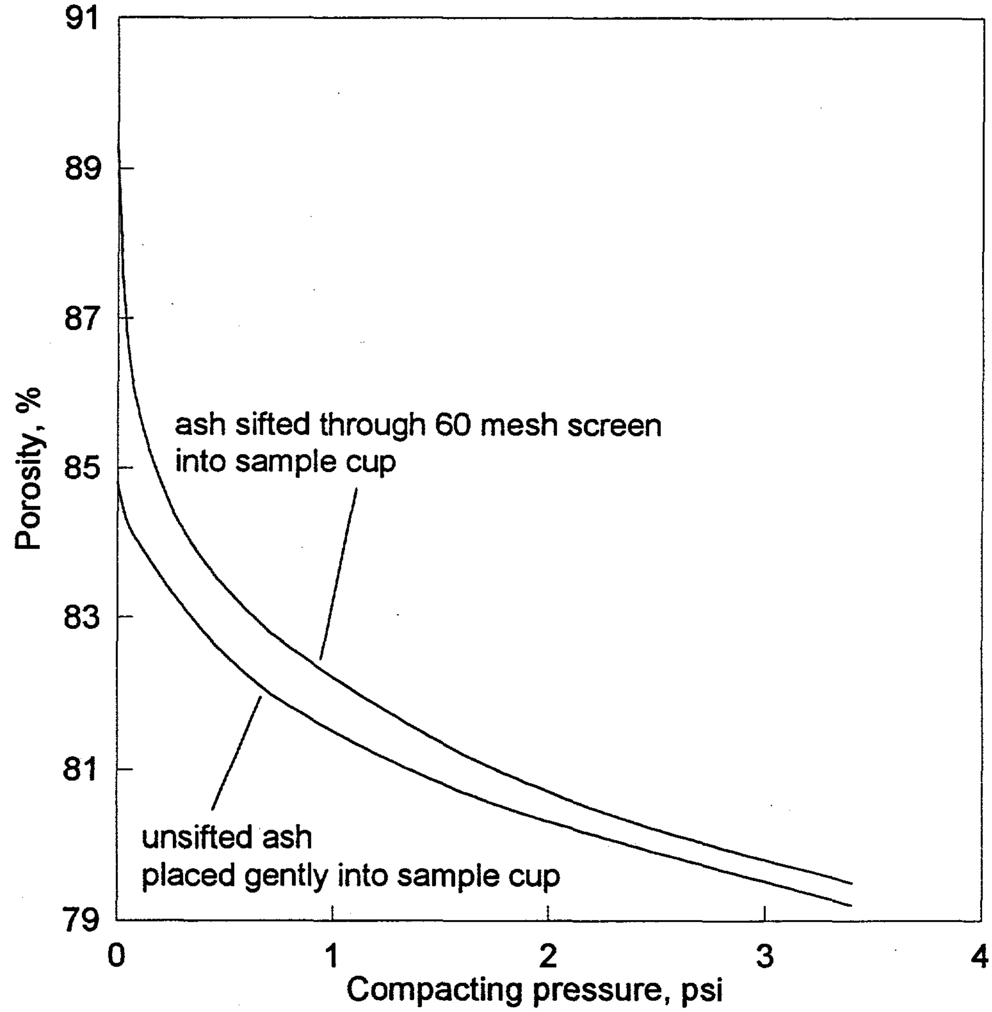

Figure 2. Data measured for the Tidd APF hopper ash (ID # 4049) showing the dependence of cake porosity on mechanical pressure applied across the cake. The procedures used to load the sample container caused initial differences in the porosity of the sample prior to compaction. As compacting pressure increased, the differences in porosity due to the different loading procedures diminish.

the ash sample as it decreases with increasing applied load. The data in Figure 1 show that a filtering pressure drop of 3.4 psi (94 in. H_2O) may be sufficient to reduce the porosity of a filter cake formed from the KRW hopper ash (ID # 2562) from around 93 % to a porosity of about 86 %. (This change is equivalent to compacting the filter cake into half its original thickness.) As with the DOE/METC MGCR hopper ash, any reduction in filter cake porosity would cause a significant increase in specific gas flow resistance.

In Figure 2, we have shown the effects of compacting pressure on samples of Tidd APF hopper ash (ID # 4049) prepared in two different ways. In the first trial, we loaded unsifted ash into the sample cup used in these tests as gently as we could with a small spoon. This procedure resulted in a porosity of about 85 % for the ash in the cup. In the second trial, we sifted the ash into the cup as we do in our measurements of uncompacted bulk porosity. This technique resulted in the ash filling the sample cup with a porosity of around 89 %. Although these two loading methods generated different initial conditions for the compaction tests, the porosities of the two samples converged as the compacting forces increased. These data support the contention that filter cakes and passively deposited ash that are originally deposited in HGCU filters are very fragile and very susceptible to compacting forces. Regardless of the procedure used to load the ash into the sample cup, the data in Figure 2 indicate that filtering pressure drop can be expected to exert a strong compacting force on PFBC filter cakes.

HGCU DATA BASE DEVELOPMENT

During the past quarter we have designed the primary structure of the HGCU data base we are constructing in Microsoft Access®. The data base comprises a collection of interrelated tables. The arrangement of the tables we have placed in the data base is shown in Figure 3. These tables can contain a variety of information, including numerical values, short or long text entries, and photographs. Once this information has been entered in the appropriate tables, Access® will allow the user to compose various graphs and data presentations based on filtered and sorted groups of data.

We have scanned in SEM photographs of the ashes in the data base and still images taken from the videotapes we made during our four site visits to the Tidd PFBC. In addition to measured ash characteristics, we intend to include background information related to the various facilities included in the data base, such as the participating organizations, the key operating personnel, process descriptions, photographs of the facility, and literature citations describing the work performed at the facility. This information will be assembled from various sources and entered in the Access® data base over the next few months.

We are designing a variety of summary reports that the user of this data base will be able to view and print. In Access®, a report is a formatted output that results from running specific queries within the data base structure. We will write the queries required to select and sort the information in the data base. Generally, the user will interact with the data base through various report forms that we will construct. Although our work on these

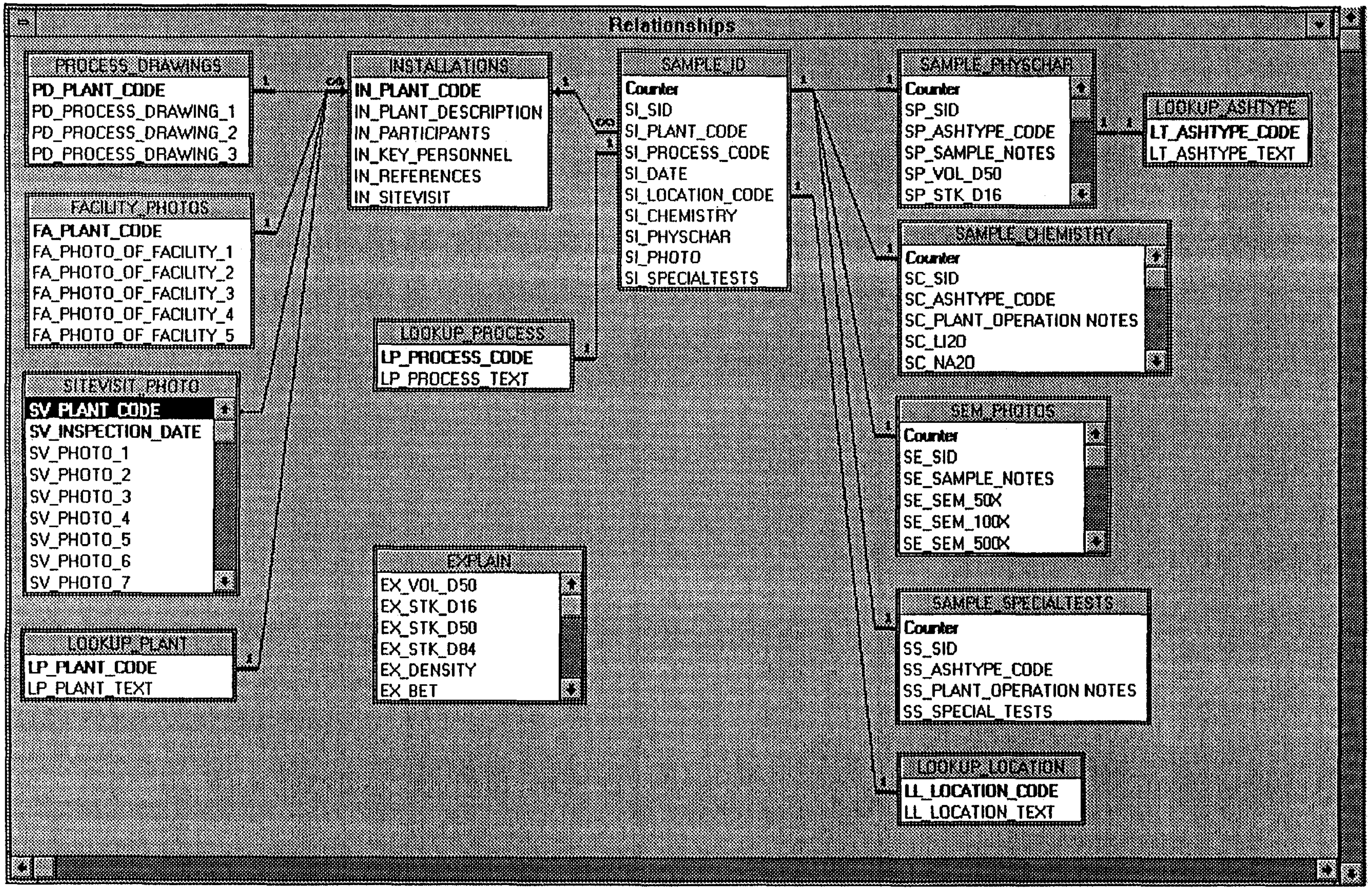

Figure 3. This diagram shows the relationships between the tables that will hold the data and information we enter in the HGCU data base. When the data base is complete, this display and the structure it represents will not be visible to the end user.

reports is still under way, we have presented in Figures 4, 5, and 6 simulations of three of the formatted reports we expect to include in the data base. From the report shown in Figure 4, the user selects what type of data about the Tidd PFBC facility he wishes to examine. By selecting "On-Site Inspections of Filter" from the menu, the user may end up (after selecting a specific operating period or type of system operation) viewing the report shown in Figure 5. When the user wishes to examine the variety of characteristics that have been measured for a particular ash sample, he will view those characteristics on a summary report like the one shown in Figure 6. (The format of the three reports shown in Figures 4 - 6 may be altered somewhat during further development of the data base.) We plan to issue the HGCU data base as a run-time version of Microsoft Access® stored in a CD-ROM format. This format will be required since the final data base will contain quite a large number of photographic images that require significant storage space.

SOLICITATION OF SAMPLES

We have been in communication with three individuals at Destec Energy, Inc. about the possibility of obtaining ash samples from their Louisiana Gasification Technology Inc. gasifier. If Destec Energy is willing to supply some samples for analysis, we hope to also receive some descriptions of system operation corresponding to the samples we receive. Our efforts to secure ash samples from this facility will continue during the next quarter.

Kumar Sellakumar of Ahlstrom Pyropower is in the process of obtaining a variety of ash samples from the Karhula PFBC facility. In conversations with him, he has stated that when he receives these samples, he will forward a portion of the samples to Southern Research Institute. We have provided him with sample information forms which will hopefully be completed and returned with the shipment of ash samples. Analyses of these samples will commence as soon as they arrive at our laboratories.

Tidd PFBC

- ☐ Participating Organizations
- ☐ Key Personnel
- ☐ Brief Description of Process
- ☐ Process Drawings / Schematics
- ☐ Photographs of Facility
- ☐ Technical References
- ☐ On-Site Inspections of Filter
- ☐ Analyses of Ash Samples

☐ Return to Prior Display

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Contract No. DE-AC21-94MC31160
T.P. Dorchak, DOE Project Manager
prepared by Southern Research Institute

Figure 4. A simulated output report from the HGCU data base. This report will allow the user to select from several types of information about the Tidd PFBC facility that we have included in the data base.

Tidd candle filter
assembly
May 5, 1994

Strong, well consolidated deposits of ash formed on the plenum support conduits and extended over much of the surface of the ash sheds. These deposits formed as a result of turbulent diffusion and entrapment of agglomerates of ash that had fallen from the candle surfaces and the tubesheet above. Most of the filter elements in the inner ring of candles in the top two plenum assemblies were enveloped by these deposits. Many of the candles in this region were bent away from the plenum support conduits by the pressure exerted on them by the weight of these deposits.

☐ Additional Related Photographs

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Contract No. DE-AC21-94MC31160
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Figure 5. A simulated output report from the HGCU data base. This report presents a still image from one of the videotapes made at the Tidd PFBC. After examining this image and the attached information, the user will be allowed to view additional related images, or to return to the previous display that allowed him to select this report.

Summary of Ash Analyses

Plant	Tidd
process notes	cyclone active
location	filter cake
date	9-30-93
type sample	nodule
tracking ID#	4012

Physical Characteristics		
Volumetric D_{50}	NM	μm
Stokes D_{16}	NM	μm
Stokes D_{50}	3.8	μm
Stokes D_{84}	NM	μm
Density	2.90	g/cm^3
BET specific surface area	3.0	m^2/g
Uncompacted bulk porosity	92	%
Morphology factor	NM	*
Drag-equivalent diameter	0.85	μm
Specific gas flow resistance	1.9	in H_2O·min·ft/lb
Tensile strength	NM	N/m^2

NM = not measured

* dimensionless

Chemical Characteristics, % wt	
Li_2O	NM
Na_2O	0.27
K_2O	1.77
MgO	7.96
CaO	13.67
Fe_2O_3	5.63
Al_2O_3	13.63
SiO_2	22.89
TiO_2	0.07
P_2O_5	0.1
SO_3	31.38
LOI	1.84
soluble $SO_4^{=}$	40.2
Equilibrium pH*	NM

☐ View SEM Photographs of this Sample
☐ Review Special Analyses Performed on this Sample
☐ Return to Prior Display

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Figure 6. A simulated output report from the HGCU data base. This report summarizes the measured characteristics of a specific ash sample. The options at the bottom of the report allow the user to examine SEM photographs of this sample, read about special analyses performed on this sample, or return to the previous display that allowed him to select this report.

TASK 2 RESEARCH ACTIVITIES

Alumina-mullite material was received from Blasch Precision Ceramics in the form of 0.5"x 0.5" square blanks. The blanks were machined to the tensile configuration shown in Figure 7. Even with the utmost care, specimen breakage during machining and test fixture assembly was frequent - an indication of low tensile strength. The material contained regions of hard "beads" that would tear out during machining. The individual data are given in Table 4 and the average properties are shown in Table 5.

A second shipment of the alumina-mullite materials was received. This batch consisted of material from billets 4-270 and 4-300, plus billets 5-270 and 5-242 which had 10% SiC. The blanks were larger - 1.0" x 1.0" square, so larger, easier-to-handle specimens were removed. The tensile configuration is given in Figure 8. The material is now being evaluated. The individual data are given in Table 6 and the average data are presented in Tables 7 and 8.

The strength and modulus from billets 4-270 and 4-300 of the second shipment do not appear to be as high as that of the first. The material from the second shipment also contained regions of hard "beads" that would tear out during machining. However, the beads appeared larger.

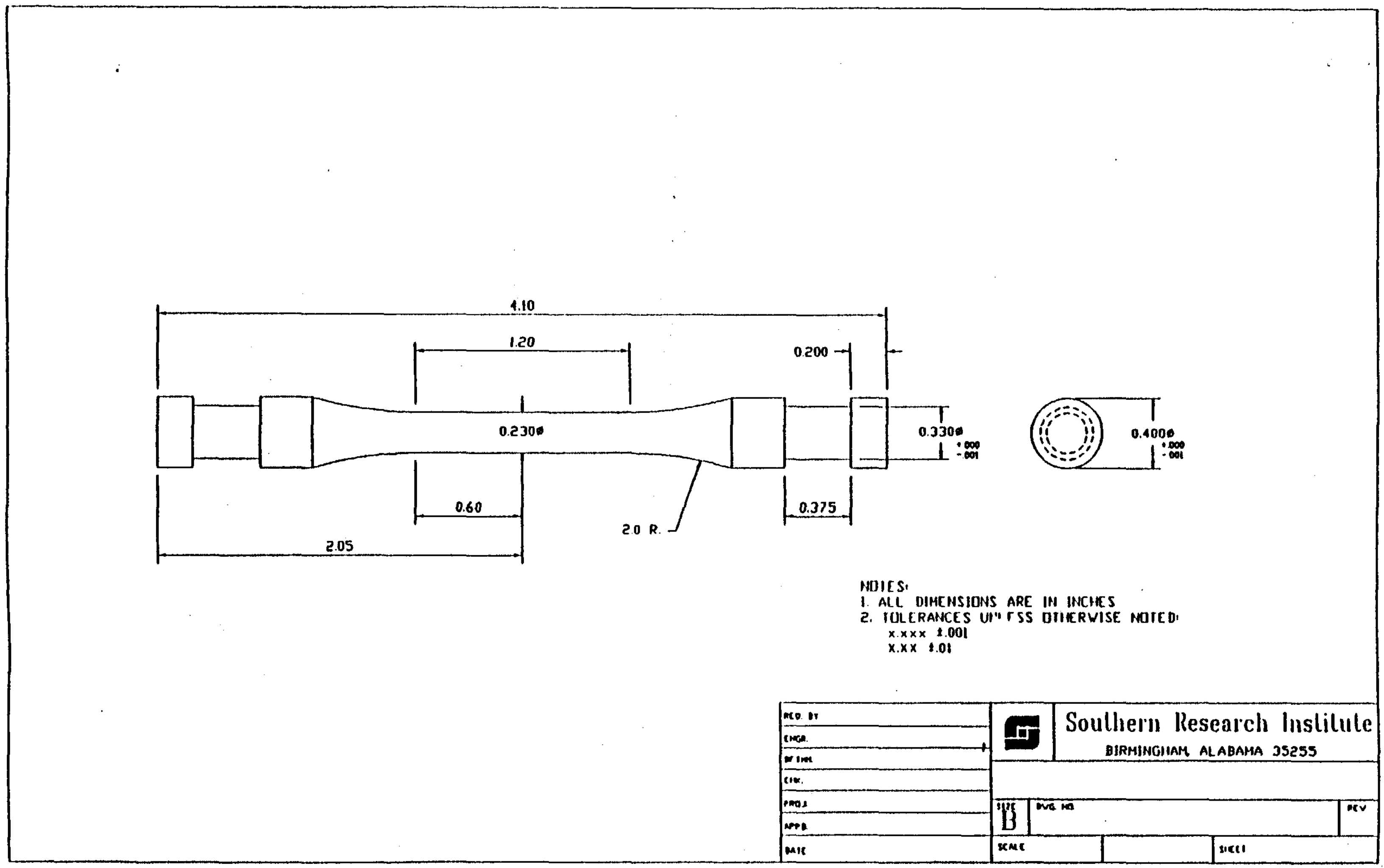

Figure 7. Specifications used to machine samples from the first shipment of Blasch alumina mullite material to the configuration required for tensile tests.

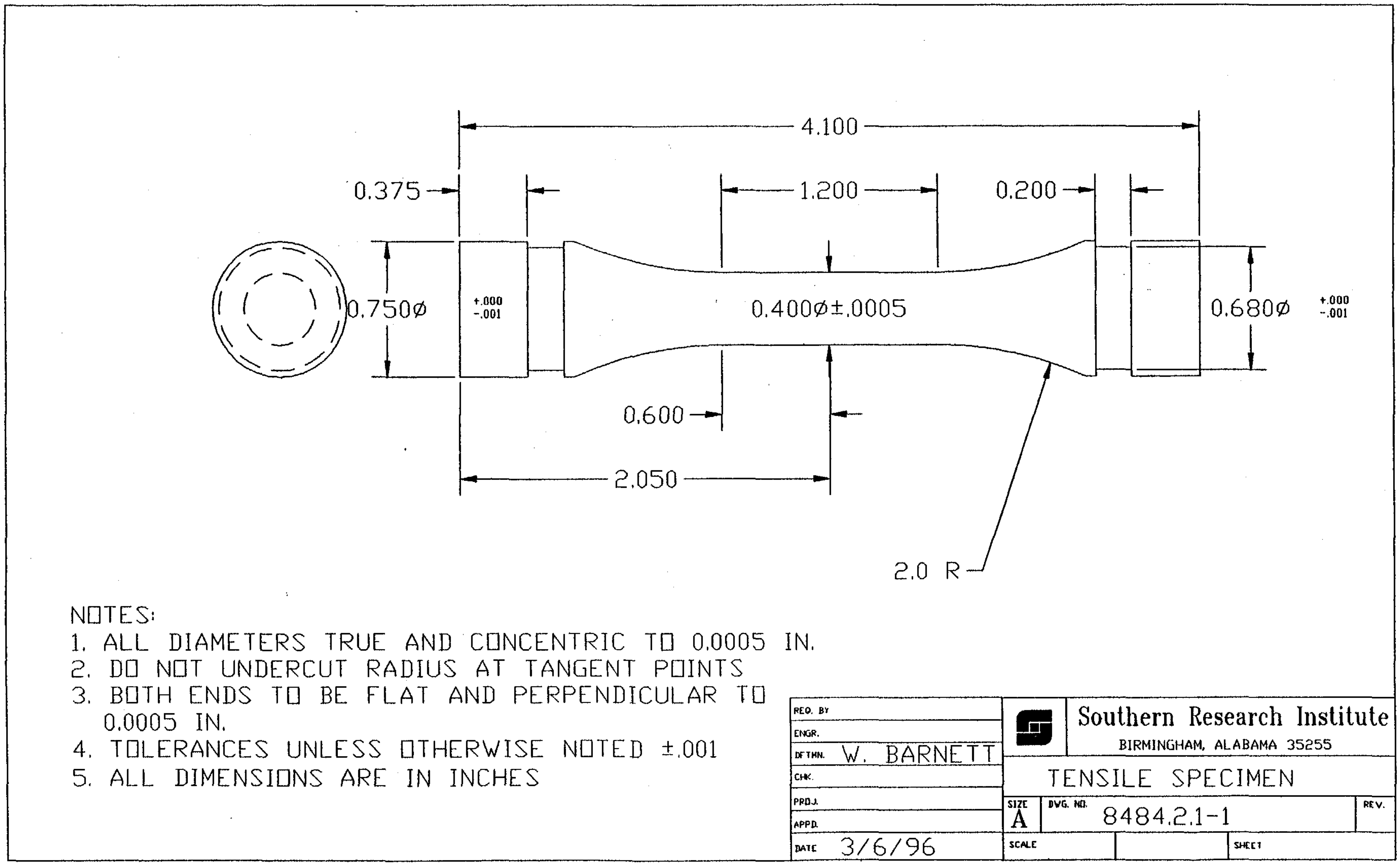

Figure 8. Specifications used to machine samples from the second shipment of Blasch alumina mullite material to the configuration required for tensile tests.

Table 4
Tensile Properties of Blasch Alumina Mullite Material (First Shipment)

Billet	Specimen #	Temp., °F	Ultimate strength, psi	Modulus, Msi	Strain-to-failure, in./in.	Remarks
4-270	TN-2	70				broken in assembly
4-270	TN-3	70				broken in assembly
4-270	TN-4	70	431			
4-270	TN-6	70				broken in assembly
4-270	TN-7	70	318	0.77	0.00048	
4-270	TN-8	70	314	0.60	0.00054	
Average			354	0.69	0.00051	
4-270	TN-9	1700	422			
4-300	TN-1	70				broken in assembly
4-300	TN-2	70				broken in assembly
4-300	TN-3	70	416	0.99	0.00047	
4-300	TN-4	70				broken in assembly
4-300	TN-8	70	432	0.85	0.00059	
Average			424	0.92	0.00053	
4-300	TN-5	1550	542			
4-300	TN-6	1550	396			
4-300	TN-10	1550	496			
Average			478			
4-300	TN-7	1700	507			
4-300	TN-9	1700	510			
Average			509			

Table 5
Billets 4-270 and 4-300 - Alumina-Mullite

Temperature, °F	Strength, psi	Modulus, Msi	Strain-to-failure, in/.in.
70	382	.80	0.00052
1550	478		
1700	480		

Table 6
Tensile Properties of Blasch Alumina Mullite Material (Second Shipment)

Billet	Specimen #	Temp., °F	Ultimate strength, psi	Modulus, Msi	Strain-to-failure, in./in.	Remarks
4-270	TN-AX-5	70	142	0.41	0.00042	
4-270	TN-AX-9	70	258	0.67	0.00049	
4-270	TN-AX-2	70	280	0.64	0.00053	
	Average		227	0.57	0.00048	
4-270	TN-AX-7	1550	309	0.60	0.00055	
4-270	TN-AX-4	1550	309	0.59	0.00059	
4-270	TN-AX-1	1550	341	0.59	0.00060	
	Average		320	0.59	0.00058	
4-300	TN-AX-10	70	386	0.90	0.00052	
4-300	TN-AX-9	70	291	0.86	0.00039	
4-300	TN-AX-3	70	305	0.73	0.00046	
	Average		327	0.83	0.00046	
4-300	TN-AX-8	1550	241	0.87	0.00032	
4-300	TN-AX-2	1550	307	0.80	0.00032	
4-300	TN-AX-5	1550	163	1.06	0.00015	
	Average		237	0.91	0.00026	
5-270	TN-AX-1	70	117	0.54	0.00024	
5-270	TN-AX-6	70	234	0.53	0.00063	
5-270	TN-AX-10	70	258	0.55	0.00062	
	Average		203	0.54	0.00050	
5-270	TN-AX-4	1550	316	0.69	0.00058	
5-270	TN-AX-8	1550	300	0.73	0.00053	
	Average		308	0.71	0.00056	
5-242	TN-AX-2	70	84	0.45	0.00030	
5-242	TN-AX-8	70	129	0.31	0.00055	
5-242	TN-AX-5	70				broken in assembly
5-242	TN-AX-1	70				broken in machining
	Average		107	0.38	0.00043	

Table 7
Billets 4-270 and 4-300 - Alumina-Mullite

Temperature, °F	Strength, psi	Modulus, Msi	Strain-to-failure, in/.in.
70	277	.70	.00047
1550	279	.75	.00042
1700	In progress	In progress	In progress

Table 8
Billets 5-242 and 5-270 - Alumina-Mullite-10% SiC

Temperature, °F	Strength, psi	Modulus, Msi	Strain-to-failure, in/.in.
70	164	.48	.00047
1550	In progress	In progress	In progress
1700	In progress	In progress	In progress

FUTURE WORK

Plans for the next quarter include continued construction of the HGCU data base and entry of additional data, photographs, and text. We will be receiving a suite of ash samples from the Ahlstrom 10 MWt Pressurized Fluidized Circulating Fluid Bed facility located in Karhula, Finland. The analyses we will perform on these samples will depend on their particular histories. We also will fully characterize a particulate sample from the gasification facility at the Energy and Environmental Research Center located at the University of North Dakota. Our efforts to procure samples from Destec Energy, Inc. will continue. Evaluations of the two different compositions of Blasch Alumina Mullite material will continue at elevated temperatures. Design and construction of the materials property data base will commence during the next quarter. This data base will include all types of data and characteristics measured for the array of filter materials that we are evaluating.

PARTICULATE HOT GAS STREAM CLEANUP TECHNICAL ISSUES

QUARTERLY REPORT

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Approved by

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