

Particulate Hot Gas Stream Cleanup Technical Issues

Ash Data Bank Development

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Introduction

Successful demonstrations of the various advanced power systems that are being developed by the Federal Energy Technology Center (FETC) depend on effective, reliable collection and handling of the entrained particulate matter. Advanced power generation processes often produce particulate matter with fine size distributions, irregular particle morphologies, and high specific surface areas. This particulate matter may contain significant proportions of added sorbent material. These characteristics, in combination with the conditions under which the particles must be collected and handled, can cause problems for Hot Gas Cleanup (HGCU) barrier filters. Because of the dependence of filter performance on particulate characteristics, FETC contracted with Southern Research Institute to collect and characterize particulate samples from the facilities demonstrating advanced power generation processes.

Task 1 of this project, *Assessment of Ash Characteristics*, is explicitly designed to address aspects of filter operation that are linked to the characteristics of the collected particles. Specific objectives of Task 1 include generation of an interactive computerized data bank of the key characteristics of HGCU ashes collected from operating high-temperature, high-pressure, particle filters. The data bank is structured to identify, when possible, relationships between HGCU particulate properties and the operation and performance of these filters. Construction of the data bank, which is the focus of this paper, is intended to help manufacturers and operators of high-temperature barrier filters tailor process design and operation to the specific characteristics of the particulate materials they are collecting. Activities conducted under Task 2, *Testing and Failure Analysis of Ceramic Filters*, are discussed in a separate paper included in the proceedings of the Advanced Coal-Based Power and Environmental Systems '98 Conference.

To date, Southern Research Institute has analyzed about 151 of the 351 particulate samples that have been collected from fifteen advanced generation facilities:

- FETC Fluid Bed Gasifier with the Modular Gas Cleanup Rig (MGCR)
- Transport Reactor Development Unit located at the University of North Dakota's Energy and Environmental Research Center
- Foster Wheeler Development Corporation Integrated Carbonizer/CPFBC Pilot Plant at Livingston, New Jersey
- M.W. Kellogg Advanced Transport Reactor at the Department of Energy / Southern Company Services Power Systems Development Facility (PSDF)
- Foster Wheeler's 10 MWt Pressurized Circulating Fluid Bed Facility in Karhula, Finland

- Sierra Pacific Power Company's Piñon Pine Power Project
- American Electric Power Service Company's 70 MWe Tidd Pressurized Fluidized-Bed Combustor
- Grimethorpe PFBC
- Westinghouse cross-flow filter at the Texaco Montebello Research Laboratory Gasifier
- M.W. Kellogg Transport Reactor Test Unit located in Houston, Texas
- New York University's Bubbling Bed PFBC
- Iowa State University's Atmospheric, Circulating Fluidized-Bed Combustor
- General Motors' Allison Coal-Fueled Turbine
- KRW Process Development Unit
- Herman Research Pty Ltd. Mulgrave Gasification Research Facility located in Australia.

The data bank comprises samples and information from a broad selection of advanced combustion processes and facilities developed and operated by a wide range of power systems developers, power producers, and researchers. The facilities included in the data bank range from bench-scale units to full-scale power plants. Because many of the processes being tested were under development and optimization when samples and operating data were obtained, the data presented in the data bank may not always be representative of normal, or optimized, process operation. In fact, a significant proportion of data and samples obtained for analysis are included precisely because they are representative of unusual, or troublesome, system behavior. In addition, the physical characteristics of particulate samples are especially sensitive to the locations in the processes from which the samples were obtained. Consequently, users of the data bank are discouraged from making extensive comparisons between different processes or samples. The data bank is intended to provide the user with information describing the characteristics and behavior of specific samples and test facilities. When sufficient operating data, samples, and sample analyses are available to draw conclusions about system or process behavior, the data bank includes discussions of these conclusions. In addition, a number of references and key personnel are listed for the processes and facilities represented in the data bank. Instead of including lengthy descriptions of these facilities, the user of the data bank is directed to these sources for more detailed information.

Data Bank Description

The data bank is structured about Microsoft Access 97[®]. Current plans call for a run-time version of Microsoft Access to be included with the data bank. The arrangement of information in the data bank allows the user to review a variety of information including photographs, scanned images, plots, figures, text, and numerical values. To facilitate presentation of this wide variety of data formats, the data bank utilizes Adobe Acrobat[®] PDF (portable document format) files at various points in its construction. Therefore, software to install Adobe Acrobat Reader[®] is included with the data bank. Minimum system requirements for running the data bank are an IBM-compatible PC with a Pentium processor or higher, Microsoft Windows 95[®] or Windows 98[®] operating system, 16 megabytes of RAM, a 4X or faster CD-ROM drive, and a video card configured for a 1024 by 768 display with a minimum of 256 colors.

Upon activating the data bank, the user initially views a title page and a disclaimer page. The next screen viewed allows the user to select from six in-depth discussions of ash behavior and/or analyses procedures. The first of these discussions presents one of the principal findings of this task - a coherent

mechanism describing how and why consolidated ash deposits form in PFBC filter vessels. This description is based on site observations made at the Tidd PFBC, field and laboratory analyses of ashes and nodules collected from Grimethorpe, Tidd and Karhula, and a review of literature describing eutectic formation, sintering, and consolidation of boiler tube deposits. The next three in-depth discussions review the factors in a PFBC that contribute to filter system failure, inertial particle collection in barrier filter vessels, and the potential for rapid increases in the thickness of transient IGCC filter cakes. The fifth and sixth discussions accessible for review from this screen detail the procedures and sampling protocol used during site visits, and the techniques used in the laboratory to characterize particulate samples.

From this same screen, the user may also proceed to examine data and samples for specific facilities. If this option is selected, the user chooses one of the fifteen HGCU facilities to examine. Once a facility has been selected, the data bank lists the primary participating organizations and principal contact personnel for the facility. The user can then select and review one of the six categories listed: brief description of the facility; process schematics; plant photographs; technical references; on-site inspections; or particulate sample analyses. Under the first category, brief descriptions, up to two pages of text, are provided for each of the facilities in the data bank from which the various particulate samples were obtained. Series of process schematics and plant photographs can be scrolled through by selecting the second or third category. Examples of the screens that are used to display process schematics and plant photographs are shown in Figures 1 and 2. The fourth category provides the user with references to more detailed information about the facility. The category for on-site inspections contains information gathered during filter inspection and sampling trips made by Southern Research Institute personnel. Information in this category covers four site visits to the Tidd PFBC, one visit to the MGCR at Morgantown, and five inspection and sampling trips to the PSDF. After selecting a particular site visit to review, the data bank provides a brief summary of the condition of the filter, the sampling procedures and the particulate samples obtained, and some of the key data obtained during the visit. A series of photographs of the filter cakes and ash deposits observed during the visit can also be reviewed.

When the user wishes to review the analyses of samples obtained from a particular facility, a scroll-down list of the samples is displayed. Included with this listing are brief descriptions of the samples, and where and when they were obtained. This screen is shown in Figure 3. After a sample is selected to examine in detail, a screen is displayed that summarizes the physical and chemical analyses that have been performed on that sample. Figure 4 presents this screen display for one of the Tidd samples. Physical attributes that have been measured and are included in this display include median particle size, specific surface area, particle morphology, bulk ash cohesivity, permeability, and tensile strength. This screen also provides access to scanning electron micrographs of many of the samples in the data bank. In general, these micrographs were obtained and can be viewed at four different magnifications. Chemical analyses of the selected sample are also summarized on this screen. Some of the samples collected which have unusual histories or unique characteristics have been analyzed with specialized techniques. When specialized analyses have been performed on the selected sample, the results of these analyses can also be accessed from this screen. This screen also provides a direct link to descriptions and explanations of the various analyses used to characterize the samples.

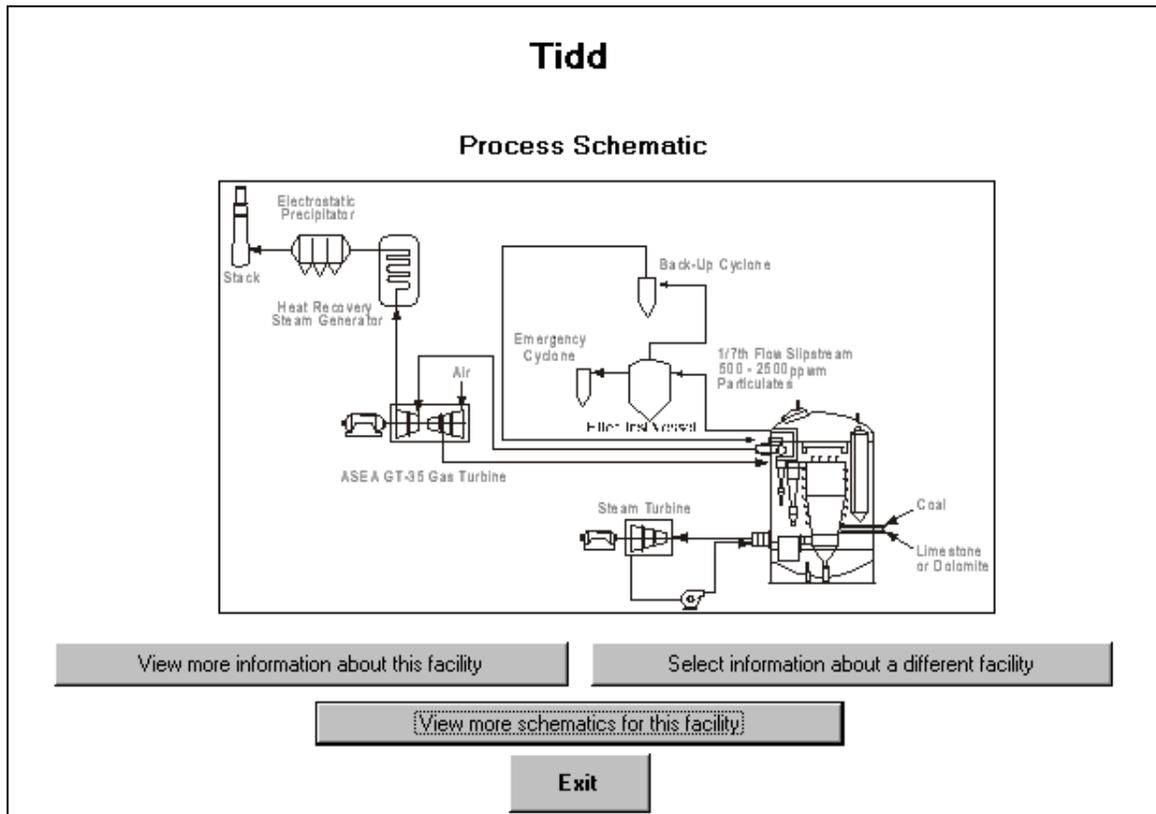


Figure 1. Example of the screen used to display process schematics.

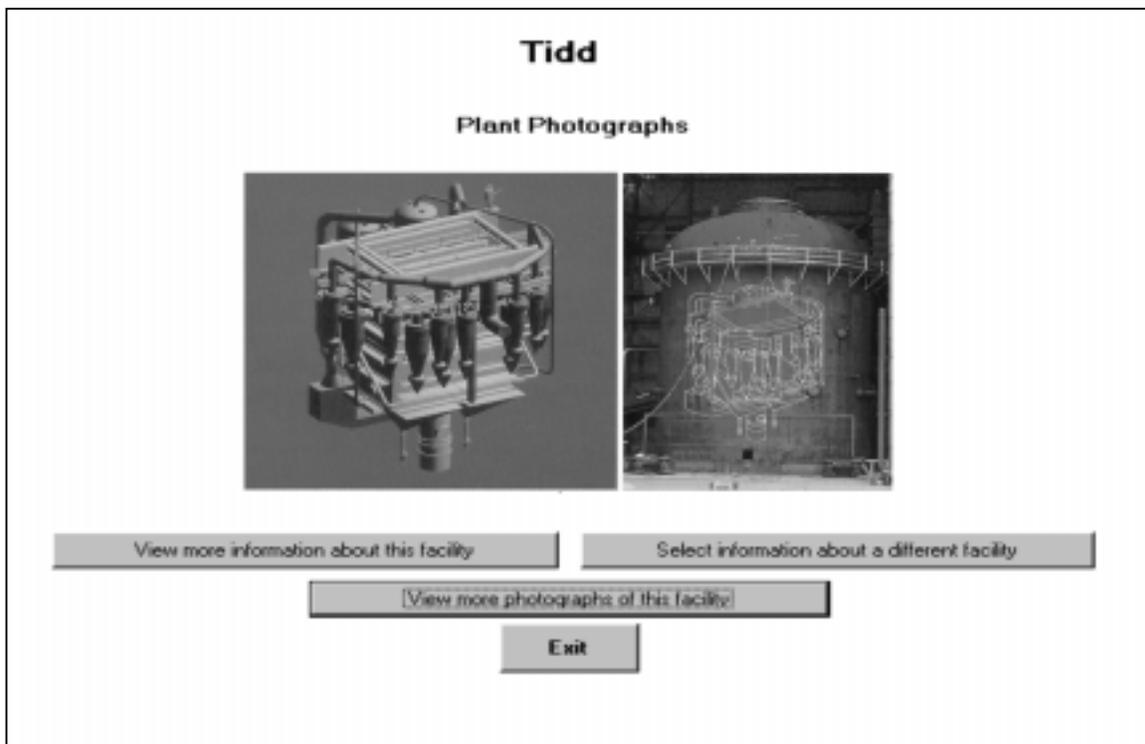


Figure 2. Example of the screen used to display plant photographs.

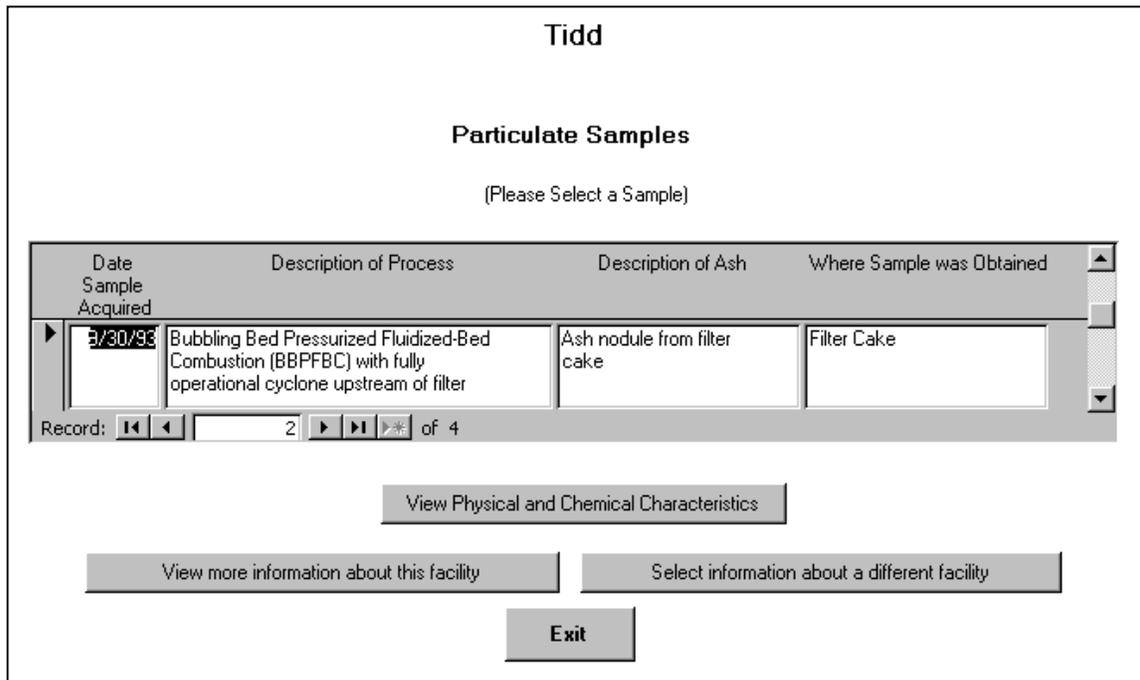


Figure 3. Samples are selected for subsequent examination of their characteristics using this screen.

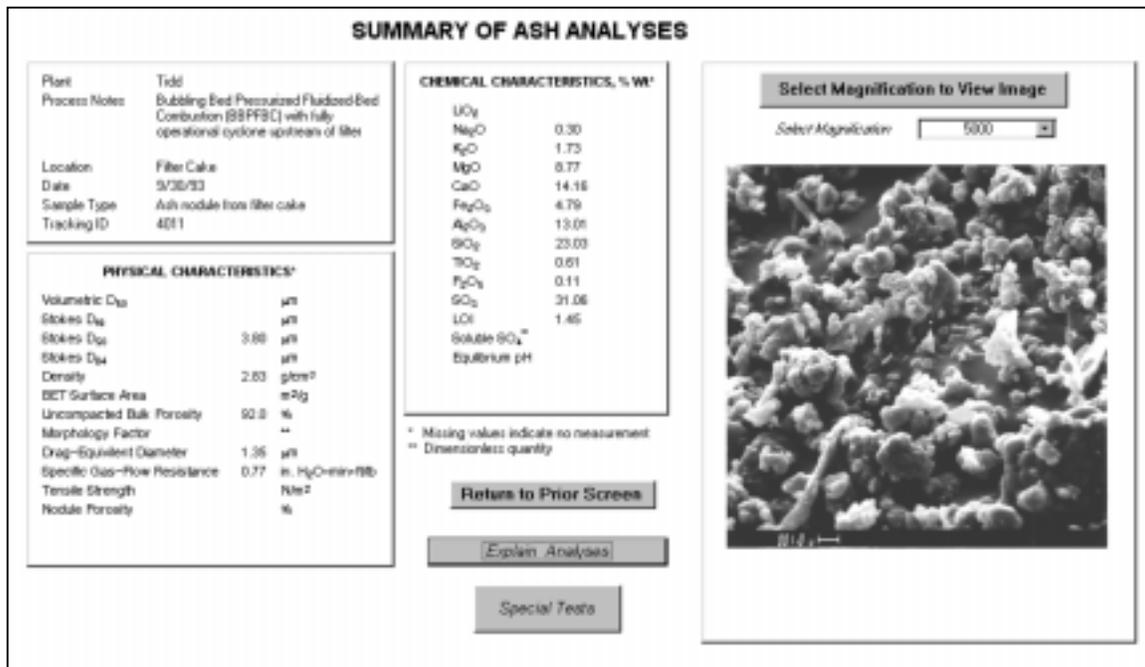


Figure 4. Measured sample characteristics are displayed on this screen.

Each screen shown during operation of the data bank offers the user the option of exiting the program. When this option is selected, a final screen is displayed which credits the various organizations and individuals that made significant contributions to the data bank. Acquisition of particulate samples and analyses of their physical and chemical characteristics is an ongoing process. Therefore information will be added to the data bank throughout the duration of this project. Current project plans call for the data bank to be issued to FETC on CD-ROM at the end of FY98.

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