DIGITAL CONTROL AND AUTOMATION SYSTEMS

Microcomputer Based Coal Analysis System Replaces Large Wet Chemistry Laboratory

Whether or not coal ever returns to its former status as a primary fuel for industrial uses may be questionable. Certainly it exists in huge amounts in the U.S. as well as in other countries. However, those supplies differ in characteristics that can affect whether or not mining certain veins of coal is practical.

Before a potential source is mined at a commercial level it is necessary to measure several intrinsic values of the coal: moisture content, ash content, oxidation level, volatile matter, BTU or calorific value, and—extremely important because of current federal regulations—sulfur content. As examples, for bituminous coal an ash content of 2 or 3% is considered good, 10% is high, and 15% is bad; a 10,000 BTU measurement is considered average and 14,000 is very good. It is also important that results of the analyses be available with the least possible amount of delay.

For many years the measurement procedures to determine these characteristics were conducted in large wet chemistry laboratories, often located at some distance from the coal fields. Now, however, the same sophistication in test procedures is provided at smaller facilities closer to the sources of the coal. In addition, these small laboratories—requiring only one to three persons and using systems controlled by microcomputers—are easy to operate, even with unskilled personnel, and are claimed to provide improved accuracy.

Nova-Coal 1, developed by Standard Instrumentation, Inc, 3322 Pennsylvania Ave, Charleston, WV 25302, allows an operator to schedule and perform major test functions under American Society for Testing and Materials (ASTM) standards. Control is maintained by a Data General Corp micro-Nova microcomputer with a 32k-word core memory (Fig 1). Other system components include dual floppy disc drive, 30-char/s printer, CRT terminal, and interfaces to the measuring devices. This system schedules work flow; acquires and logs data from an electronic balance, an oxygen bomb calorimeter, a sulfur analyzer, an ash fusion furnace, and several other devices (Fig 2); and controls the temperatures of four furnaces. All interim and final results are provided as hard copy by the printer; the operators do not have to make notes and are automatically alerted to equipment problems.

Basic Functions

There are four subsystems in Nova-Coal 1: logging in, scheduling, laboratory equipment control, and reporting. Both logging in and scheduling are entirely software. Programs are based on ASTM methodologies and are

Fig 1 Micro-Coal 1 control console. MicroNova microcomputer is in cabinet at right, just above dual floppy disc drive. Interfacing circuitry and audio alarm are in upper section of cabinet. CRT displays main menu, allowing operator to choose laboratory functions. Balance at left corner of desk weighs samples of up to 30 g at accuracy to 0.0001 g. Pedal switch to left of CRT terminal strobes microcomputer for reading balance

set up to prompt the operator on every action. Because operator capabilities vary from area to area, the commands are organized on two levels—one for the beginner and another for the advanced technician. Specific instructions prompt an inexperienced operator from step to step, but an experienced operator is instructed by only one or two key words and can ignore the remaining details.

During logging in, the console asks the operator specific questions about each sample, such as the day's date, sample identification, and what analyses are required. The computer schedules the work for the day according to predetermined priorities, but priority interrupts occur whenever an analysis of higher priority than the one currently in progress requires immediate attention.

Furnace controllers vary according to the specific type of furnace to be controlled. For an ash fusion furnace, the controller is a power-proportioning type that increases power to the furnace in proportion to an increase in the input signal. The computer determines the amount of power by comparing its reading of actual furnace temperature and the programmed time/temperature relationship. Other furnaces, not as sensitive to power changes, are controlled by time-proportioning units.

Reports of analyses are available in several formats, either on the CRT or as hard copy from the printer. Trial summaries, for instance, can be requested at the end of the day or anytime during the day. Also, intermediate calculations can be provided on completed analyses for any specific sample. At the end of the day, reports on all completed analyses can be provided as hard copy, including the number of tests run that day.

Fig 2 View of laboratory. Components (from right to left) include control console, sulfur analyzer and controller, printer, and moisture oven

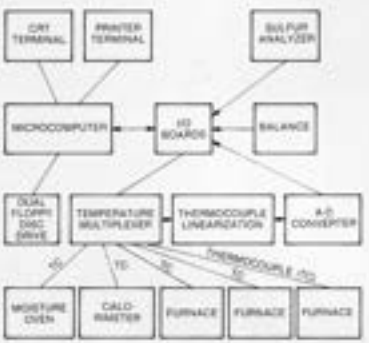


Fig 3 Hardware block diagram. Microcomputer with 32k-word core memory interfaces to laboratory instruments through I/O boards and temperature multiplexer. Each I/O board has 16 input and 16 output lines. MUX routes thermocouple signals through linearization network and then to ADC. Since calorimeter requires no linearization, it is actually read directly to the ADC (circuit not shown on diagram)

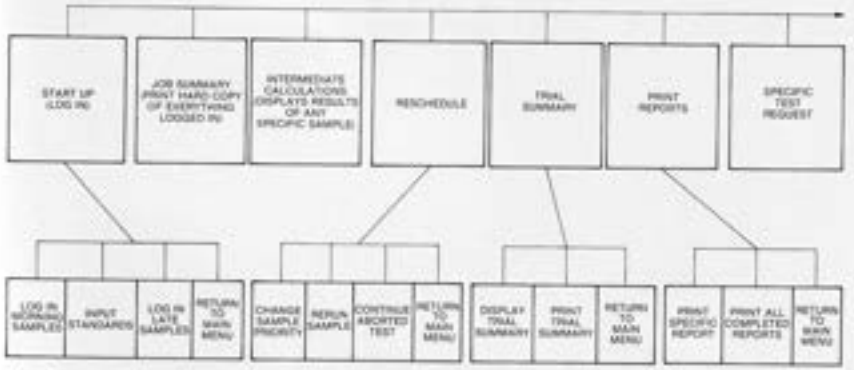


Fig 4 Software block diagram. ASTM based programs prompt beginning operators at every step, but allow experienced operators to proceed with only key word instructions. CRT reports are available at any time during analyses; hard copy reports from printer are available at end of day or at specified intervals

the amount of time required for these tests, and the number of samples completed.

Hardware

As shown in Fig 3, the microcomputer system interfaces to all measurement devices and furnaces through digital input/output (I/O) boards, each with 16 input and 16 output lines. A multitasking realtime operating system combines data from all subsystems to increase speed and precision. Two I/O boards interface to a balance that has a capacity of either 30 or 160 g, depending on the model, and can measure to 0.0001 g. Output of the balance is in BCD, requiring 4 bits/digit; one board carries digits to the right of the decimal, the other carries digits to the left. Two other boards are used to read temperatures from a multiplexing system that interfaces to the moisture oven, calorimeter, and furnaces.

The temperature multiplexer (MUX) reads temperatures from as many as 16 different sources of three thermocouple types. Since different thermocouples require different linearization circuits, the multiplexer decides which thermocouple is being read and routes the incoming signal to its appropriate thermocouple linearization network and then to the analog to digital converter.

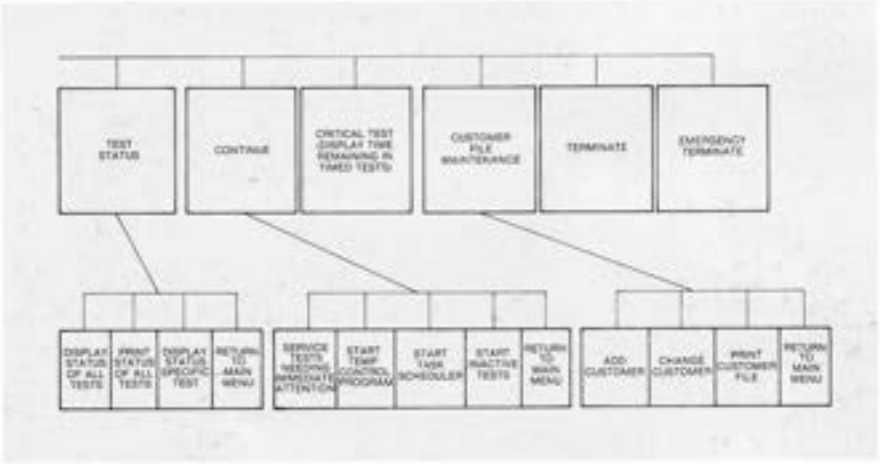
Temperatures at various measurement devices vary widely. The moisture oven is at about 106 °C, the calorimeter is at 26 or 27 °C, and a volatile matter furnace runs at from 950 to 970 °C. Yet actual temperature measurements are read to 0.001 °C.

The CRT terminal has a 1920-char display and a detached keyboard; the 30-char/s, 132-col line printer also has a keyboard for inputting instructions. A dual-diskette drive provides 752k bytes of mass memory (a hard disc drive can be included for larger systems).

Software

After turning on power to the system and inputting reference information such as day, date, and time, the operator calls the laboratory program. The main menu, or the major procedures that are to be conducted (Fig 4), include Start Up, Job Summary, Intermediate Calculations, Reschedule, Trial Summary, Print Reports, Specific Test Request, Test Status, Continue, Critical Test, Customer File Maintenance, Terminate, and Emergency Terminate. Routinely, unless a priority problem occurs, these procedures are run consecutively in the order shown on the main menu.

Start Up involves logging in identification of the sample, customer code, and tests to be run. For example, one customer might want to analyze moisture, ash, and BTU; another might want moisture, ash, and sulfur. As an option, a customer might want a standard sample to be run along with the specified tests as a check on



the accuracy of that day's analyses. Other samples can also be logged in for later processing.

Job Summary allows a hard copy to be printed of everything logged in, including sample numbers and a list of tests to be run. Intermediate Calculations is included in the main menu to enable a customer to obtain results of all tests completed at some time prior to the end of full test procedures.

The fourth function, Reschedule, allows a change to be made in priority so that the sequence of tests to be run can be varied according to a reestablished need for specific information. It also enables a sample to be rerun if some results do not seem to be correct, or if an aborted test is to be continued.

Next, Trial Summary offers the capability to request an abbreviated report of the day's tests, either as a CRT display or as a hardcopy printout. Print Reports provides the option of printing a specific report or printing all completed reports. Any given sample can be printed on its particular report form, whether or not the analysis is complete. This function is the only one that permits an incomplete analysis to be printed on a report form.

Specific Test Request allows complete data for any sample to be displayed on the CRT screen. Such data include, for example, weights of all crucibles without samples, with samples before testing, with samples after testing, and with samples after extended drying. Similar data are maintained on all other test areas in order to assure a review of all factors if any test results are questioned. For example, if an analysis indicated an 80% ash content but the operator knew that it should never be more than 30%, all data could be recalled to determine if there had been an improper reading from the balance or some other wrong input. Test Status informs the operator which tests are complete and which are not, allows the operator to display the status of all tests on the CRT or to print them on the printer, and permits the status of any specific test to be displayed.

After all samples are logged in and the main menu is back on the screen, the operator's first action is to strike the key that initiates the Continue function, possibly the most frequently used. This begins actions of the multiplexer so that temperatures are read into the computer. It also starts the task scheduler so that the order of items presented to the operator on the CRT are controlled. Then it begins the inactive tests and services tests that require attention.

Critical Test displays the time remaining in timed tests. Customer Maintenance allows a customer to be added or changed and prints customer files. Terminate provides an orderly shutdown of the system at the end of a day's operations, while Emergency Terminate enables a quick shutdown of the system but saves all data for later recovery.

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Innovative Instrumentation for the Coal Industry

FA57:

- Operator Unattended
- Improved Repeatability
- Computer Controlled
- Improved Accuracy
- Complete Furnace Control
- Printed Results
- Reduced Labor

Options:

- Complete Furnace Subsystem
- Tripod Mounting for Camera
- Right Angle Mounting for Camera
- Platform Mounting for Camera
- Audible Alarm for End-of-Test
- Video Recorder for taping/playback

WHERE QUALITY INSTRUMENTATION IS STANDARD

STANDARD INSTRUMENTATION, INC.

A SUBSIDIARY OF STANDARD LABORATORIES, INC.

3322 Pennsylvania Ave., Charleston, W.Va. 25302 304/345-4727

Accurate and Fully Automatic. The FA57 Automatic Ash Fusion Sy from Standard Instrumentation

Operator Unattended Ash Fusion Testing

Standard Instrumentation's Model FA57 Ash Fusion System is a fully automatic instrument designed to perform in accordance with ASTM Standard D-1857 for the observation of temperatures at which prepared cones of coal and coke ash pass through defined stages of fusion when heated at a specified rate in a controlled atmosphere. The system is made up of three subsystems:

- Camera Assembly
- Computer/Monitor
- Printer

Video Processing Technology

The camera subsystem consists of a high resolution video camera with matched lens, a 2X extender and a density filtering system. Output from the camera is fed directly to the video interface network for conversion to electronic signalling for processing by the microprocessor computer.

Computerized for Accuracy

The microprocessor-based system provides the greatest accuracy possible with latest state-of-the-art electronic design. The pre-programmed memory accepts the video-processed information, storing the initial scan for comparisons to all later scans. As the scans provide the information indicating the changes in the cones, the computer compares them to the initial information, relative to the temperature changes. These comparisons are all stored and later recalled as the test results. Each separate cone recognized by the video camera is assigned an individual identity. This identity's area of memory then maintains comparisons of the changes for that cone. The changes in the cones are never misread or confused, due to the identity assignment by the computer. There is also a 6" monitor screen for periodic viewing of the cones as seen by the video camera. This screen can also be used for video tape playback of cones previously recorded.

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ASH FUSION
(OXIDIZING)

3 CONES LOCATED


CONE #1
T1= 2047
T2= 2340
T3= 2370
T4= 2415


CONE #2
T1= 2050
T2= 2345
T3= 2380
T4= 2419


CONE #3
T1= 2046
T2= 2342
T3= 2380
T4= 2410
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Atmosphere Selection

The FA57 provides for selectio regulation of either oxidizing ducing atmospheres into the te nace by use of gas solencid valv adjustable gas flow meters. Th ture allows the necessary contro atmospheres, safely and at your tips.

Permanent Records

A printer subsystem provides t results, with each cone and it responding temperatures clearly

stem

tified and printed on durable thermal paper for permanent records. Also provided to the operator is the pertinent start-of-test information, printed immediately after the first scan is made by the system. The operator is reminded of which atmosphere is selected and the number of cones located by the video camera, allowing for any changes wished before continuing the test.

Repeatability

The advanced video processing technology and computerization allow for the accuracy necessary to insure test repeatability. The FA57 performs the test in the exact same manner, each and every time, with nothing to calibrate, nothing to adjust . . . just load the cones and start the system.

Furnace Control

Also available, by way of the microprocessor technology of the system, is total furnace control by the FA57. The system holds the furnace at an idle temperature when not in use, bringing the temperature up to start only after the system has been initiated. Throughout the test sequence, a 15°/min. rate of rise is maintained. At the end of the test, the furnace temperature will be brought back down to idle and held until the next start.

Automatic furnace control and automatic ash fusion determination with the FA57 . . . you can't get any more efficient than that!

STANDARD INSTRUMENTATION, INC.

3322 Pennsylvania Ave. Charleston, WV 25302 304/345-4727

D24R RESEARCH DILATOMETER

In addition to the features of the D24, the Research version also allows for:

- Variable Set Temperature - set is variable from ambient to 650°C.
- Variable End Temperature - end is variable from set to 650°C.
- Variable Rate-of-Rise - rate is variable in .1°C increments from 1.0°C to 9.9.°C.
- Variable Print Interval - selectable at 10 second or 60 second print intervals.
- Other parameters available upon request.

Where Quality Instrumentation Is Standard.

D24 & D24R Available Options & Accessories

D24-Ruhr	for testing by the Ruhr Dilatometric method
D24-02-220	Paper Tape
D24-02-242	Strip Chart Recorder/Plotter
D24-03-143	Thermocouple
D24-03-510	Sample Tube
D24-03-530	Audibert-Arnu Piston
D24-03-610	Ruhr Piston

Specifications

120 vac(± 5%), Single phase, 60 cycle, 15 amp
Set: 330°C End: 540°C Rate: 3°C/Min.
4½ digit resolution of temperature, automatic print
3½ digit resolution of expansion and contraction
for both samples, in mm or %, automatic print
5 x 7 dot matrix printer with standard thermographic paper
Manual print and paper advance buttons on printer
End-of-test and over-temperature alarm
Switch malfunction indicator
Packing accessories kit provided
Cleaning kit provided

STANDARD INSTRUMENTATION, INC.

D24

DILATOMETER

For determination of coal expansion and contraction as a function of temperature

The Model D24 Dilatometer, designed with the latest state of the art microprocessor technology, is our most precise and efficient model available. Fully automatic, the operator need only pack and load the sample for the most accurate and timely results possible.

Designed around ISO Standard 349 for the Audibert-Arnu Method of Dilatometric measurements, the D24 Dilatometer significantly increases the rapidity, ease and reliability of analyses performed on coal samples. The furnace is of low thermal inertia design, thereby making possible the rapid interchange of heat between the furnace itself and the dilatometer tube assembly situated in the high grade brass alloy core of the furnace. The low thermal inertia of the furnace permits rapid cooling to initial test temperatures for increased utilization of the dilatometer, equipped to run two samples simultaneously.

The Linear Variable Differential Transducers (LVDT's) are connected to the dilatometer tube pistons by low mass connector arms. The vertical movement of these pistons produces a linear voltage signal transmitted through a highly stable voltage conditioning circuit to separate digital display panels for each sample.

The microprocessor control unit provides necessary power to the furnace by monitoring a type K (Chromel-Alumel) thermocouple and comparing that actual temperature to the programmed rates and adjusting automatically to insur proper proportion. During the actual test, the temperature of the furnace is increased at a uniform rate of 3°C/minute fro 330°C to 540°C with automatic return-to-start upon reaching the final temperature permitting unattended operation of the dilatometer.