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ATR DATA SYSTEM OPERATIONAL GUIDE
Volume 1 - CDC-636 Computer System

Edited by J. C. Tappendorf

Aerojet Nuclear Company

NATIONAL REACTOR TESTING STATION

Idaho Falls, Idaho — 83401

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Date Published - June 1972

PREPARED FOR THE

U. S. ATOMIC ENERGY COMMISSION

IDAHO OPERATIONS OFFICE UNDER CONTRACT AT(10-1)-1375

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Volume 1 - CDC-636 Computer System

Edited by J. C. Tappendorf

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ABSTRACT

The ATR Data System Operational Guide report has been prepared to aid ATR Operations' personnel in the operation of the ATR Data System. Additionally, this report establishes the guidelines for ATR Data System operation during reactor operation and shutdown.

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I. INTRODUCTION

The Advanced Test Reactor Data System is an on-line computer system which monitors analog signals and the aspects of two-position switches and relays which describe the operation of the reactor and the plant. Storage of these signal values during reactor operation for future reference is provided by a magnetic tape unit. The current value of any analog signal or aspect of any of the two-position switches or relays is available by request from any one of a number of peripheral data terminals. The ATR Data System also uses a number of these analog signals as input parameters in nuclear and reactor calculations (eg, absorber concentrations and reactor lobe power distribution). The system also monitors its own operation and provides diagnostic messages on the data terminals when an abnormality is detected.

A PDP-15 computer has been recently installed and tied to the original CDC-636 to expand the capabilities of the ATR Data System. In addition, three Syner-Data printers have been installed to replace and augment the slower IBM typewriters as data terminals for experiment sponsor output. Three paper tape punches have also been added to the system in order to provide the experiment sponsors a faster means of transmitting information to their home offices. A block diagram of the components of the expanded ATR Data System is shown in Figure 1.

In the near future a visual display system will be added to the ATR Data System. The visual display will be located in the ATR reactor console and will provide the operator with a more immediate and accessible link with the conditions of the reactor and plant. Presently proposed displays include (a) a display of the values of the reactor power parameters, (b) a display of the variation of parameters as a function of time, (c) a display of suggestions for shim movement to achieve a desired power division, and (d) a display of requested Standard Practices, Operating Limits, and Operating Procedures.

This report will discuss only the operations and the operational guidelines for the CDC-636 and its peripheral devices. The operations and the operational guidelines for the PDP-15 will be reported when the PDP-15 becomes fully operational.

Contents of a number of CDC-636 core locations are referred to throughout this report. These contents are subject to being moved to another core location as a result of reassembling the system programs. These changes in the location of these contents will be transmitted in the updates to the ATR Data System Catalog of Output Requests. Thus prior to making changes in the core location contents mentioned in this report, refer to the ATR Data System Catalog of Output Requests for any changes in the location of these contents.

FIG. 1 BLOCK DIAGRAM OF THE COMPONENTS OF THE EXPANDED ATR DATA SYSTEM.

II. CDC-636 CONSOLE OPERATIONS

This section describes the functions of the switches found at the CDC-636 console. Additionally, procedures are given which enable the user to start up and shut down the CDC-636 and to load the systems program. Any diagnostic messages which may appear on the output devices are interpreted and corrective action to be taken is given.

The different programming and nonprogramming functions available at the system control panel after the systems program is loaded are also discussed.

1. GENERAL DESCRIPTION OF COMPUTER PROGRAMMING RACK

The CDC computer programming rack, located in the ATR Computer Room consists of three panels: (a) the breakpoint control panel (the top panel), (b) the computer control panel (the middle panel), and (c) the system control panel (the bottom panel).

The breakpoint control panel is used to select and monitor the instruction, operand, and external access address. The address is selected by the 5-octal-digit BREAKPOINT ADDRESS thumb-wheel register. When the MODE SELECT on the computer control panel is in the BREAKPOINT position and when one of the BREAKPOINT MODE pushbuttons is depressed (other than NONE), the computer will idle when the breakpoint address is reached in the programs. The BREAKPOINT indicator will also illuminate. This BREAKPOINT indicator will illuminate when the breakpoint address is sensed, even if the computer is not operating in the BREAKPOINT mode, unless the BREAKPOINT MODE/NONE pushbutton is depressed.

The computer control panel has controls and indicators which permit the computer operator to start, stop, program, and monitor the computer system. The control panel consists of a mode select switch, control switches, a register select switch, and indicators.

The MODE SELECT switch is key-activated to prevent unauthorized operation. Its five switch positions permit operation in one of five modes: (1) BREAKPOINT, (2) MEMORY PARITY, (3) CONTINUOUS, (4) SINGLE COMMAND, and (5) LOAD.

The control switches (eleven backlighted switches) are used to control the operation of the computer, as discussed in pertinent sections of this document.

The configuration of a selected register is displayed by 15 indicators, numbered 01 to 15. Each indicator represents a binary bit position, and the pattern of illuminated indicators displays the register value in binary notation. A register to be displayed is selected by positioning the REGISTER SELECT knob to the appropriate register designation printed on the face of the panel.

The three lamps located above the register indicators show computer status. The IDLE indicator illuminates when the computer is idle; the TPE indicator illuminates when a transmission parity error occurs; and the MPE indicator illuminates when a memory parity error occurs. The computer also idles on a memory parity error when the MODE SELECT switch is in the MEMORY PARITY position.

The system control panel permits the selection and initiation of programming and nonprogramming functions. There is a key operated on/off switch which activates or deactivates the panel. There are also two sets of thumb-wheel registers. The address thumbswitches are octal switches and can be used for entering octal numbers into the system. The value thumbswitches are decimal switches and can be used for entering decimal or octal numbers into the system. Also included is a function select knob that can be dialed to any one of 10 positions (windows) for which program functions are assigned. The DATA HOLD button, when depressed, provides the function select knob with 10 more window functions. The remaining pushbutton is denoted ENTER. When pushed, this button activates an interrupt that notifies the system that a request is being made.*

2. CDC-636 STARTUP PROCEDURE

In order to start the computer properly without leaving any locked-in and/or set-up conditions and without destroying any part of the memory, the following procedure must be followed, step by step.

CAUTION

It is imperative that no step be started prior to the successful completion of the previous step. Failure to comply may result in loss of memory information or incorrect program operation.

1. At the computer control panel:
 - a. Set MEMORY POWER to OFF
 - b. Set MODE SELECT key to CONTINUOUS
 - c. Set MEMORY CONTROL to OFF
2. At the power control panel:
 - a. Turn COMPUTER POWER to ON
 - b. Turn AUX. AC power to ON
 - c. Depress RUN button

*It is not necessary to wait for a typeout to finish before making another request. Up to eight requests can be entered. If a back-log of more than eight requests builds up, the output will not come out at the request terminal. However, in making requests for a core or drum location read-out or change, it is necessary to wait for a typeout before making another request.

3. At the drum logic control panel:
 - a. Turn DRUM SELECT knob to OFF
 - b. Depress the ERROR RESET until all error lights are out, except the idle light*
 - c. Turn DRUM SELECT knob to NORMAL.
4. At the computer control panel:
 - a. Depress START button
 - b. Depress ERROR RESET* button
 - c. Set MODE SELECT key to SINGLE COMMAND
 - d. Turn MEMORY POWER to ON
 - e. Set MEMORY CONTROL to ON
 - f. Depress ERROR RESET* button.

3. CDC-636 LOADING PROCEDURE

1. Select the most recently edited loading tape (ie, the tape with the most recent date or cycle number on it).
2. Check to see this tape does not have a write ring on it.
3. Mount the system loader tape at load point and ready the tape unit (using Steps 5 and 6 in Section V.6).
4. Turn MODE SELECT key on computer control panel to LOAD.
5. Lift and release the auto-load toggle switch on the mag tape logic panel. This should move the tape forward off of the load point. If there are any parity lights illuminated on the magnetic tape logic panel, rewind the tape to the load point, ready the tape unit, and repeat this step.
6. Dial any number except 06000 into the ADDRESS register at the computer control panel.
7. Push the RELEASE AND ACQUIRE button.
8. Turn the MODE SELECT key to CONTINUOUS.

*It is important that all error indications remain off before starting computer operation. If the computer has been off for a long period of time, a warm-up period is usually required before errors will remain off.

9. Push START button.

There should be the following message on the computer room typer:

"YOU WANT TO LOAD SO UNPROTECT DRUM AND HIT START."

IMPORTANT

If there should be the following typer message:

"YOU WANT TO UPDATE SO UNPROTECT DRUM AND HIT START."

the warning in Step 6 has been ignored. In that case, change the ADDRESS register value, turn MODE SELECT key to LOAD, and start again at Step 7.

10. Push START button.

The program tape should read in and the following message should type out:

"IF MAG TAPE LOGIC PANEL SHOWS NO ERRORS, THEN REAL TIME SYSTEM IS READY FOR INITIALIZATION. MOUNT NEW TAPE, TURN PRINTER ON, HIT START, ENTER THE TIME INTO THE VALUE SWITCHES, AND HIT START."

If there are any lights on the magnetic tape logic panel, rewind the tape to load point, ready the unit, and start again at Step 4.

11. Unload the system loader tape and load a cycle data magnetic tape at load point and ready the unit, using the procedure in Section V.6. The tape must have a write ring on it. Enter the pertinent information for this tape into the magnetic tape log book as specified in Section V.6.
12. Turn the line printer to ON.
13. Push the START button..

There may be a typer output of DE. This indicates a drum error in trying to retrieve previously stored data for the system. Repeat this step as long as DE appears, or if this message persists, notify an instrument technician.

14. Enter a time into the VALUE register switches.

15. When the real time value entered in Step 14 is reached, push the START button.
16. The magnetic tape output and contact closure sequence are not automatically inhibited after the computer has been loaded. To inhibit these features refer to Section II.9.3 and II.9.7.
17. Check the core and drum content change board in the computer room for any core and drum content changes which might not be on the loading tape. Make the necessary core and drum content changes and note in the log book that these changes have been made.

4. CDC-636 LOADING PROCEDURE WHEN COMPUTER ROOM TYPERS ARE INOPERATIVE

If both computer room typers are malfunctioning, the following procedure can be used to load the CDC-636:

1. Do Steps 1 through 5 in Section II.3.
2. Load the following values into the following core locations:

<u>Value</u>	<u>Location</u>
00263	00261
70000	00262

This loading is done in the following manner:

- a. Turn MODE SELECT key to the LOAD position
- b. Load 00261 into the display register
- c. Select the A-register on the REGISTER SELECT knob
- d. Push the two control switches, A→Y and START, simultaneously
- e. Load 00263 into the display register
- f. Select the A-register on the REGISTER SELECT knob
- g. Push the two control switches, A→M and START, simultaneously
- h. Do the same basic steps above to load 70000 into location 00262
- i. Proceed with Steps 6 through 15 in Section II.3

5. ERROR MESSAGES DURING INITIAL PROGRAM LOAD

A number of error messages may occur during the CDC-636 loading procedure. These are included to insure a properly executed system loading. The meaning of these messages is described below:

1. Error: If the drum is not initially ready to accept transfers, there will be the following message:

" CANNOT TRANSFER RECORD 00"

Action: Drum status should be checked and the error condition corrected if possible. Turn MODE SELECT key to LOAD and start again at Step 7. If the error persists, an instrument technician should be notified.

2. Error: If the drum fails to make a proper transfer, you will get the following message:

"CANNOT READ RECORD XX"*

Action: Tape will rewind to load point. Ready the magnetic tape unit and start again at Step 4. If failure occurs again, try loading one of the system loader backup tapes. If failure occurs with the backup tape, an instrument technician should be notified.

(Past experience has shown that cleaning the heads may clear up this problem.)

4. General Error: If anything occurs that leaves a doubt about the validity of the load, restart at Step 3.

6. STARTUP PROCEDURE AFTER COMPUTER STALL

If a computer instruction appears less often than prescribed, or if a memory parity error, a program stall, or a power failure occur, the computer stall alarm logic operates a relay that provides a control room COMPUTER STALLED annunciator.

The only safe recovery from a stall alarm is to restart the system by way of an initial program load.

IMPORTANT

Before executing the initial program load procedure following a stall alarm, it is desirable that the contents of the computer memory be saved for analysis by the system programmers. This can be done by:

1. Turn the MODE SELECT key to LOAD
2. Advance the line printer paper to a new page
3. Push RELEASE and ACQUIRE buttons
4. Turn the MODE SELECT key to BREAKPOINT
5. Push the START button
6. Enter 07000 into the A-register by pushing buttons 10, 11 and 12 on the computer control panel and using the REGISTER SELECT knob to select the A-register.

*Where XX is a number of value 01 to 30. This is the record number where the failure occurred.

7. Push the START button.

An octal core map should be produced on the line printer. The printer will stop when the entire core map has been printed. If no print-out occurs, it means that the dump program has been destroyed. If there is a core map print-out, save it.

8. Reload the system according to the computer loading procedures in Section II.3. (If the computer power has been OFF, it is necessary to perform the startup procedures in Section II.2 prior to the computer loading procedure.)

7. CDC-636 SHUTDOWN PROCEDURE

In order to shut down the computer properly without losing any memory or damaging any of the hardware, the following procedure must be followed step by step.

1. Write end-of-file and unload magnetic data tape (refer to Section II.9.6).
2. At the computer control panel: Set MODE SELECT key to SINGLE COMMAND
3. At the drum logic panel: Set select knob to OFF
4. At the computer control panel:
 - a. Set MEMORY CONTROL switch to OFF
 - b. Set MEMORY POWER to OFF
5. At the power control panel:
 - a. Push STOP button
 - b. Turn COMPUTER POWER to OFF
 - c. Turn AUX. AC POWER to OFF

8. EMERGENCY SHUTDOWN PROCEDURE

In order to shut down the computer in an emergency, the following procedure must be followed step by step.

1. At the power control panel:
 - a. Push the STOP button
 - b. Turn COMPUTER POWER to OFF
 - c. Turn AUX. AC POWER to OFF

9. PROGRAMMING FUNCTIONS AVAILABLE AT THE SYSTEM CONTROL PANEL

Described on the following pages are the programming functions available only at the CDC-636 system control panel in the computer room.

CAUTION

Care should be taken when performing these functions, because an improperly executed step can cause a system program failure.

9.1 Core Location Content Readout

Control Panel	Computer Room
FUNCTION SELECT	1
DATA HOLD	Depressed
ADDRESS	00000 through 27777
VALUE	Not Used
Output	Typer

Example: To find the contents of core location 24200, set up the computer room control panel as above with 24200 in the ADDRESS register. When the ENTER button is pushed, the following message will be typed out: (Time and Date) COMPUTER CORE ADDRESS 24200 CONTENT IN OCTAL IS 04341.

9.2 Core Location Content Change

Control Panel	Computer Room
FUNCTION SELECT	2
DATA HOLD	Depressed
ADDRESS	Desired Core Address in Octal
VALUE	New Content in the low order 5 positions.*
Output	Typer

* Extreme caution should be used when using this function as there are many core locations that must not be changed. Before making a core location content change, always make a core location content readout. In this way, it is always possible to restore the core location to its original value should the wrong core location be changed.

Example: To change the content of core location 24200 to 20455, set up the computer room control panel as above with 24200 in the ADDRESS register and the value +0020455 in the VALUE register. When the ENTER button is pushed, the following message is typed out:

(Time and Date) COMPUTER CORE ADDRESS 24200
CONTENT CHANGED to 20455.

9.3 Inhibit, Restore Contact Sequence on Printer

Control Panel	Computer Room
FUNCTION SELECT	3
DATA HOLD	Depressed
ADDRESS	Not Used
VALUE	0 is inhibit 1 is restore
Output	Typer

When the ENTER button is pushed, one of the following messages will be typed:

(Time and Date) CONTACT CLOSURE SEQUENCE ON LINE PRINTER INHIBITED
(Time and Date) CONTACT CLOSURE SEQUENCE ON LINE PRINTER RESTORED

If no message appears, it means that the condition requested already is in effect.

9.4 Read in a Message and Put it on Drum

Control Panel	Computer Room
FUNCTION SELECT	4
DATA HOLD	Depressed
ADDRESS	Not Used
VALUE	Not Used
Input	Paper Tape Reader
Output	Typer

Position the message tape in the reader and turn the reader on. TAPE COLUMNS toggle switch should be set to 7. DELETE CODE toggle switch should be set to READ. When the ENTER BUTTON IS PUSHED, THE MESSAGE WILL READ IN AND BE TYPED OUT TO VERIFY THAT IT IS CORRECT.

The parity light has no meaning unless the message did not read to its end. For an incomplete read, no verification will be typed out. If this happens, reposition the message at the start and try again.

Continuous failure in reading can mean that the message tape has a parity error, or that the reader is not working properly. In the latter case, an instrument technician should be notified.

9.5 Read in N-16 Coefficients

Control Panel	Computer Room
FUNCTION SELECT	5
DATA HOLD	Depressed
ADDRESS	Not Used
VALUE	Not Used
Input	Paper Tape Reader

Position the coefficient tape in the reader and turn the reader on. TAPE COLUMNS toggle switch should be set to 7. DELETE CODE toggle switch should be set to READ.

The parity light has no meaning unless tape stops before the end of the coefficient data. In case a parity error was really detected, try reading the tape again from the start. Continuous failure can mean that the tape does have a parity error, or that the reader is not working properly. In the latter case, an instrument technician should be notified.

9.6 Write End of File and Unload Magnetic Tape

Control Panel	Computer Room
FUNCTION	6
DATA HOLD	Depressed
ADDRESS	Not Used
VALUE	Not Used
Output	Typer

All magnetic tapes should be unloaded by way of this function; Otherwise, the tape will not have an end of file mark on it. This is important if any further processing of these tapes is to be done on the 360/75 computer system.

Response to this function is not immediate, so wait at least 2 minutes for the unload to occur.

This function will work only when the MAG TAPE NEEDS REEL CHANGE message has come out on the reactor control room typer. This message appears when the record count has reached 2500. To unload a type that has not written 2500 records, change location 05740 to 04704 (refer

to core location content change in Section II.9.2 and wait for the above mentioned message to appear).

Refer to magnetic tape reel change procedure in Section V.6.

9.7 Inhibit or Restore Magnetic Tape Output

Control Panel	Computer Room
FUNCTION SELECT	7
DATA HOLD	Depressed
ADDRESS	Not Used
VALUE	0 is inhibit 1 is restore
Output	Typewriter

When the ENTER button is pushed, one of the following messages will be typed:

(Time and Date) MAG TAPE OUTPUT INHIBITED
(Time and Date) MAG TAPE OUTPUT RESTORED

If no message appears, it means that the condition requested already is in effect.

9.8 Signal Transfer to PDP-15

Control Panel	Computer Room
FUNCTION SELECT	8
DATA HOLD	Depressed
ADDRESS	Not Used
VALUE	Not Used
Output	Typewriter

When the ENTER button is depressed, the following message will appear on the computer room typewriter:

(Time and Date) VALUES SENT TO THE PDP-15

This means that all current values of the analog signals and all current configurations of the contact closure words have been transferred to the PDP-15.

9.9 Drum Location Content Read and Drum Location Content Change

Control Panel	Computer Room
FUNCTION SELECT	9

DATA HOLD	Depressed
ADDRESS	Low order 5 digits of drum address*
VALUE	Transfer direction, drum module (high order digit of drum address), and new content if a change is being made.**
Output	Typer

* This address can be any octal value of 00000 through 77777 when referring to drum module 0 or any octal value of 00000 through 71377 when referring to drum module 1.

** The value will have the form of +xyzzzzz where:

x is the transfer direction
 x = 0 is drum location content read
 x = 1 is drum location content change

y is the drum module No.
 y = 0 is drum addresses 000000 through 077777
 y = 1 is drum addresses 100000 through 171377

z is the new value if a change in content was specified. That is, if

x = 1, z = new content value. If
 x = 0, z is ignored.

Extreme caution should be used when using this function. An incorrect transfer can alter the system program and cause a failure. If in doubt as to what you are doing, do not use this function.

Example: To read the contents of location 021367 on the drum, set up the computer room control panel as above with 21367 in the ADDRESS register and 00zzzzzz (the z values are ignored) in the VALUE register. When the ENTER button is pushed, the following message will be typed:

(Time and Date) DRUM ADDRESS 0 21367 CONTENT IS
 12345

To change drum location 021367 to 54321, set up the computer room control panel as above with 21367 in the ADDRESS register and +1054321 in the VALUE register. When the ENTER button is pushed, the following message will be typed:

(Time and Date) DRUM ADDRESS 0 21367 CONTENT
 CHANGED TO 54321

10. REQUEST FUNCTIONS AVAILABLE AT SYSTEM CONTROL PANEL

The following are the request functions available at the computer system control panel in the computer room. It is important to note that all the request functions listed in the ATR data system catalog of output requests are not available at the computer system control panel. The following function descriptions are only a brief outline. More detail and samples of output can be found in the ATR Data System Catalog of Output Requests. This list is intended to be a quick reference for someone who is already familiar with these functions.

10.1 Single Analog Parameter Value

Control Panel	Computer Room Control Room Second Basement
FUNCTION SELECT	1
DATA HOLD	Not Depressed
ADDRESS	Not Used
VALUE	Data Point No.*
Output	Typer

*Values +0000001 through +0000768

Refer to ATR Data System Catalog of Output Requests for signal number identification.

10.2 Contact Closure Configuration (By Word)

Control Panel	Computer Room Control Room Second Basement
FUNCTION SELECT	2
DATA HOLD	Not Depressed
ADDRESS	Not Used
VALUE	Contact Word No.*
Output	Typer

*Values +0000001 through +0000040

Refer to ATR Data System Catalog of Output Requests for contact word number and contact bit identification.

10.3 Health Physics Stack Calibration Constants Entry

Control Panel	Computer Room
FUNCTION SELECT	10
DATA HOLD	Not Depressed
ADDRESS	Instrument No.*
VALUE	Calibration Constant**
Output	Typer

<u>*Instrument</u>	<u>Address</u>
Any-1 (Beta-Gamma)	00001
Any-2 (Alpha)	00002
Any-3 (Gas)	00003
Any-4 (Gaseous)	00004

**Format of the constant is +xx000yy
where:

xx is a two-digit value of the form .xx
yy is the exponent to the base 10 of xx

Example: To change the beta-gamma calibration constant to 2.1×10^{-10} , rewrite the number such that the significant digits are a decimal fraction (that is, $.21 \times 10^{-9}$). Set up the computer control panel as above with 00001 in the ADDRESS register and +2100009 in the VALUE register.

When the ENTER button is pushed, a typer message will appear that explains which constant was changed and to what value.

10.4 Reactor Power Parameters Group

Control Panel	Computer Room Control Room Second Basement
FUNCTION SELECT	4
DATA HOLD	Not Depressed
ADDRESS	Not Used
VALUE	Not Used
Output	Typer

10.5 Control Rod and Shim Positions Group

Control Panel	Computer Room Control Room Second Basement
FUNCTION SELECT	5
DATA HOLD	Not Depressed
ADDRESS	Not Used
VALUE	Not Used
Output	Typewriter

10.6 Xenon and Samarium Transient Projection

Control Panel	Computer Room Control Room Second Basement
FUNCTION SELECT	6
DATA HOLD	Not Depressed
ADDRESS	Not Used
VALUE	New Power Value*
Output	Line Printer

*New total reactor power value in MW. Values of +0000000 through +0000300.

10.7 Contact Closure Sequence

Control Panel	Computer Room Control Room Second Basement
FUNCTION SELECT	7
DATA HOLD	Not Depressed
ADDRESS	Not Used
VALUE	Not Used
Output	Line Printer

10.8 Shim Suggest

Control Panel	Computer Room Control Room Second Basement
FUNCTION SELECT	8
DATA HOLD	Not Depressed
ADDRESS	Not Used

10.8 Shim Suggest (Cont'd.)

VALUE	Power and Lobe Information*
Output	Line Printer

*Power and Lobe information of the form +00 x yyyz

where:

x is the priority
 yyy is the power
 z is the lobe number,
 or subfunction number

10.9 Poison Concentration Summary

Control Panel	Computer Room Control Room Second Basement
FUNCTION SELECT	9
DATA HOLD	Not Depressed
ADDRESS	Not Used
VALUE	Not Used
Output	Typer

10.10 Cancel Previous Requests

Control Panel	Computer Room Control Room Second Basement
FUNCTION SELECT	10
DATA HOLD	Depressed
ADDRESS	Not Used
VALUE	Not Used
Output	Typer output is stopped at the end of line presently typing.

III. DATA SYSTEM LINE PRINTER AND SATELLITE CONSOLES

This section gives a brief description of the line printer and satellite console. It also describes request functions available from the satellite consoles, and provides an interpretation of special messages appearing on the consoles and line printer. Where the messages require corrective action, such action is discussed.

1. GENERAL DESCRIPTION OF SATELLITE CONSOLE AND LINE PRINTER

There are three satellite consoles located in the ATR building. Two satellite consoles are located in the second basement and the other console is located in the ATR control room. Each console contains a typewriter and a System Control Panel. The typewriter is a ball-type, stationary carriage machine capable of typing 15 alphanumeric characters per second. The typed lines are generated under computer control and provide requested data, automatic data logging, or messages related to the operation of the computer system itself.

The System Control Panel permits the selection and initiation of nonprogramming functions. Such functions are described in detail in the ATR Data System Catalog of Output Requests. (A catalog is located at each satellite console.) Provided below is a description of the function of the switches on the system control panel which are used to make requests:

- (1) Each panel has a key operated on/off switch which activates or deactivates the panel.
- (2) The address register thumbswitches on each panel are presently not used for any requests.
- (3) The value register thumbswitches on each panel are used to enter data (right-adjusted decimal numbers) or to identify a particular request.
- (4) The FUNCTION SELECT knob on each panel is used to identify one of ten positions (windows). A unique request or program function is assigned to each of these windows.
- (5) The DATA HOLD button, when depressed, identifies a second set of ten functions for the FUNCTION SELECT knob.
- (6) The ENTER button, when pushed, activates an interrupt and enables the transfer of the switch information from the panel to the system. This sets in motion the operations to acknowledge the request. The maximum backlog of requests to the system is eight.

The line printer produces printout in accordance with data supplied from the CDC-636. The printer essentially consists of an engraved printer roll that rotates over a row of solenoid actuated print hammers. As each row of characters on the print roll turns into printing position over the print hammers, pulses identifying the character are generated. Data

transferred for a line of information is stored in an internal buffer. The code stored in each column position of the buffer is compared with the code of the print roll character in printing position. If the codes are the same, the corresponding print hammer is actuated to press the inked ribbon against the print roll, printing the character for that column.

2. REPAIR PROCEDURE FOR LINE PRINTER AND SATELLITE CONSOLES

Any abnormalities detected in the operation of the output devices or satellite consoles should be noted in the log book located in the computer room. Additionally, an instrument technician should be called to locate and correct the abnormality. In the case of a typer malfunction, the instrument technician will generally replace the inoperative typer with a spare (if available) and report this occurrence such that an IBM service representative can be notified.

3. INTERPRETATION OF SPECIAL MESSAGES ON OUTPUT DEVICES

A number of output messages is generated by the computer which indicates a system abnormality or the status of the system. Such messages and their interpretation are described in the following pages. These messages may be generated on one of the satellite consoles, on the typers located in the computer room, or on the line printer. These messages are important and should not be ignored. Thus, the output of the devices should be periodically checked to detect their presence. Should they occur, the appropriate response will be found in the following discussion of each of them.

3.1 Message: "COMPUTER UTILIZATION FACTOR XX.X PERCENT"

OUTPUT DEVICE(S) ON WHICH MESSAGE APPEARS: Computer room typer

INTERPRETATION: This message appears every hour on the computer room typer. It indicates the amount of time the computer has been active during the previous hour. Normally, when the reactor is at a stable power level, this factor is approximately 46-56 percent. At other times (after a reactor scram, during shutdown, and during startup) the factor may be as high as 60 percent.

ACTION: See Section VII.1.2.

3.2 Message: "SIGNAL NO. XXX ON TERM. XXXXX CUT FROM SCAN XXXXX XXXX"

OUTPUT DEVICE(S) ON WHICH MESSAGE APPEARS: 1. Computer room typer
2. Line printer

INTERPRETATION: Unusually noisy signals are automatically removed from the computer scan and are replaced by a 0 mV standard signal. When this happens, the computer room typer and the line printer both output the above message. An example of an output is given below:

(TIME AND DATE) SIGNAL NO. 226 ON TERM 00341 CUT FROM SCAN 24200 04341

This message means that Signal No. 226, which is connected to octal terminal No. 341, has been replaced in the scan by the 0 mV standard signal. Signal No. 226 occupies location 24200 in the scan list and normally should contain the octal value 04341. The number 04341 is a code identifying the terminal number (341) and the expected signal noise level (± 4 bits). When this signal is replaced by the 0 mV signal, the scan list location is automatically changed to 04455.

ACTION: In the event a large number of signals is being deleted from scan or if the same signal is repeatedly deleted from scan, this fact should be noted in the computer room log book and an instrument technician should be contacted.

3.3 Message: "SCAN CONTROL LIST RESTORED COMPLETE"

OUTPUT DEVICE(S) ON WHICH MESSAGE APPEARS: 1. Control room typer
2. Line printer

INTERPRETATION: Every hour the computer should automatically restore the scan list to its proper configuration. Spurious noise often results in signals being deleted from scan. Since these signals should be restored to the scan list, all signals are automatically restored in the scan list every hour. The above message will appear only when the list has been restored and if a signal has been deleted from the scan during the previous hour. This restore feature can also be manually requested (See ATR Data System Catalog of Output Requests). In this case also, the above message will appear only if a signal has been deleted from the scan since the last time the list has been restored.

ACTION: After recognizing this message, determine what signals were deleted from scan and then follow the action procedure described in Section VII.1.3

3.4 Message: "MAG TAPE NEEDS REEL CHANGE"

OUTPUT DEVICE(S) ON WHICH MESSAGE APPEARS: Control room typer

INTERPRETATION: When 2500 (decimal) records have been written on a magnetic tape, this message appears on the control room typer once every minute until the magnetic tape is changed. If this message is not heeded, records will continue to be written up to the end of the reel. Should this happen it is not possible to write an end-of-file mark on the tape, which in turn makes data retrieval from the tape very difficult.

ACTION: Contact an instrument technician and inform him of the need for a magnetic tape reel change.

3.5 Message: "LINE PRINTER SEQUENCE LISTOUT RESTORED (INHIBITED)"

OUTPUT DEVICE(S) ON WHICH MESSAGE APPEARS: Computer room typer

INTERPRETATION: The output of contact closures and a xenon transient occur automatically following a scram, setback, or reverse. This feature can be inhibited or restored, as described in Section II.9.3. When this feature is restored or inhibited the above message may appear on the computer room typer. This message will appear only if the condition of the feature has been changed.

ACTION: This message is for information. No action is required. However, this feature must not be inhibited during reactor operation, unless the Shift Supervisor permits such action. When the reactor is operating, the CDC-636 checks once an hour to see if the sequence has been inhibited. If it has been inhibited, the computer automatically restores the sequence.

3.6 Message: "INHIBIT (RESTORE) MAG TAPE OUTPUT"

OUTPUT DEVICE(S) ON WHICH MESSAGE APPEARS: Computer room typer

INTERPRETATION: The transfer of data from the computer to magnetic tape can be inhibited or restored as described in Section II.9.7. When this transfer is restored or inhibited the above message will appear on the computer room typer only if the condition of this transfer has been changed.

ACTION: This message is for information. No action is required. However, the transfer of data to magnetic tape must occur during reactor operation. Thus, except under unusual circumstances for which Shift Supervisor permission is obtained, this transfer shall not be in the inhibited condition. When the reactor is operating, the CDC-636 checks once an hour to see if the magnetic tape output has been inhibited. If it has been inhibited, the computer automatically restores the output.

3.7 Message: "SIGNAL VARIANCE GREATER THAN DELTA - X.XX XX.XX X.X"

OUTPUT DEVICE(S) ON WHICH MESSAGE APPEARS: Line printer

INTERPRETATION: There are three standard analog signals in the computer scan: (a) a 0 millivolt signal, (b) a -5.2 millivolt signal, and (c) a 42.08 millivolt signal. When these signals (as all other analog signals) are scanned, they pass through the multiplexer, amplifier, and the analog-to-digital converter. The digital representation (from the A/D converter) of these signals is then used to calculate an equivalent millivolt value. When the sum of these three millivolt values differs by a preassigned value from the expected value, the above message appears on the lint printer. The appearance of this message can mean trouble in the multiplexer, amplifier, or A/D converter. If one or more of these standard signals are abnormal, possibly all or some of the analog signal values are being perturbed. However, it is possible that only one (or more) of the standard signals are noisy. In either case, these messages must not be ignored.

3.7 Message: "SIGNAL VARIANCE GREATER THAN DELTA . . ." (Cont'd.)

ACTION: If the appearance of this message is regular, note this in the computer log book and contact an instrument technician.

3.8 Message: "LINE PRINTER OUT OF OPERATION"

OUTPUT DEVICE(S) ON WHICH MESSAGE APPEARS: Computer room typer

INTERPRETATION: The above message means that the line printer has been turned off or is out of operation. It also means that the output load of the line printer will be automatically transferred to the control room typer (the backup device for the line printer) which is a much slower device and which may not be able to handle the load fully.

ACTION: If the line printer has been turned off, it should be turned back on. If the line printer is malfunctioning, call an instrument technician.

3.9 Message: " _____ TYPER OUT OF OPERATION"

OUTPUT DEVICE(S) ON WHICH MESSAGE APPEARS: Computer room typer

INTERPRETATION: This message indicates that a typer has been turned off or is out of operation. The leading two words of the message can be: (a) 2nd BASEMENT, (b) 1st BASEMENT, or (c) CONTROL ROOM. This means that the output load for that typer will be transferred to its backup device, increasing its load but preserving data.

ACTION: Check that the typer has not been turned off. If so, turn it on. If the typer is out of operation, refer to the repair procedure (see Section III.2).

3.10 Message: "MAG TAPE UNIT NOT ON READY STATUS"

OUTPUT DEVICE(S) ON WHICH MESSAGE APPEARS: Control room typer

INTERPRETATION: If the magnetic tape unit is not on ready status (indicated by the ready light on the magnetic tape unit) the magnetic tape unit will not accept information from the computer.

ACTION: Call an instrument technician to get the magnetic tape unit back on ready status.

3.11 Message: "TAPE UNIT SLOW TO RESPOND TO COMMAND"

OUTPUT DEVICE(S) ON WHICH MESSAGE APPEARS: Control room typer

INTERPRETATION: If the magnetic tape unit diagnostic circuitry indicates to the computer that excessive time has elapsed since a write command has been given or that no successful conclusion of the writing operation was obtained, the above message appears on the reactor control room typer.

ACTION: An instrument technician should be called when this message appears. 69: 36

4. ILLEGIBLE TYPER OUTPUT

Sometimes a typer will become locked in upper case. This will give illegible output similar to the sample below:

[illegible]

ACTION: This problem can be corrected by making any request of a contact closure word. Refer to Section II.10.2 for request operation for contact closure word. If this fails to work, contact an instrument technician.

5. RESTRICTION ON BASEMENT SATELLITE CONSOLES

The basement satellite consoles are for the output of sponsor information and for the output of analog signal values during loop maintenance. Any unnecessary requests from these consoles restrict the amount of time the console can devote to these purposes. All output from these consoles should be considered classified, and disposition of this output shall be determined by ATR Operations, in compliance with established procedures.

6. FUNCTIONS AVAILABLE AT SATELLITE CONSOLES

Located at each satellite console is a copy of "ATR Data System and Catalog of Output Requests from Satellite Consoles". This catalog describes in detail available output options from the satellite consoles and how to make requests. Additionally, a sample output is shown for each type of output in the catalog. These catalogs are updated whenever changes in the data system affect this catalog.

IV. MAGNETIC DRUM MEMORY SYSTEM

This section briefly describes the magnetic drum memory system. It also provides interpretation of the switches and indicators on the drum logic control panel.

1. GENERAL DESCRIPTION OF DRUM

The drum in the ATR computer provides bulk storage for the system. It has a potential for 256 tracks, and each track is 256 words long. To be functional, each track must have its own read-write head. Since, at present, only 244 tracks have read-write heads, the drum has approximately a 62 K word capacity. This capacity is reserved as follows:

- 32 K for message skeletons (ie, 2000 skeletons)
- 16 K for history storage (ie, 4000 history storages)
- 8 K for calculational routines
- 4 K for message skeletons and program for unraveling and output of 5-minute prior history (a feature not yet implemented)
- 2 K for paper tape load and unload of the computer

The drum rotates at 1800 rpm. Thus, half-track access time is ~ 16 msec.

2. REPAIR PROCEDURE

Any abnormalities detected in the operation of the magnetic drum should be noted in the log book located in the computer room. Additionally, an instrument technician should be called to locate and correct the abnormality.

3. DRUM LOGIC CONTROL PANEL

The drum logic control panel contains a number of switches and indicators. Described below is the function of each of these switches and indicators:

MODE SELECT SWITCH - This switch determines the aspect of the drum logic (ie, OFF, FINISH RUN, and NORMAL). When operating, the aspect of this switch is NORMAL. The FINISH RUN position allows the drum to finish the current read or write operation.

ERROR RESET - The error reset button allows any error signal to be reset if the mode selection is at OFF.

IDLE - This light illuminates when the drum is not performing a read or write operation.

TIMING ERROR - This light illuminates if the timing signals obtained from the drum unit and developed by the drum counters do not agree.

DRUM SPEED - This light illuminates if the speed of the drum falls outside acceptable limits.

GUARDED ADDRESS - This light illuminates if a core-to-drum transfer is attempted to a drum area not permitted by the permissible track switches.

DPE - This light illuminates if a parity error is detected when a word is read from the drum storage.

DTPE - This light illuminates when a parity error is detected in a word transferred to the drum.

CWPE - This light illuminates when a parity error is detected in one of the three drum control words read from the core.

LOWEST RECORDING TRACK ADDRESS - This bank of 10 toggle switches determines the lowest track number on which information may be recorded (it is imperative that the configuration of these switches not be changed except when the mode select switch is at OFF).

V. MAGNETIC TAPE TRANSPORT UNIT

This section discusses some of the characteristics of the magnetic tape transport unit. In addition, the interpretation of the indicators on the magnetic tape logic panel and the procedure for changing data tapes are given.

1. GENERAL DESCRIPTION OF MAGNETIC TAPE TRANSPORT UNIT

The Model 642 Magnetic Tape Transport is an auxiliary storage device for computer system information. When the proper computer instruction is executed, the tape unit performs either a read or write operation. Data are transferred from the computer to the tape unit in multiples of a record, where a record is 2048 words (15 bits/word) long. The transfer from tape to core is also performed in multiples of a record, but the record length can be variable. Once a transfer is initiated, the actual transfer proceeds without any loss of computer calculational time because the data are transferred through an independent external access channel. A parity error occurring during the transfer of data from the magnetic tape to the computer or from the computer to the magnetic tape is indicated by parity lights on the magnetic tape logic panel.

2. REPAIR PROCEDURE

Any abnormalities detected in the magnetic tape transport unit should be indicated in the log book located in the computer room. In addition an instrument technician should be called to determine the cause of the abnormality. Questions regarding proper operation of the magnetic tape transport unit should be referred to one of the programmers or maintenance personnel on the Trouble Call List (located by the telephone in the ATR computer room).

3. MAGNETIC TAPE LOGIC PANEL INDICATORS

On the magnetic tape logic panel, there are 15 indicator lamps. The three lamps grouped at the left of the panel are the TAPE UNIT ADDRESS lamps which illuminate to indicate which tape unit is addressed by the magnetic tape unit logic. The TIMING ERROR lamp indicates that information transfer was not synchronized with the computer. The PROGRAMMING ERROR indicator lamp illuminates if the tape logic is busy, if an improper function code occurs, or if there is an illegal BCD indication in the even parity mode. The SHORT RECORD and LONG RECORD indicators show that the record on the tape is shorter or longer, respectively, than the length specified by the program.

There is also a bank of indicators at the right of the panel which are identified by numbers representing the tape channels. The first indicator, identified by the letter T, indicates a transverse parity error in the record just read. The other indicators, numbered from 7 to 1, show a longitudinal parity error in the channel denoted by the illuminated lamp.

4. RECORD COUNTER LOCATION

The computer keeps track of the number of records (2048 words/record) written on a magnetic tape. The computer core location (in octal) in which the number of records is stored is 05740. The ATR cycle history tapes will hold in excess of 2500 records.

5. RECORD FREQUENCY

The computer transfers data to the magnetic data tape once every minute. The transfer takes place only when there are one or more records to be transferred. Every minute, the number of records available for transfer is checked. The transfer will then take place whenever there is at least one full record of history (2048 words/record) available for transfer. Normally (at a steady power level) one or two records of history are transferred every minute. The number of records transferred can be easily counted, because the mag tape stops momentarily between the writing of each record.

6. MAGNETIC TAPE REEL CHANGE PROCEDURE

When the magnetic tape unit has written 2,500 records of reactor history on a magnetic tape reel, the message "MAG TAPE NEEDS REEL CHANGE" begins to be typed out on the reactor control room typer. It is repeated once each minute until a change of magnetic tape reel is performed. The following procedure shall then be followed. Step 5 and 6 of this procedure shall be followed when loading computer loader tapes.

1. Inspect the next magnetic tape reel ready for mounting. It is the reel with the number immediately following the number of the tape just removed. When the last reel is used in the mag tape storage cabinet, the tapes will be reused, starting with the first tape in the cabinet. Verify that a write ring is firmly in place in the groove on the reel surface.
2. Enter the present time, plus two minutes, in the log book as the final time on the full reel. Also enter the initial time for the reel to be mounted.
3. Turn the console FUNCTION SELECT switch to illuminate window 6, and depress the DATA HOLD button. When less than a minute remains until the change time entered in the magnetic tape log book, depress the ENTER button.
4. Within one and one half minutes, the computer should respond by writing a file mark on the tape, rewinding the full tape, and unloading the tape unit. The following message should appear on the computer console typer: "MOUNT NEW TAPE REEL AND READY TAPE UNIT."

5. Mount the new reel and thread the tape around the idlers and onto the take-up reel. With four or five winds on the take-up reel, rotate the idlers to the down position and tighten the tape as tight as the idler motion allows.
6. Depress the LOAD button. Loops of tape should drop into the vacuum columns, and the tape should advance to the load position, as indicated by the illumination of the LOAD button. Excessive searching for the load point indicates that the initial mounting has bypassed the load point reflective strip. In that case, hit the CLEAR button and then the REWIND button. The tape should position at the load point. When the LOAD button is lighted, depress the READY button. The tape unit is ready for operation when both buttons are lighted.
7. If for any reason the tape unit does not achieve the ready status, the following message appears each minute on the reactor control room typer: "MAG TAPE UNIT NOT ON READY STATUS". If such a message appears, hit the CLEAR button and then the READY button of the tape unit. Call an instrument technician if the message persists.
8. The dismounted full reel should have the write ring removed. Put it into a protective reel case, and place it in its appropriate position (by number) in the magnetic tape storage cabinet.
9. A preliminary check, corresponding to item 1 above, should be made on the next reel available for mounting, so that any discrepancies or defects may be corrected before the next tape is needed.

When the reel change message first appears, two to five hours of recording capacity still remain on the reel. Thus, immediate response, although desirable, is not essential and no immediate threat of data loss is present.

7. MAGNETIC TAPE OUTPUT INHIBIT AND RESTORE FEATURE

Available at the computer system control panel is a feature to inhibit or restore the transfer of data from the computer to the magnetic tape. This feature is described in Section II.9.7. This feature was incorporated into the system so that the useless data transfer during reactor shutdown can be inhibited. However, it is essential to restore the data transfer from computer to tape prior to reactor startup.

VI. OPERATING CHARACTERISTICS OF CDC-636 PROGRAMS

This section discusses some of the operating characteristics of the systems and engineering programs. The material presented will enable the user to better utilize the data system for his data requirements.

1. ROUTINES PERFORMED AT REGULAR TIME INTERVALS

5 SEC INTERVAL

- Reset stall alarm
- Update time branch word
- Check typewriters and line printer for message problems
- Check standard Signals

1 MINUTE INTERVAL

- Reactor thermal power
- Loop thermal power
- Stack gas release
- Lobe power
- Xe-Sm inventory up-date
- Transfer history data to tape
- Xe-Sm transient (by request)
- Shim suggest program (by request)
- Contact closure group output (by request)
- All integrations
- ¹⁶N Water power constraint determination

5 MINUTE INTERVAL

- Sum of loop parameters
- Power status group output
- Clock reinitialized
- Check regulating rod being used and place in-use rod in Scan Group 1.
- Check for false interrupts

30 MINUTE INTERVAL

All integrated values and poison concentrations are transferred to drum for storage.

60 MINUTE INTERVAL

System utilization factor

Experimental loop log output

Magnetic tape and contact closure restore

24 HOUR INTERVAL

Output experimental loop values for 24 hour period.

2. STANDARD SCAN GROUPS

The analog signals multiplexed by the ATR data system are divided into four different scan groups. Each of the signals in each group are scanned at the same rate. However, each group has a different scan rate associated with it. Shown below are typically the four groups of signals and their scan rates.

ANALOG SCAN PRIORITY ASSIGNMENTS

GROUP 1	<u>Signal</u>	<u>No. of Signals</u>	<u>Approximate Scan Rate of Each Signal</u>
	Neutron Level Recorders	(4)	4 times/second
	Log N Recorders	(2)	
	Period Recorders	(2)	
	Position of Regulating Rod #1 or Regulating Rod #2	(1)	
GROUP 2	Quadrant Outlet Flow	(4)	1 time/second
	Primary Inlet Temp.	(1)	
	Quadrant ΔT	(4)	
	Reactor Inlet Pressure	(1)	
	Reactor ΔP	(1)	
	N ¹⁶ Monitors	(10)	
	Rapid Fission Break Monitors	(2)	
	Loop Inlet Flow	(6)	
	Loop Inlet Pressures	(6)	
	Standard Signals	(3)	
	Palm Position	(1)	
	Analog Signals for Special Tests	(8)	

GROUP 3	<u>Signal</u>	<u>No. of Signals</u>	<u>Approximate Scan</u>
			<u>Rate of Each Signal</u>
	Outer Shim Positions	(8)	1 time/30 seconds
	Quadrant Outlet Temp.	(4)	
	Primary Outlet Temp.	(1)	
	Stack Radiation	(4)	
	Stack Pressure, Temp. Flow	(3)	
	Heat Exchange Radiation	(5)	
	Loop Outflow	(6)	
	Loop ΔP	(6)	
	Loop Inlet and Outlet Temp.	(12)	
	Three thermocouples per loop	(18)	
	Primary and Secondary Outlet ΔP	(10)	
	Primary System ΔT	(1)	
	Secondary System Flow	(1)	
	Secondary System Inlet Temp.	(1)	
	Secondary System ΔT	(1)	
	15 Auxiliary Neutron Detectors	(15)	
	S and NW CALM Positions	(2)	
	Log Count Rate Recorders	(2)	
GROUP 4	Diesel Unit Information	(10)	1 time/3-1/2 minutes
	Primary and Secondary pH and Conduct	(5)	
	Loop Inlet and Outlet Temp.	(12)	
	Loop IX Flow	(4)	
	Loop ΔP	(6)	
	Loop ΔT	(6)	
	Loop Outflow	(6)	
	Loop Inlet Temp. Backups	(6)	
	16 Thermocouples per loop	(96)	
	Position of Reg. Rods #1 or #2		

3. ^{16}N MASK WORD

Word 27736₈ is used to tell the computer which ^{16}N detectors are to be used in the ^{16}N determined lobe power calculation. Normally all the detectors are used in the calculation. The exception would be when a detector fails. The word also tells the computer what degree of water power normalization is to be used. In other words, a full water power constraint would mean the sum of the five lobe powers would equal the average reactor water power (computer value). The bit configuration for the above word is shown below.

The normal representation for this word is 77743₈ which says that all 10 ^{16}N s are used in the calculation with a full water power constraint. If a water power constraint was not wanted, the actual representation of the word would be 77740₈. A 1 or 2 value for the last digit would mean some intermediate water power constraint.

4. ^{16}N MULTIPLIERS

Since the computer does not directly monitor the output of the ^{16}N detectors but only a value proportional to the detector reading, a constant (multiplier) is used to multiply this input to make it representative of the ^{16}N detector output. Thus, if there is a gain change on an amplifier for a particular ^{16}N detector, the output of the ^{16}N detector would still be the same, but the computer would see a decrease or increase in signal depending on the gain change. A corresponding change in the multiplier for that ^{16}N would be made which would adjust the signal sensed by the computer accordingly. In addition, the multiplier compensates for variations in piping lengths, sensitivities, etc., for the different ^{16}N channels. A current list of the ^{16}N multipliers is displayed in the ATR Data System Room.

5. INTERVAL OF INTEGRATION FOR INTEGRATED QUANTITIES

All the integrated quantities are updated every minute. However, since it is impractical to integrate these quantities over the lifetime of the reactor, an interval of integration is defined for each integrated quantity. At the end of the interval of integration, these quantities are zeroed, and the integrations are resumed. Shown below are the integrated quantities and their interval of integration:

<u>Integrated Quantity</u>	<u>Interval of Integration</u>
Average Reactor Thermal Power	Fuel Cycle
Sum of Quadrant Thermal Powers	Fuel Cycle
Total Reactor Thermal Power	Fuel Cycle
Center Lobe Power	Fuel Cycle
Northeast Lobe Power	Fuel Cycle
Northwest Lobe Power	Fuel Cycle
Southeast Lobe Power	Fuel Cycle
Southwest Lobe Power	Fuel Cycle
Stack Alpha Activity Release Rate	Cycle
Stack Beta-Gamma Particulate Activity Release Rate	Cycle
Stack Fission Gas Activity Release Rate	Cycle
Poisons Inventory	Fuel Cycle
Quadrant #1 Thermal Power	Fuel Cycle
Quadrant #2 Thermal Power	Fuel Cycle
Quadrant #3 Thermal Power	Fuel Cycle
Quadrant #4 Thermal Power	Fuel Cycle

6. PARAMETERS STORED ON CYCLE HISTORY TAPE

The parameters stored on magnetic tape are listed below:

- (1) All Analog signals which go through only an engineering unit's conversion are stored. This includes signals which go through a linear, resistance bulb, flow, period, logarithmic, or thermo-couple conversion routine. This does not include parameters such as thermal power, stack release rates, and most of the integrated quantities. All of the loop parameters are not stored on tape because they constitute classified information.
- (2) All of the contact closure words which have changed are stored.
- (3) Lobe powers from ^{16}N calculation are stored.
- (4) Integrated lobe powers over eight hours are stored.

An analog signal is not converted to its engineering unit's value until it has changed by a prescribed delta, and thus is not stored on magnetic tape until it has changed by that delta. A contact closure word is stored on magnetic tape only if a bit has changed in the word.

7. INHIBIT ON POWER DISTRIBUTION CALCULATION AND OUTPUT

There is an automatic inhibit on the power distribution calculation and the five-minute interval printout of power distribution status until all three of the following conditions exist: (a) run button energized, (b) all safety rods at upper limit, and (c) above N_L .

When all three of the above conditions do not exist, the thermal powers are not calculated. This condition also prohibits lobe power integrations, zeroes the lobe powers, and suppresses the five-minute power distribution output. The poison inventory calculations are continued using zero lobe powers, in order to keep the poison transients up-to-date.

8. ^{16}N WATER POWER CONSTRAINT DETERMINATION

Whenever a large discrepancy exists between the total reactor and the sum of the quadrant thermal powers, the ^{16}N power normalization is altered automatically.

The ^{16}N lobe powers are normally fully normalized to the average reactor thermal power. The average reactor power is the average of the total reactor and sum of the quadrant thermal powers. Thus, if either or both of the reactor or quadrant thermal powers is in error, it will cause an error in the average power value. This will in turn cause an error in the absolute values of the lobe powers determined by the ^{16}N system.

Once a minute the CDC-636 computes the ratio of the total reactor thermal power and the sum of the quadrant thermal powers. Based on the value of this ratio, the degree of normalization to thermal power is changed. The change in the normalization is reflected in the ^{16}N mask word. Specifically, the last digit of the word indicates the degree of the normalization (eg, a 3 indicates a full normalization, while a 0 indicates a minimum normalization). Shown below is the value of the last digit of the ^{16}N mask for various values of the ratios:

		Digit of <u>^{16}N Mask Word</u>
<u>Smallest of the two water powers</u>	≥ 0.984375	3
<u>Largest of the two water powers</u>	≥ 0.9375 and ≤ 0.984375	2
	≥ 0.75 ≤ 0.9375	1
	< 0.75	0

VII. ATR DATA SYSTEM OPERATIONAL CHECKS

The ATR Data System monitors its own operation. When an abnormality is detected the system outputs a message describing the abnormality. Since it is impractical to monitor the entire data system operation, only those aspects of operation that are most likely to fail are monitored. In order to provide surveillance of those operational aspects not monitored by the system, additional checks of the system are required. This section discusses these additional checks and the frequency at which they should be made.

1. TWENTY-FOUR-HOUR OPERATIONAL CHECKS

Every 24 hours certain checks of the ATR Data System are necessary to insure the system is operating properly. Described on the following pages are system checks which should be performed once a day.

1.1 Classified Output on Computer Room Typer

Once each day the computer room typer should be checked for classified output which might have backed up from the basement typers. The disposition of this output will be determined by the ATR Shift Supervisor.

1.2 Computer Utilization Factor

Every hour the ATR Data System prints out a "Computer Utilization Factor" on the computer room typer. This factor represents the fraction of every hour that the computer was performing desired operations. Normally at a stable power level this factor is $51.0 \pm 5\%$. Computer utilization factors of 57% and larger for several hours are generally abnormal and indicate the data system is spending additional time in a routine or routines. This could be a result of noisy analog signals, programming errors, etc. Small deviations should be noted in the computer room log book. Deviations of 6% or greater from the normal should be indicated in the log book and reported to someone on the Trouble Call List (located next to the telephone in the computer room).

1.3 Signals Deleted from Scan

The ATR Data System will delete an analog signal from the scanning process if it is exceptionally noisy. When this is done, the data system sends a message describing the signal deleted from scan (described in Section III.3.2). It is important to note that in this event, values for the deleted signal values are not stored on magnetic tape and are therefore not available for future reference should abnormal reactor behavior occur. Moreover, if the signal value is used in a calculation, the value previously scanned will be used in that calculation until the scan list is restored. If one or more signals are deleted from the scan every hour, this fact should be indicated in the log book, and an instrument technician should be contacted.

1.4 Records/Minute Transferred to Magnetic Tape

The number of records transferred to the magnetic tape should be 1-2 every minute (see Section V.5) for a stable reactor power level. If this rate increases significantly (ie, 4 or more every minute), it indicates either an impending failure of the multiplexer or problems in plant power supplies. If this rate increases significantly, it should be noted in the log book, and an instrument technician should be contacted.

If no records are being transferred to the magnetic tape during an interval of one or two minutes, it may indicate that the transfer of data has been inhibited (see Section II.9.7). It may also indicate that the magnetic tape unit is not in operation, due to failure or incorrect aspect of a switch. In such an event, an instrument technician should be contacted.

1.5 Error Lights on Magnetic Tape Panel

Once a day the magnetic tape logic panel should be checked for illumination of any of the 12 lights located on the right-hand side of the panel. A brief description of these lights is given in Section V.3. Illumination of any of these lights indicates some abnormality in the transfer of data from the core to the magnetic tape. If any such illumination is detected, that fact should be noted in the log book, and an instrument technician should be notified.

1.6 Error Lights on Drum Logic Control Panel

Once a day the drum logic control panel should be checked for illumination of any of the six error lights located on the right-hand side of the panel. A brief description of these lights is given in Section IV.3. Illumination of any of these lights indicates some abnormality, and this fact should be noted in the log book and an instrument technician should be notified.

2. ONCE EVERY SUBCYCLE OPERATIONAL CHECKS

2.1 ATR Data System MWd vs MWd Determined by Operations

Three types of integrated thermal water power values are computed and are available by request from the satellite consoles. These are (a) integrated total reactor thermal power, (b) integrated sum of the quadrant thermal power values, and (c) integrated average reactor thermal power.

The integrated total reactor thermal power is an integration over the fuel charge of the total reactor thermal power. This thermal power is determined using the total flow (sum of four quadrant flows), overall reactor ΔT , and the reactor outlet temperature. The integrated sum of the quadrant thermal power values is the sum of the four integrated quadrant thermal powers. Each quadrant thermal power is determined using the individual quadrant flow, the individual quadrant ΔT , and the reactor outlet temperature. The integrated average reactor thermal power is merely the average of the above two integrated quantities.

The sponsors are given the value for integrated average reactor thermal power on their data sheets. It is important that this value and that determined by Operations be within 2% of one another. If discrepancies larger than this occur, note this fact in the log book in the computer room and notify someone on the trouble call list.

2.2 Recorder Quadrant and Total Water Powers vs Same Powers Calculated by the Data System

The four quadrant water powers and the total reactor water power indicated by the recorders in the control room should be compared against those same powers calculated by the data system once every sub-cycle. The comparison of each power should be within 2%. Deviations larger than this could indicate trouble upstream of the water power recorders or trouble in the transmission of the signals that the data system uses in determining these powers. If the trouble appears to be with the data system, indicate this in the log book in the computer room and notify someone on the trouble call list.

2.3 TC Reference Box Temperature

Normally the two thermometers inserted in the two TC reference boxes should read $150^{\circ} \pm 2^{\circ}\text{F}$. Readings outside these tolerances should be indicated in the log book in the computer room and an instrument technician should be contacted.

VIII. RECORD KEEPING AND DISPOSITION OF ATR DATA SYSTEM OUTPUT

In order to provide adequate documentation of data system malfunctions, changes, and system's programs; a data system log book, a change board, and spare loading tapes are provided. The proper use of these record-keeping methods is discussed in this section. Additionally, the disposition of the output from the different peripheral devices is discussed.

1. RECORD KEEPING

Described below is the method to be used to document (a) temporary changes in the ATR Data System operation, (b) permanent changes in the ATR Data System operation, (c) abnormal occurrences, and (d) methods used to correct the abnormal occurrences.

1.1 Computer Room Log Book

A log book located above the computer programming rack in the computer room shall be used to record all temporary changes in the ATR Data System operation, the nature of any abnormal occurrences, and the manner in which these abnormal occurrences were corrected. All entries should include a time and date. Examples of each type of entry are given below:

- (1) Temporary changes in the ATR Data System operation--placing experiment thermocouples in a faster scan group, and ¹⁶N multiplier changes.
- (2) Abnormal occurrences--large number of analog signals deleted from scan (including signal number), computer utilization factor too large (including value), and computer stall (including plant conditions at time).
- (3) Manner in which these abnormal occurrences were corrected--description of the suspected cause of the occurrence and the specifics of its correction.

1.2 CDC-636 Core and Drum Location Content Change Board

All changes in core and drum location contents since the system's tapes have last been updated are to be listed on this board located in the computer room. These changes shall be incorporated into the system each time the system is reloaded. After the system's tape has been updated (ie, incorporating the core and drum location content changes necessary since the last tape update), these changes will be deleted from the board. In addition the current list of ¹⁶N multipliers is displayed for convenience on this board.

1.3 Loading Tape

The CDC-636 system's program and the constants used in the calculations (eg, ^{16}N multipliers) are loaded into the computer core using a magnetic tape (loading tape). Thus the loading tape contains a permanent record of the system's program and constants. Any permanent change in the system's program or constants will necessitate an update of the loading tape. This work shall be performed by the ATR Data System programmers. One loading tape is routinely used to load the computer. Two other identical loading tapes are maintained current in case the routinely used tape is misplaced, damaged, or erased. On occasion, time is not available to update all three of the loading tapes; thus, the date of the tapes should always be checked and the tape with the most current date should be used. All three of the loading tapes are stored in the magnetic tape storage rack.

2. DISPOSITION OF ATR DATA SYSTEM OUTPUT

The disposition of all of the printed and typed output from all the output devices is discussed below.

2.1 Line-Printer Output

Once a week the output from the control room line printer is to be placed in an appropriately marked box in the ATR computer room. These data will be subsequently edited and filed by Nuclear Technology personnel.

2.2 Control Room Typer Output

The output from the control room typer may be disposed of in a manner determined by the ATR Operations Branch.

2.3 Computer Room Typer

The computer room typer output will be stored in an appropriately marked box in the ATR computer room. These data will be periodically examined by those responsible for the maintenance and programming of the system.

2.4 Cycle History Magnetic Tapes

Eighty-two magnetic tapes are available for the ATR Data System to record ATR cycle history. These tapes represent approximately a 100-day backlog of cycle history. These 82 tapes will be continuously recycled (ie, when all the 82 tapes have been used, they shall be reused beginning with the earliest tape). Thus, at any one time, 100 days of past cycle history are available for analysis. These tapes are stored in a magnetic tape storage cabinet located in the ATR computer room.

2.5 Basement Typer Output

All the output from the basement typers is to be considered classified material. The disposition of this material will be determined by ATR Operations personnel in compliance with the requirements associated with such information.

IX. ATR DATA SYSTEM OPERATIONAL GUIDELINES

This section discusses the requirements for the data system during reactor operation and shutdown. In addition, guidelines for removing the data system from service during reactor operation or shutdown are discussed.

1. ATR DATA SYSTEM GUIDELINES DURING REACTOR OPERATION

1.1 Definition of "Reactor Operation"

The period of time beginning when the temperature of the first loop is raised above 400°F prior to a scheduled reactor startup and ending 24 hours after a scram for a scheduled reactor shutdown.

1.2 ATR Data System Preparation Prior to Reactor Startup

To insure that the data system is adequately prepared to provide and log reactor data during reactor operation, the following steps should be performed.

- a. Reload the CDC-636 with the systems loading tape showing the most recent date of update.
- b. Check the ^{16}N multipliers in core with those on the core and drum location content change board. (The multipliers on the change board are to be considered valid.)
- c. Load the magnetic tape unit with a data tape.
- d. Restore the contact closure sequence and the magnetic tape output.
- e. Check to make sure data are being transferred to magnetic tape.
- f. Check typers and line printer for proper operation and make sure sufficient paper supplies are available.
- g. Transfer all signal and configuration data to the PDP-15 computer.

1.3 ATR Data System Requirements During Reactor Operation

The data system must, at a minimum, be capable of (a) providing hourly on-line printouts of loop test conditions and (b) providing a lobe power distribution from the ^{16}N system. Capability less than this requires that the data system be removed from service until these minimum capabilities are restored. Reactor operation while the data system is out of service shall be in accord with contingency procedures in the ATR Shim Control Guidelines and the directives supplied by Project Engineering for loop monitoring.

The course of data system operation for system capabilities less than maximum but greater than the minimum defined above will be decided on an individual basis by data system personnel and the ATR Shift Supervisor.

1.4 Guidelines for Taking Data System Out of Service During Reactor Operation

When it is deemed necessary to take the data system off-line during reactor operation, request the following information (if possible) prior to system shutdown:

- (a) Reactor Power Parameters Group
- (b) Poison Concentration Summary
- (c) Xenon and Samarium Transient Projection for 0 MW.
- (d) Core Dump

1.5 ATR Data System Requirements During Xenon Shutdown

The data system is required to be on-line during a xenon shutdown. If the data system is to be removed from service for any reason during this shutdown, approval is required from Project Engineering and the ATR Shift Supervisor.

2. ATR DATA SYSTEM GUIDELINES DURING REACTOR SHUTDOWN

2.1 Definition of "Reactor Shutdown"

The period of time beginning 24 hours after a scram for a scheduled reactor shutdown and ending when the temperature of the first loop reaches or exceeds 200°F, or reactor power reaches N_L , whichever occurs first, prior to a scheduled reactor startup.

2.2 ATR Data System Requirements During Reactor Shutdown

After the reactor has scrammed for a scheduled reactor shutdown, the ATR Data System can be taken off-line following the next 24-hour loop printouts. Prior to removing the data system from service, request the following information:

- a. Reactor Power Parameters Group
- b. Poison Concentration Summary
- c. Xenon and Samarium Transient Projection for 0 MW

2.3 Guidelines for Data System Operation During Reactor Shutdown

ATR Data System operation during reactor shutdown will be scheduled. The scheduling of the data system will be dependent on the demands for system programming, system maintenance, and calibrations of reactor plant equipment requiring the data system.

2.4 System Program Changes During Shutdown for Instrument Calibration

In order to simplify the shutdown checkout and calibration of those ATR instruments tied to the data system, a number of software changes are necessary in the operating program of the CDC-636. Two major inadequacies exist with the system's program when it is used for calibrating. First, most of the loop instrumentation is on a scan rate of approximately once every four minutes. This scan rate requires too much time to calibrate these instruments. Second, the assigned standard signal variance (delta) for each signal prevents, in a number of cases, a precise calibration of the data system to the instrument.

The following core location content changes are recommended for the CDC-636 when the reactor is shut down. These changes make the scan rate for all signals equal to once every three seconds and insure that all signal values for nondeleted signals are updated each scan.

<u>CDC-636 Core Location</u>	<u>Change Content to</u>
1551	00001
1552	00001
1630	02031

In addition to the above changes, an end-of-file should be written on the magnetic data tape on the magnetic tape unit. The magnetic tape should then be removed and the magnetic tape unit shut down.

APPENDIX A - ATR MAGNETIC DATA TAPE READ PROGRAM

1. COMPUTER PROGRAM ABSTRACT

1. TITLE: ATRHIST, Advanced Test Reactor History Retrieval
2. COMPUTER: IBM 360
3. PURPOSE: To retrieve data from the ATR Data System History Tape.
4. SOLUTION: To read, unpack, and sort the tape for hard copy output.
5. RESTRICTIONS: This version limits the plots to 8,192 values per signal. The input tape cannot be read from the remote terminals.
6. RUNNING TIME: Very dependent on size of input and the options used.
7. UNUSUAL FEATURES: This program permits the user to:
 1. Bypass reading to advance the tape to a general area.
 2. Search the tape for an exact time area.
 3. Print all signals in their recorded sequence.
 4. Sort, print, and/or plot selected signals.
 5. To do problems continuously until finish is indicated.
8. AUXILIARY PROGRAMS: This program uses the IBM 360 sort/merge and the integrated graphics programs when needed.
9. REFERENCES: ATR Data System Programs, Larry Walton or Darwin Metcalf. Catalog of ATR Data Systems Output Requests, Jerry Tappendorf interoffice correspondence, TAPP-1-70.
10. MACHINE REQUIREMENTS: 350K of IBM 360 core, auxiliary storage as needed by sort.
11. PROGRAMMING LANGUAGE: PL/I
12. OPERATING SYSTEM: Standard

13. OTHER PROGRAMMING INFORMATION: This program is already designed to handle some future expansion and can be easily modified for user requests.
14. AUTHOR AND COMPANY: Larry Walton, Aerojet Nuclear Corporation.
15. DISTRIBUTION: No Restrictions

2. GENERAL DESCRIPTION

One of the functions of the ATR Data System is to maintain a recorded history of reactor operation. This is done by storing all significant changes that occur in the analog signals and the contact closures. These values are periodically recorded on magnetic tape and are kept as a temporary or permanent history. Since there are a limited number of tapes in use at the ATR Data System, these tapes are generally used in a circular manner; that is, a tape will be assigned a new identification and reused approximately once every three months. If the data on any tape is to be kept for a longer period of time, the tape in question must be duplicated and filed apart from the regularly used ATR tapes. Each ATR History Tape is assigned a unique number at the time it is loaded. This number and the load time are recorded in the ATR Tape Log. Any peculiar or unusual happenings associated with this tape are also entered into the ATR Tape Log.

An IBM 360 program (ATRHIST) has been written to extract information from the ATR History Tapes. A description of that program is attached. Although this program will handle large amounts of data, its primary purpose is to examine short segments of history data. Such use is well suited to the analysis of scrams, setbacks, and short transient tests. If the program is used to retrieve large amounts of data, the only restriction will be that only the first 8,192 values of each signal can be plotted. Furthermore, since general "do it all" plotting package is used, the use of log, semilog, or an unusual grid scale (such as the reactor period) may not produce a high quality plot. However, in such events, there are other programs available which will handle large amounts of data and give more plotting control for particular types of plots. For such cases, this program can be used to extract the required input data.

3. PROGRAM OUTPUT

There are three files of printed output generated:

- (1) A brief trace of the program flow. This trace will summarize program input and list messages pertaining to success or failure of the program operation. Each request is separated by a dashed line. The messages are quite self explanatory.
- (2) A summary of the sort/merge program operation.

- (3) A list of signal values. Line No. 1 is the signal identification. Line No. 2 is the base time. The text follows with the time given in 60^{ths} of a second from the base time. Analog signal values are given in single precision floating point.

Contact closures are printed in binary notation. There are 15 contacts per word, and they are numbered from right to left. The contact identity can be found in the ATR Catalog of Output Requests. The first printout of a contact closure word shows the contact that has changed its status. This is indicated by a "1" in the appropriate position of the "bits-changed" word. The second printout of the contact closure word shows the status of all contacts in this word. A "1" indicates that the closure is set, and a "0" indicates that the closure is not set.

If plots have been specified, they will be on microfilm. The axes of the plots will be time in seconds versus value. The zero time coordinate is the base time. The scaling of the plots is done by a general plotting program which sets up a grid according to the minimum and maximum values. There will be a printed message that summarizes the microfilm output.

4. MAGNETIC DATA TAPE FORMAT

Diagrammed below is the storage structure for data on the ATR History Tape:

This tape is: 7 track
 Binary
 Odd Parity
 No Label
 Fixed Record Length (3840 Bytes)
 Blocksize = Record Length
 File Length Variable

Time Base

Words 1 and 2 contain the system initialization time as it was set by means of the ATR CDC-636 VALUE switches. Word 3 is the system clock overflow value. Word 4 is the system 60 cycle clock value.

Analog Signal

First word is the signal identification. Second word is the signal value in normalized fixed point. Third word is the output control word containing the following information:

- a. Sign
- b. Significance
- c. Scale Factor

Fourth word is the system 60 cycle clock value.

Contact Closure

First word is the contact closure word identification. Second word is the contact change indication. Third word is the contact word status. Fourth word is the system 60 cycle clock value.