ANL/EBR-063

DATA-PROCESSING SYSTEM FOR INSTRUMENT MAINTENANCE AND CALIBRATION AT EBR-II

by

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June 1972

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ABSTRACT

Early in the operation of EBR-II, it was recognized that a computer program was required for the periodic calibration and maintenance of the more than 1600 instruments in service. Computer Program No. I, set up in 1964, evolved into Computer Program No. II by addition of updated scheduling, history cards, and a new computer to execute the program. Computer Program II, combined with the required procedures, has been operative for about one year. This report describes that program and its operation.

I. INTRODUCTION

Approximately 1600 instruments are necessary to satisfy the monitoring and control requirements for the EBR-II reactor, secondary-sodium, and steam-power plants. Each instrument must be regularly scheduled for maintenance and calibration, a history of its performance maintained, and a listing prepared for visibility regarding its status. The scheduling requirements are complicated by plant conditions. For example, 2% of the instruments must be serviced with the plants in operation, 8% must be serviced only when the plants are shut down completely and when no refueling is in progress, 40% can be serviced with only the plants shut down, and the remaining 50% can be serviced any time, providing that the primary monitors and their backup units are not serviced simultaneously. With this number of variables, manual control of the maintenance program is essentially impossible with the limited number of personnel available for documentation control.

Early in 1964, a computerized instrument-maintenance program (Computer Program I) was set up. It operated successfully throughout the early years of the plants. Computer Program I was tailored to use the local small computer. As the number of plant instruments increased, the small computer lacked the storage capacity to handle the increased load. The original program was divided and then subdivided until finally the large amount of computer time required made the program unacceptable. At that time, justification for a larger computer and action to procure such a computer had been completed. During the interim period between computers, maintenance history was handled manually, but scheduling was virtually impossible.

In 1968, the need for a new computer program was recognized, and a study was initiated to prepare a new program. The problems encountered with Computer Program I were reviewed, and an evaluation was made of each problem. Studies were made of three computerized systems for maintenance records: the Maintenance Data System (MDS); one used by General Electric Corporation; and another used by North American Rockwell. The three systems studied had the following characteristics in common: (a) all would solve the problems encountered with Computer Program I, (b) all were geared to larger systems than our maintenance system, and (c) all required more computer and computer-support time than considered necessary for our program. Because the systems studied were candidates for usage, we never completely ruled them out. In fact, we used many parts of them in Computer Program II. By streamlining the existing systems, we reduced the computer and computer-support time to roughly one-third of that required for the MDS program.

The rest of this report discusses the basic elements of the new computer program. It concludes (in Section VI) with an evaluation of our experience to date in operating the program and a discussion of future expansion.

II. COMPUTER PROGRAM II

Computer Program II provides the following:

(1) a permanent record of information required to identify each instrument;

(2) information for scheduling maintenance, calibration, and replacement of each instrument;

(3) means for updating maintenance and calibration history and for accommodating additional instruments and deleting instruments no longer required;

(4) information for evaluating instrument performance; and

(5) visibility for all instruments installed in-plant and for all standards used for in-plant calibration.

The primary elements of Computer Program II are described here.

A. Master Card

The master card (see Fig. 1) serves as the permanent record of the information necessary to identify and process an instrument. There is one for each instrument. Each card has a duplicate stored on magnetic tape for computer operation. The information stored on a punched master card for each instrument is as follows:

1. Card No. (Cols 1-5)

Each master card has a card number to be used for computer operation. This number is also called the file number and, for cross-filing, also appears on the instrument history card (see Section III).

2. Mfg. (Cols 6-8)

Identifies the instrument manufacturer.

3. Print (Cols 9-13)

Indicates the number of the plant drawing of the subject instrument and how the instrument is used in the overall plant operation.

4. Model (Cols 14-18)

Indicates the manufacturer's model number. This information is used for identification of spare parts.

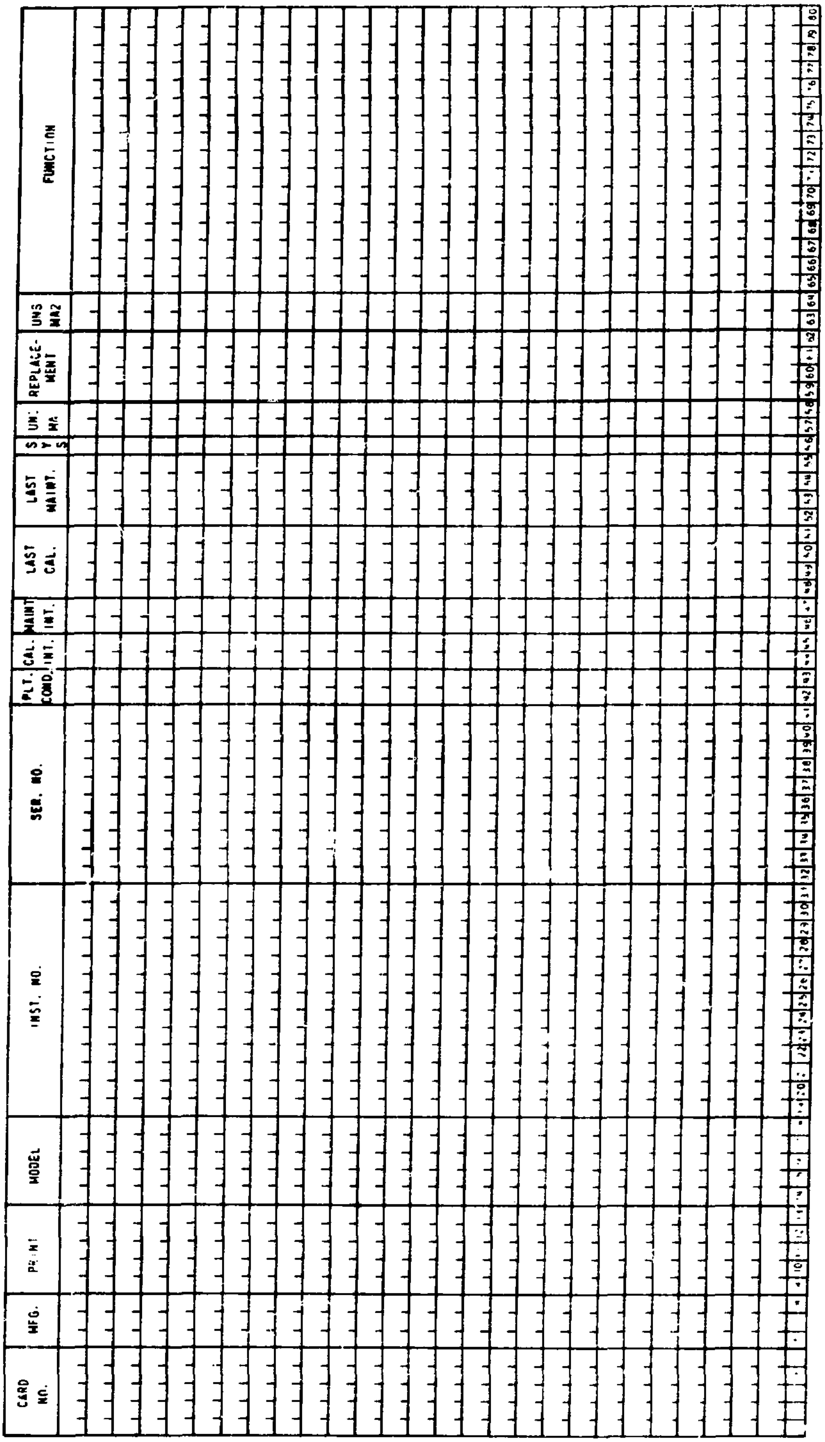

Fig. 1. Master Card

5. Instrument No. (Cols 19-31)

Designates the instrument number according to "Division 300X" specification. This method of designation is shown in Appendix A.

6. Serial No. (Cols 32-41)

Indicates the serial number of the instrument.

7. Plant Conditions (Cols 42-43)

Indicates the plant condition required for calibration or routine maintenance of the instrument.

8. Calibration Interval (Cols 44-45)

Designates the desired time, in months, between calibrations.

9. Maintenance Interval (Cols 46-47)

Designates the desired time, in months, between periods of routine maintenance.

10. Last Calibration (Cols 48-51)

Contains the last date of calibration, by month and year.

11. Last Maintenance (Cols 52-55)

Contains the last date of routine maintenance, by month and year.

12. Systems (Col 56)

Indicates any special category (e.g., test instrument, instrument standard).

13. *Unscheduled Maintenance 1 (Cols 57-58)*

Indicates the number of times the instrument has had required nonroutine maintenance.

14. Replacement (Cols 59-62)

Indicates the date the instrument was replaced.

15. Unscheduled Maintenance 2 (Cols 63-64)

Indicates the number of times the instrument has had nonroutine maintenance since replacement.

16. Function (Cols 65-80)

Contains a written description of the system in which the instrument operates.

B. Calibration and Maintenance Card

The calibration and maintenance card (see Fig. 2) is used to update the master card. After information about the services performed is received, reviewed, and routed through the maintenance coordinator, a calibration and maintenance card is punched to reflect the new dates. The specific fields on this card are:

1. Card No. (Cols 1-5)

Required for the computer to identify the instrument. This number is the same as that on the master card.

CARD NO.	CALIB. DATE	MAIN. DATE	UM 1	REPLA-CEMENT	UM 2	SERIAL NO.	MODEL NO.
1 2 3 4 5	6 7 8 9	10 11 12 13	14 15	16 17 18 19	20 21	22 23 24 25 26 27 28 29 30 31	32 33 34 35 36

Fig. 2. Calibration and Maintenance Card

2. Calibration Date (Cols 6-9)

Indicates the new date of calibration. If calibration was not performed, this field is 0000.

3. Maintenance Date (Cols 10-13)

Indicates the new date of routine maintenance. If routine maintenance was not performed, this field is 0000.

4. Unscheduled Maintenance 1 (Cols 14-15)

Indicates the number of times nonroutine maintenance was performed since the last computer run. Must be 00 if no nonroutine maintenance was performed.

5. Replacement (Cols 16-19)

Indicates when the instrument was replaced. If the instrument has not been replaced, this field is 0000.

6. Unscheduled Maintenance 2 (Cols 20-21)

Indicates the number of times nonroutine maintenance was performed since the instrument was replaced. Must be 00 if no nonroutine maintenance was performed since then.

7. Serial No. (Cols 22-31)

Used for updating a serial number on the master card (i.e., inserting serial number of a replacement instrument).

8. Model No. (Cols 32-36)

Used for updating a model number on the master card (i.e., inserting model number of a replacement instrument).

C. Function Card

The punched function card (see Fig. 3) is used as a part of the software program to provide instructions to the computer regarding desired output.

1. Function Code (Cols 1-2)

The number in these columns will determine the computer output.

2. Plant Condition (Cols 3-4)

Used for output for certain plant conditions required. Must be 00 if not to be used.

3. Current Date (Cols 5-8)

Contains current date for calculating the instruments due for maintenance or calibration.

4. System Code (Col 9)

Indicates any special category of instrument on master card.

D. Computer Input

The input data for the program consist of master cards as stored on magnetic tape, calibration and maintenance information as stored on the punched calibration and maintenance cards, and additions to or deletions from the master cards as stored on punched cards. The master cards (on tape) will always be used for computer input. Use of the other cards is dependent on the computer output desired.

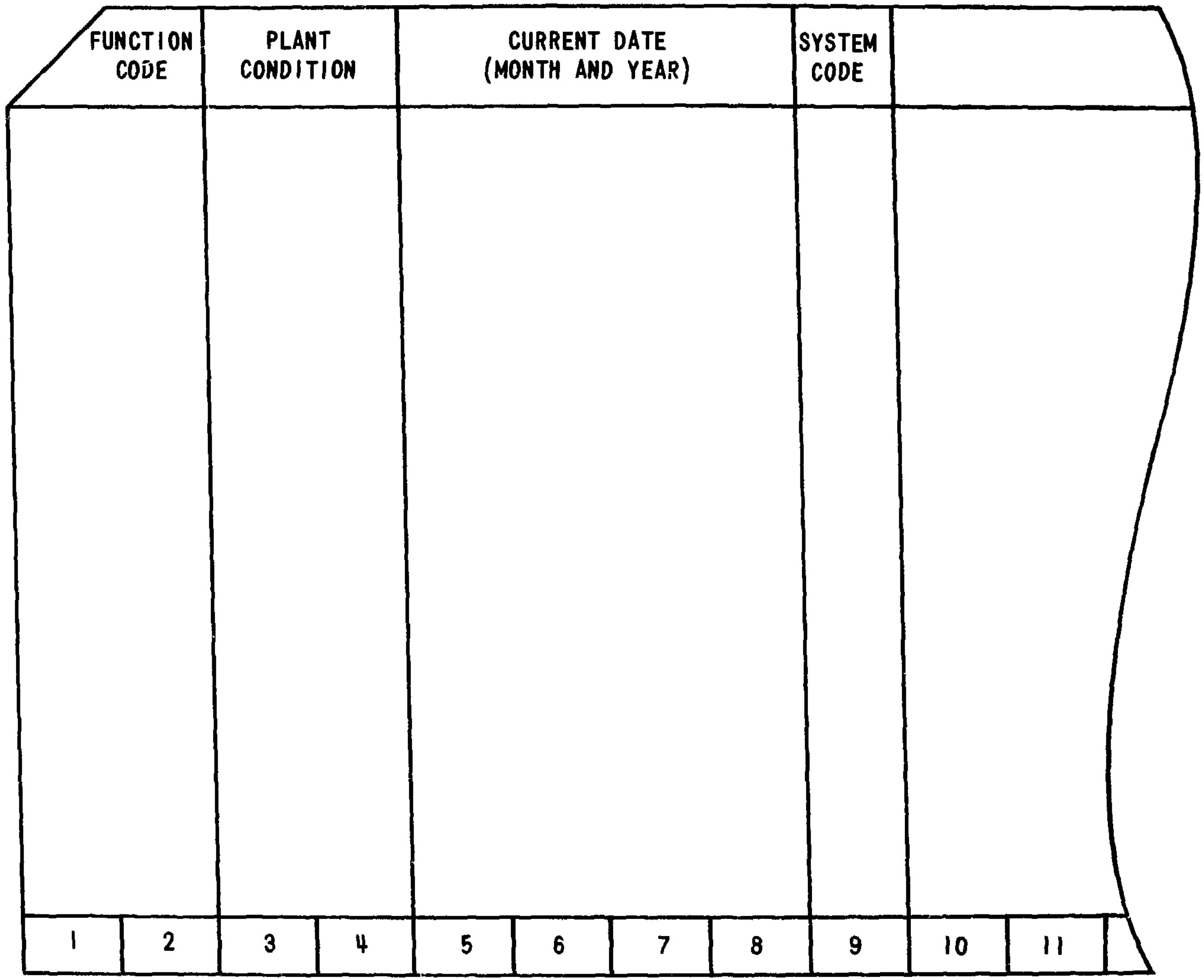

Fig. 3. Function Card

E. Computer Output

The output of the computer program is controlled by the first two columns of the function card. Any one or all of the function-card codes can be used for the computer output required. These codes are as follows:

1. Function Code 01

The computer will list, on the on-line printer, all instruments along with the corresponding plant conditions as indicated in columns 3 and 4. The only input needed is the master-card magnetic tape.

2. Function 02

The computer will list, on the on-line printer, all instruments requiring calibration or maintenance along with the corresponding plant conditions as indicated in columns 3 and 4. The only input required is the master-card magnetic tape.

3. Function 03

The computer will list, on the on-line printer, all test instruments. The only input required is the master-card magnetic tape.

4. Function 04

The computer will change the master-card tape to correspond with changes (additions or deletions) made on the master cards. The input is the changed master cards and the master-card tape. The output is the changed master-card tape.

5. Function 05

The computer will list, on the on-line printer, all NBS calibration standards. The only input required is the master-card magnetic tape.

6. Function 07

The computer will update the master-card magnetic tape and will list, on the on-line printer, all instruments due for calibration or maintenance, including test instruments and standards. The input required is the master-card magnetic tape and the calibration and maintenance cards.

7. Function 08

The computer will list, on the on-line printer, all instruments in master-card file. The only input required is the master-card magnetic tape.

8. Function 09

The computer will punch new master cards from the master-card magnetic tape. The only input needed is the tape.

9. Function 00

The computer will end program by writing on two duplicate magnetic tapes all of the updated (from Function 04 or 07) master-card information. (The duplicate tapes are stored in separate locations to minimize the possibility of data being lost by fire.)

III. INSTRUMENT HISTORY FILE

A complete and accurate record of all instruments maintained and calibrated is kept as the instrument history file. This file has direct traceability to the computerized system. The major components of this history file are described here.

A. <u>History Card</u>

This card is shown in Figs. 4A and 4B. The items on Side 1 of the card (Fig. 4A) are as follows:

1. <u>File No.</u>

Same as the Card No. on the corresponding master card and maintenance and calibration card.

2. <u>Type</u>

This identifies the type of instrument (e.g., recorder, indicator, transmitter, MV/I).

3. <u>Manufacturer</u>

Name of company that manufactured the instrument.

4. <u>Model No.</u>

The manufacturer's model number.

5. <u>Serial No.</u>

Serial number assigned by the manufacturer. In cases where there is no assigned serial number, the program can function without it.

6. <u>System</u>

In-plant system describing function of the instrument as installed.

7. <u>Instrument No.</u>

The number assigned to this particular instrument.

HISTORY CARD

File No. ____________

Type ____________ Manufacturer __________________ Model No. ________ Serial No. ________

System __________________ Instrument No. ____________ Date Installed ______ ____________

Scheduled Maintenance and Calibration __________ Mo. Maintenance Instruction No. ____________

CALIBRATION DATA

Date									
%	Input	Output Des.	Output Actual						
0									
10									
20									
30									
40									
50									
60									
70									
80									
90									
100									

Date									
%	Input	Output Des.	Output Actual						
0									
10									
20									
30									
40									
50									
60									
70									
80									
90									
100									

Date									
%	Input	Output Des.	Output Actual						
0									
10									
20									
30									
40									
50									
60									
70									
80									
90									
100									

Date									
%	Input	Output Des.	Output Actual						
0									
10									
20									
30									
40									
50									
60									
70									
80									
90									
100									

Fig. 4A. History Card: Side 1

MAINTENANCE HISTORY

Date: ______________________

Remarks: ____

____

Date: ______________________

Remarks: ____

____

Date: ______________________

Remarks: ____

____

Date: ______________________

Remarks: ____

____

Date: ______________________

Remarks: ____

____

Date: ______________________

Remarks: ____

____

Date: ______________________

Remarks: ____

____

Fig. 4B: History Card: Side 2

8. Date Installed

Date when the instrument was first installed either in an existing system as a replacement or in a new system.

9. Scheduled Maintenance and Calibration

The interval at which the instrument is to be scheduled for maintenance and calibration according to instrument maintenance list. (This list is the output from Function 08.)

10. Maintenance Instruction No.

The number of the maintenance and calibration procedure written for the instrument system.

11. Calibration Data

The computerized program and the filing system require a history card for each instrument. If a system calibration is made, the history card for each instrument in that system must be completed and the data regarding the instrument recorded.

The "Calibration Data" section is divided into four separate sections. Each section will--in most cases--have enough space for recording the results of a complete calibration of the instrument. The history card should last through four calibration-and-maintenance intervals.

Work done during the scheduled maintenance and calibration is recorded under "Maintenance History" on the reverse side of the history card (see Fig. 4B) and noted as "scheduled maintenance." If any type of work--such as zero check, span check, parts replacement, or adjustment--is done other than at the scheduled date, it is also recorded there and noted as "unscheduled maintenance."

Each entry under "Calibration Data" and "Maintenance History" must be dated and initialed by the person or persons making the entry, and the service request number must be recorded there.

The NBS-traceable standard used for the calibration must be identified on the history card by recording the (a) serial number of the standard, (b) date the last calibration was performed on the standard, and (c) date the next calibration is due on the standard.

B. Calibration Sticker

At the successful conclusion of the calibration or maintenance work on the instrument, a calibration sticker (at left in Fig. 5) must be attached to the instrument. The sticker identifies the person(s) performing the calibration, the date of the calibration, the instrument number, the due date for the next calibration, and the calibration file number.

C. Calibration Required Sticker

Temporary deviation from established calibration schedules may be granted by the manager of Instrumentation & Control (I & C) or his designated alternate when an experiment is being conducted. A tag (at right in Fig. 5) must be attached to the item(s), authorizing the deviation for a limited time. Upon expiration of the extended time, the instrument must be calibrated.

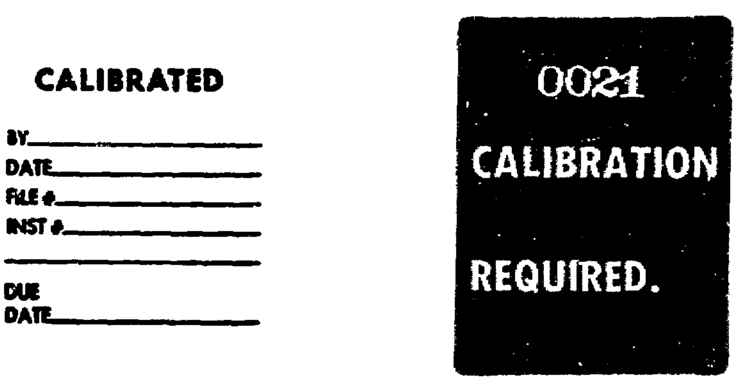

Fig. 5. Calibration Sticker (left) and Calibration Required Sticker (right)

IV. OPERATION OF DATA-PROCESSING SYSTEM

Figure 6 shows how the various record cards and files of the program interconnect with maintenance operations. Start with the magnetic tape, assuming it to contain all the latest information regarding the status of each instrument and, as such, to match the master cards. Assume that a shutdown period has just been completed and that both maintenance and modifications were performed during that period. Because both maintenance and modifications were performed, there will be both "maintenance cards" for updating the maintenance record and "additions and/or deletions cards" as a result of the modifying. We know from the reactor operating schedule that there will be a shutdown for refueling next month, and we wish to have a print-out of the maintenance that will be due during the month following that shutdown. We punch a function card (see Fig. 3) with the information necessary to provide a computer output listing the instruments due maintenance and calibration during that month. Because we have made additions and/or deletions, we also desire a complete print-out of all the instruments for record purposes and for use in the shop as an index or directory for print numbers, manufacturers' numbers, file numbers, etc.

The function card(s), along with maintenance cards and additions and/or deletions cards, are processed through the computer to correct and update the magnetic tape. The corrected and updated tape is then processed back through the computer so that the on-line printer can put out two lists. One is a listing of the complete inventory of the instruments; the other is a listing showing the maintenance and calibration due, naming all the instruments requiring service for the period desired. Each listing is made on four-copy dry-carbon paper. The four copies of each listing are distributed to the personnel requiring copies for scheduling, auditing, evaluating performance, etc.

From the listing showing maintenance and calibration due, a schedule is prepared for the next shutdown and for the planning period before the shutdown. Service requests (see Fig. 7) are prepared, special approvals obtained, prerequisite work completed, and the service requests filed until work can be completed. After the work is completed, the service requests are processed (see Section V), and the completed service requests and maintenance history cards are returned to the maintenance

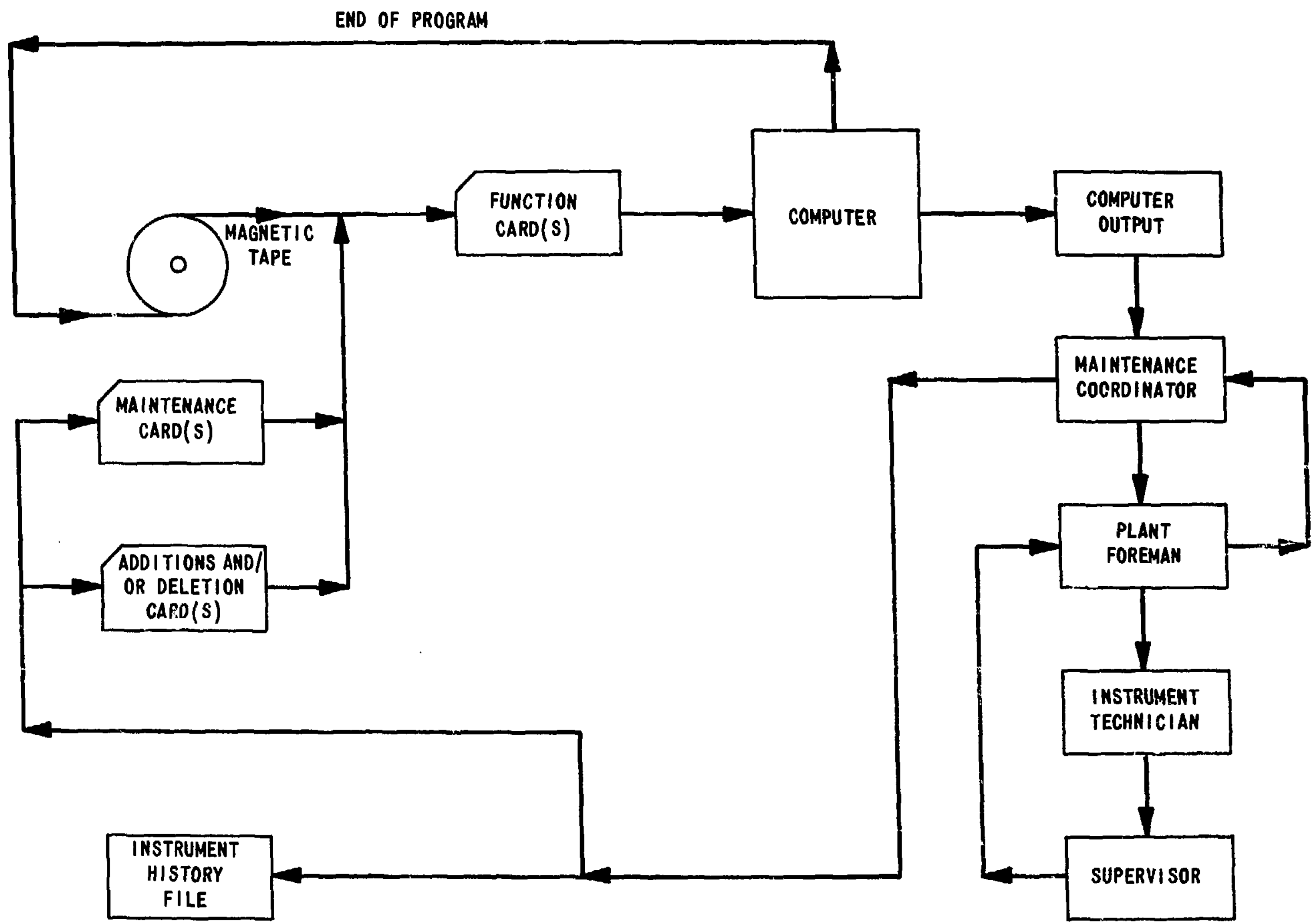

Fig. 6. Typical Route of Data Related to EBR-II Instrument Maintenance

I & C SERVICE REQUEST

No. 06068

WORK CLEARANCE BY SHIFT SUPERVISOR

Date
Requestor
Supervisor
Instrument System

Instrument Numbers

Description of Work to be Performed

Approved ______ Date
Red Tag No.
Safe Work Permit Required: Yes No
Welding Permit Required: Yes No
H. P. Coverage Required: Yes No
Date Completed
Approved for Operation

Cost Account No.
Division or Group

TIME RECORD

Days
Hours $
O. T. Hours

Special Instructions

Work Performed

Parts and Material Used

Technician (s) on Job

Remarks

Fig. 7. EBR-II I & C Service Request Form

coordinator. The maintenance coordinator enters the updating information on the calibration and maintenance card (Fig. 2), files the history card (Figs. 4A and 4B), and has the maintenance and calibration cards punched for the next computer run.

V. WORK PROCEDURES

The computer is limited to providing general information, information for scheduling, special information regarding plant conditions, etc. To perform maintenance and calibration tasks properly, the personnel doing the work must be given adequate written instructions, or procedures. Typical procedures and how they originate are discussed in this section.

A. Service Request

The EBR-II I & C service requests (Fig. 7) provide for supervisory approval and work clearance, by EBR-II Operations, of any maintenance or modification work in the power plant, reactor building, sodium boiler building, and cooling tower. They ensure that the proper steps are taken for the safety of personnel and plant equipment and that a record is made of maintenance activities so that the necessary notation can be made in the equipment history record.

These request forms have three primary purposes: (1) reporting malfunctions and requesting remedial maintenance; (2) requesting routine preventive-maintenance jobs that do not originate because of malfunctions; and (3) reporting system abnormalities that may not necessarily indicate needed maintenance, but point up problem areas.

Figure 8 shows the flow diagram for a service request. A service request can be initiated by the operating crew to cover a malfunction, by the I & C group, or by anyone else desiring service. The service request is a four-copy NCR form that has a perforated top edge for separation of the copies. Each copy has a different color.

The normal flow of events, indicated by solid lines in Fig. 8, occurs when the service request is originated in the I & C shop. These requests are normally prepared from the print-out of maintenance and calibration due by the computer and from requests for work from

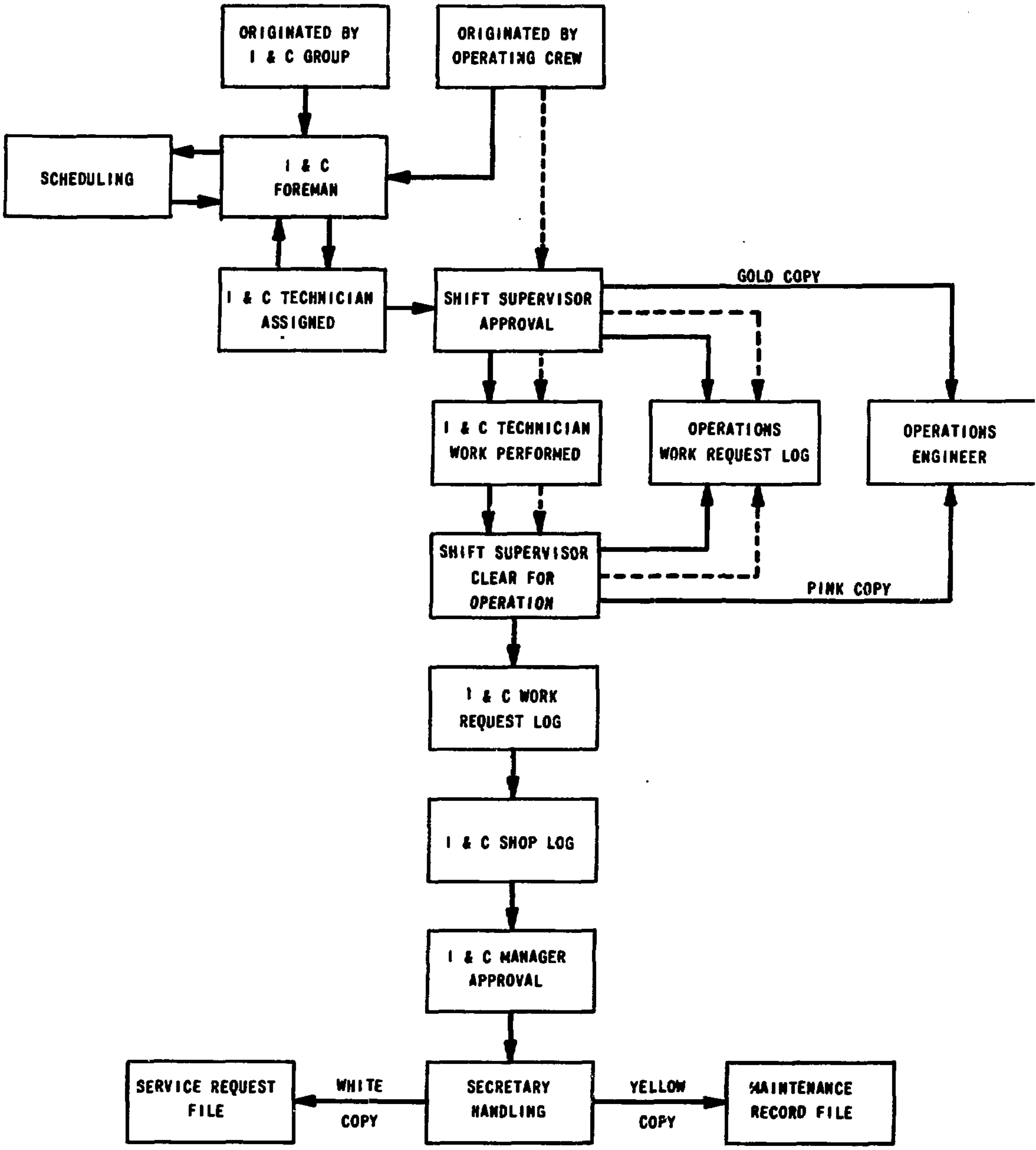

Fig. 8. Flow Diagram for a Service Request

operating crews that does not require immediate action. The requests are written up, categorized for plant conditions required, and reviewed for prerequisite requirements. Prerequisite work, if any, and the requested work are scheduled. Before the request is assigned for in-plant performance, all special approvals on such things as bypass requirements, radiation safety, industrial safety, etc. are cleared to eliminate, as much as possible, all time-consuming details at the time the work is being done. The service request is received by the I & C foreman from Scheduling, he assigns the request to an I & C technician, and the technician presents the request to the Operations shift supervisor for approval. If the service request is not approved, it is returned to Scheduling, through the I & C foreman, for rescheduling.

After the shift supervisor approves the service request, he logs it in the Operations work request log and sends the gold copy of the request to the Operations engineer. The I & C technician performs the work described in the request and clears the instrument system for operation with the shift supervisor. The shift supervisor logs the service request as completed in the Operations work request log and sends the pink copy of the request to the Operations engineer for action if required. The remaining two copies of the request are hand-carried to the I & C shop by the I & C instrument technician. There, the service request is logged in both the I & C work request log and the shop log, and the maintenance history card is attached. Both the request and the card are placed in the I & C manager's mail basket for review and approval. If the I & C manager approves work done as noted on the request, the request is processed by the secretary. The secretary files the white (original) copy of the service request. The remaining (yellow) copy follows the maintenance history card to the maintenance coordinator, from whose office data enters the computer system. If the I & C manager does not approve the work, a new service request is issued and, in this case, is treated as a new request.

If the service request covers an equipment malfunction and can be processed immediately, the Operations shift supervisor can approve it for immediate action. This flow of events is indicated by the dashed line on the flow diagram of Fig. 8. After the work has been completed, the request follows the normal path as described above.

B. Types of Procedures

1. Maintenance and Calibration Procedure (MCP)

The instrument technicians employed for the maintenance and calibration work are all graduates of an accredited technicial school with certificates in either instrumentation or electronics. The maintenance and calibration procedures are written in the language most familiar to the technicians.

The MCP contains the information required by the technicians regarding plant conditions, radiation safety, industrial safety, supplementary procedures, prerequisites, and a step-by-step approach to the assignment. A sample MCP is shown as Appendix B.

2. Equipment Replacement Procedure (ERP)

The replacement of a component in some instrument systems requires a procedure that will ensure proper operation of the system after the replacement. The ERP provides the correct information for this type of system and includes methods to ensure the proper interfacing with reactor operations. A sample ERP is shown as Appendix C.

3. Operating Procedure (OP)

The operation of certain instruments requires special conditions, interconnections, etc. Operating procedures are provided for the use of many of these instruments. A typical example is shown as Appendix D.

4. Test Procedure (TP)

Some assignments are not necessarily maintenance or calibration, but still require a procedure for uniform performance. A typical example of this type of procedure is shown as Appendix E.

VI. EXPANSION OF COMPUTER PROGRAM II

Computer Program II has been in operation for about a year. Through use of the program, a number of expansion possibilities are evident and are now being studied and evaluated. Three of these are mentioned here.

A. Spare Parts

The maintenance and calibration of the instrument system require that an inventory of spare parts is available for repair and replacement. At present, spare parts are stocked in accordance with the number of particular instruments in use and the manufacturers' recommendations. With usage of spare parts included in the computer program, a more realistic inventory could be obtained, and in most cases, spare-parts requirements could be indicated more reliably.

B. Interlocks

The operation of EBR-II as an irradiation facility and prototype reactor plant requires checking of about 1000 alarm and control functions and their interlocking. At present, there is a maintenance and calibration procedure for performing this task. The integration of these alarm and control checks into a computerized system similar to the one described would gain the advantages of decreased time for performance of the checks, ease of revision, a better overall visibility of the checks, and scheduling of the checks along with maintenance.

C. Time Records

Maintenance is often done during periods of unscheduled reactor shutdown. The length of these shutdowns usually can be estimated reasonably well. The trick is to schedule the right amount of due (or almost due) instrument maintenance and calibration for the shutdown period. Adding to the computer program the time required to maintain and calibrate an instrument system would increase the efficiency of scheduling the maintenance and calibration during these shutdowns.

APPENDIX A

EBR-II Coding Designation for Instrument Components

(This appendix is Part I, Section A - "Equipment Numbering Schedule" - of Division 300X, "Instrument Specifications for Nuclear and Process Systems," the document of the first specifications of plant instrumentation for EBR-II.)

The following coding designation will be used for instrument components on the EBR-II Project.

The coding designation is to be carried on all flow sheets, drawings, and specifications.

A. INSTRUMENTS

Each instrument will be identified by this code, as follows:

(1) Location (relative to building or section of plant where measurement is being accomplished).
(2) System.
(3) Parameter.
(4) Function.
(5) Instrument Number.
(6) Points of Measurement.

I. LOCATION - First prefix designates location.

B Boiler Plant - Wing.
C Cooling Tower.
E Electrical Substation.
F Process Plant.
G Guard House.
K Ambulance and Fire Station.
L Laboratory Building.
M Pump House and Well No. 1.
N Pump House and Well No. 2.
P Power Plant (including auxiliary boilers).
R Reactor Plant.
S Sodium Plant - Wing.
T Temporary Facilities.
W Waste Treatment Plant.
Y Yard and Services (including fuel oil pumping station and main oil storage tank).

II. SYSTEM

System code will follow the location designation. The code for the various systems is listed below.

System	Code
Primary System	1
Secondary System	2
Steam Power System	3
Shutdown Cooling	4
Feedwater System	5
Argon	6
Cooling Tower	7
Shield Air Cooling	8
Steam Heating System	9
Electrical	10
Suspect and Contaminated Gas	11
Waste Disposal	12
General Ventilation	13
Air Conditioning	14
Potable and Fire Water Systems	15
Fuel Oil System	16
Space Air Cooling	17
Water Treatment	18
Miscellaneous	19

The sodium clean-up systems will carry the same prefix as the systems with which they are identified.

III. PARAMETER

	Letter
Nuclear	N
Temperature	T
Flow	F
Pressure	P
Level	L
Radiation	M
pH	pH
Current	Q
Voltage	V
Power	KW
Volt. Amp.	Va
Differential Pressure	dP
Differential Temperature	dT
Conductivity	C
Position	B

Leak Detector	Y
Relative Humidity	RH
Speed	S
Chlorine Concentration	C
Miscellaneous	X
Annunciator	A

IV. FUNCTION

	Letter
Record	R
Control	C
Indicate	I
Alarm (or electrical contact)	A
Integrate	s (subletter)
Analytical	Z
Data Logging (only)	D

Instruments will be identified by letter designation for parameter being measured and function performed.

V. INSTRUMENT NUMBER

1. The instrument number follows the function letter in the instrument coding designation.

2. The instrument function designation is followed by a number equal to the number of points recorded or indicated in the receiving instrument. When the receiver shows a single point, this suffix is omitted.

VI. INSTRUMENT COMPONENTS

Component	Letter
Nuclear Detector	Q
Thermocouple	TC
Resistance Thermometer	RT
Temperature Transmitter (pneumatic)	TT
Pressure Cell	PT
Level Transmitter	LT
Amplifier	AM
pH Cell	pHT

Potential Trans.	VT
Current Trans.	CT
Primary Element (dead ended)	E
Flow Transmitter (except magnetic)	FT
Control Valve (pneumatic, hydraulic, or electrical)	VC
Solenoid Valve	VS
Pressure Switch	PS
Power Supply	KS
Miscellaneous	X
Flow Transmitter (magnetic)	FM
Sodium Detector	SD
Leak Detector	LD

VII. INSTRUMENT COMPONENT IDENTIFICATION

1. The same number basically assigned to a specific instrument will be used for all instrument components (see Paragraph VI) connected to that instrument, including the control valve or valves. Where more than one component and/or valve is associated with the instrument, each component number will be followed by a letter or letters to identify the specific component and/or valve.

2. The letters I, J, L, O, and U shall not be used, and double letters are employed where required (if more than 21 components are involved).

VIII. INSTRUMENT DESIGNATION

1. Two-pen temperature recorder controller with alarm in primary system in Reactor Building.

R1-TRCA502-2

2. Flow recorder controller in steam system.

P3-FRC506

3. Multi-point temperature indicator with alarm in steam system, located in Power Plant.

P3-TIA503-24

Location	System	Temp.	Indicator	Alarm	Inst. No.	No. of Points of Meas.
P	3	T	I	A	503	24

4. Thermocouple in Boiler Plant used with P3-TIA503 is B3-TC503AD.

APPENDIX B

Typical Maintenance and Calibration Procedure

1. TITLE

Calibration of RMS Detectors and Monitors

2. PURPOSE

To provide uniform instructions for calibrating gamma detectors using a ^{60}Co source and for aligning the monitors to match the assigned detectors.

3. SUPPLEMENTARY PROCEDURES

3.1 EBR-II I & C Work Request

3.2 SA 3-69, "EBR-II Electrical System - General Safety Requirements for Maintenance and Installation."

4. HEALTH PHYSICS REQUIREMENTS

4.1 A Health Physics representative must be present while handling the ^{60}Co source and must approve the calibration setup and location.

4.2 Notify Health Physics shift technician when monitor and chamber are to be removed.

5. INDUSTRIAL SAFETY REQUIREMENTS

As per 3.2

6. PLANT CONDITIONS

6.1 Reactor

The plant must be shut down for removal of the units from the reactor building.

NOTE: Two monitoring systems (ICC No. 2 and FHC) are in the shutdown circuit.

6.2 Power Plant, Lab and Office, and HFEF South and North

These units can be calibrated at any time, subject to approval by Health Physics.

7. PRELIMINARY

7.1 Read the entire procedure before starting.

7.2 Two gamma detectors, one Model IC-33 and one Model IC-34, will be used as references in the calibration. It is required that one of each model have been processed through Central Facilities' calibration standard within the last year. Data should be taken on the reference detectors at 1 R/hr, 100 mR/hr, and 25 mR/hr, with a high voltage of 170 volts. The reference detectors should be so marked and should not be used in regular service unless they are the last available spares. Once in service, the detectors must be recalibrated at Central Facilities before their use as reference detectors.

7.3 The ^{60}Co source used in the calibration has a source strength of 264 mCi, which produces a dose of about 5 R/hr at 1 foot. The source is stored in a lead shield and has Serial No. 407 on the shield. Obtain keys for the shield from the I & C Section Manager prior to starting the calibration.

7.4 With Health Physics representative present, remove the ^{60}Co source and set it on a piece of blotter paper. Set up a high voltage supply, picoammeter, and cables at a distance from the source sufficient to reduce the dose to a negligible amount.

7.5 Connect the reference IC-33 to the power supply and picoammeter. Set the detector on the floor and move it as necessary until the current reads whatever the detector's calibrated current for 1 R/hr is. The high voltage should be 170 volts. When the current is equal to the calibrated 1 R/hr reading, lay lead bricks on the floor in such a way as to make a cradle for the detector so that its position can be reproduced. Do not place any lead between the ^{60}Co source and the detector. Mark this position 1 R/hr.

7.6 Move the detector back until the current is equal to the calibrated current for 100 mR/hr. Again make a cradle with lead bricks and mark the position 100 mR/hr.

7.7 Repeat step 7.5 for the 25 mR/hr calibrated current.

7.8 After all positions are fixed, place the reference IC-33 in each position and confirm that the current in each position is equal to the calibrated current for the corresponding dose rates. Make any needed adjustments.

8. DETECTOR CALIBRATION

8.1 With facility supervisory approval, remove one or more detectors at a time to the location selected in step 7.

NOTE: Knowledge of trips and high radiation fields is a must.

8.2 Place each of the detectors in the 1 R/hr, 100 mR/hr, and 25 mR/hr positions, recording the current at each position. Also record the location, RMS number, and serial number on the data sheet.

8.3 Return the detectors to their locations and place into operation.

9. MONITOR CALIBRATION

9.1 CD 179 Monitor

9.1.1 Turn the "test current adjust" to maximum clockwise position and leave it there.

9.1.2 With the "test current range" switch on 10^{-9}, adjust the level until the meter reads one decade down from the top end of the scale.

9.1.3 Switch to 10^{-11} and note reading with reference to the mark one decade up from the bottom end.

9.1.4 If reading is high, turn the "span adjustment" clockwise by a small amount.

9.1.5 Adjust the level to give a correct reading at 10^{-11}.

9.1.6 Switch back to 10^{-9} and check reading.

9.1.7 Repeat steps 8.1.3, 8.1.4, and 8.1.5 until monitor reads correctly.

9.2 CD 179 Monitor Trip Level

9.2.1 Set the "test current range" and "test current adjust" to give a meter reading at the desired trip level.

9.2.2 Connect Simpson meter leads on the terminal board points 9 and 10. "Simpson" switch to be in the "RX1" position.

9.2.3 While holding the "reset" button down, turn the "trip level" dial clockwise until the unit resets, noted by trip light going out.

9.2.4 The Simpson meter should indicate a "closed" contact.

9.2.5 Release "reset" button.

9.2.6 Slowly turn the "trip level" dial counterclockwise until the trip light comes on and leave it set at that point.

9.2.7 The audible alarm should function and the Simpson meter should show an "open" contact.

9.2.8 Depress the "silence" push button to de-energize the audible alarm.

9.2.9 Return switch to "normal" position.

9.3 The data collected on the detectors is now to be used to calibrate the associated monitors. The current source used for this procedure should be the Keithley picoampere source.

9.4 Disconnect the signal cable from the detector and feed the monitor with the current source. Using the values of current determined from the calibration of the chamber, check the calibration of the monitor and adjust the span and level as necessary. If the monitor cannot be brought into close adjustment, set it so that the correct reading is obtained at the setpoint. Then get other readings as close as possible. For each monitor, record the meter reading on the monitor for input currents corresponding to 25 mR/hr, 100 mR/hr, and 1 R/hr. Note that the normal length of cable must be connected between the source and the monitor.

9.5 Repeat 9.4 for all remaining monitors.

NOTE: The sensitivity of the two types of chambers is as follows; if any one chamber is more than 1/2 decade low in sensitivity, replace the unit with a proven spare chamber:

Short chamber (IC-33) - 10^{-10} amps per R/hr

Long chamber (IC-34) - 10^{-9} amps per R/hr

10. SUPPLEMENTARY INFORMATION

10.1 Lab and Office

The two vault monitoring systems are acknowledged at EBR-II reception building and at Central Facilities, and are on the criticality alarm system. The other two will evacuate the cave area. Detector removal with Health Physics approval.

10.2 ZPPR

10.2.1 Obtain the key (Chicago Lock Co. #7661) for the criticality alarm cabinet from the ZPPR Operations Supervisor. This cabinet is located in the ZPPR basement, and contains the alarm bypass switch.

10.2.2 Open the cabinet door and place the switch in the bypass position.

10.2.3 Check monitors, perform maintenance, calibration, etc., as necessary.

10.2.4 Return each monitor to operate and reset each monitor.

10.2.5 Put the bypass switch to the normal position. In the event the switch is left in the bypass position, the door lock will put the switch in the normal position when the door is locked.

10.2.6 The key can only be removed with the lock in the locked position.

10.2.7 Return the kev to the ZPPR Operations Supervisor.

10.3 Reactor

10.3.1 Note that a trip on RMS 20 or RMS 21 will isolate the reactor building. To remove the systems RMS 20 and RMS 21, inform the shift supervisor that these units will be removed and request than an operator is assigned to monitor the building with instructions to isolate manually in case of an increase in level on any one other RMS unit in the building.

10.3.2 Note also that a trip on RMS 15 will shut off the purification cell exhaust fans. Be careful of high radiation fields around and in the purification cell. Clear with shift supervisor prior to removal.

10.4 HFEF South and HFEF North

All monitoring systems evacuate personnel from the building. The normal monitors use the control room annunciation with a taped message and the criticality "local" signal with an all-page announcement.

When the normal monitors are serviced, somebody is needed in the control room to acknowledge the alarm before the evacuation signal is energized. Removal of detectors requires Health Physics approval.

10.5 Criticality Detection Systems

A red tag, with white letters "Criticality Monitor," attached to the monitor mounting bracket indicates the location of such systems.

Monitoring system is ready for the standard calibration procedures when the two leads labeled "Criticality Leads" are removed from terminal points on back of monitor chassis. (DO NOT SHORT LEADS)

APPENDIX C

Typical Standard Procedure for Replacing Instrumentation and Control Equipment

1. TITLE

Replacement of EG & G Picoammeters and Power Design High Voltage Power Supplies

2. PURPOSE

To provide a standard procedure for replacing the picoammeters and high voltage power supplies that are used on the reactor nuclear channels.

3. SUPPLEMENTARY PROCEDURES

3.1 EBR-II I & C Work Request.

3.2 SA 3-69, "EBR-II Electrical System - General Safety Requirements for Maintenance and Installation."

4. HEALTH PHYSICS REQUIREMENTS

None.

5. INDUSTRIAL SAFETY REQUIREMENTS

None.

6. PLANT CONDITIONS

Reactor supervisor's permission.

7. EG & G PICOAMMETER REPLACEMENT

7.1 General

Do not turn off the high voltage supply to the unit unless all picoammeters on the high voltage supply are turned off.

7.2 Turn off the power.

7.3 Remove the input, output, and power cables and replace unit.

7.4 Connect cables.

Note: Discharge input cable by shorting center conductor to shield before connecting the cable.

7.5 Turn on the power and set to correct range.

7.6 Check and set trip level.

8. POWER DESIGN HIGH VOLTAGE POWER SUPPLY

8.1 General

Turn all picoammeter power switches to the "off" position that are associated with the power supply. A shift in calibration or component damage may result if the power to the picoammeters is left in the "on" position when the high voltage power supply is turned off or on.

8.2 Disconnect cables and replace power supply.

8.3 Connect cables.

8.4 Select proper high voltage and turn on the power.

8.5 Check and set high voltage trip.

8.6 Turn on the picoammeters.

APPENDIX D

Typical Standard Procedure for Operating Instrumentation and Controls

1. TITLE

Stress Reliever Operating Procedure

2. PURPOSE

To provide a standard procedure for operating of stress reliever control cabinet.

3. SUPPLEMENTARY PROCEDURES

3.1 Electrical Safety Procedure SA 3-69, "EBR-II Electrical System - General Safety Requirements for Maintenance and Installation"

3.2 EBR-II I & C Work Request

4. HEALTH PHYSICS REQUIREMENTS

None.

5. INDUSTRIAL SAFETY REQUIREMENTS

As stated in 3.1.

6. PLANT CONDITIONS

None.

7. STRESS RELIEVER OPERATING PROCEDURES

7.1 Starting Up Prior to a Stress Relieving Run

7.1.1 Establish that main breaker on cabinet is open. Do not close until heater power is desired.

7.1.2 Connect 480-volt power cord to nearest available outlet

7.1.3 Setpoint on local controller to zero and program switch on Trendtrak controller to "Off."

7.1.4 Control power on.

7.1.5 All alarms are silenced and reset with their related push buttons. Temperature deviation alarm will not reset until system temperature matches setpoint

<u>Note</u>: A high temperature alarm will trip out the 480-volt breaker on the cabinet.

7.1.6 Depress control push button such that it is in the "Local" control mode.

7.1.7 Set up desired high and low temperature trips with built-in test source, depressing appropriate push button to inject test signal to MV/I. Use recorder indicator for temperature readout.

7.1.8 Install program chart on Trendtrak controller, and align photocell detector and program chart so that they are at the starting point of the heating cycle. <u>Do not</u> install or remove program charts unless program switch is "Off." This switch stops the chart drive and de-energizes the photocell detector circuit.

7.1.9 Place new chart on the temperature recorder and align it for the proper time. This is circular L & N chart No. 620001, 0-2000°F, 24-hour cycle.

7.1.10 Insert heater plug into 480-volt outlet from SCR's in cabinet. (Crew E will have installed the heater element on the equipment to be treated.)

7.1.11 The temperatures of the item being treated will be read on thermocouples 1-16, selected by the switch on the front panel, and read on the recorder. The control thermocouple is No. 18, and routes directly to the local controller. The 0-100% power output meter is fed by 0-5 milliamperes from the local controller.

7.1.12 Close the 480-volt breaker on the cabinet. There is about a 10-second time delay before the controller output is fed to the SCR panel. After this, you will still show zero power because the setpoint is below the system temperature.

7.1.13 Determine starting temperature of program chart on Trendtrak and bring setpoint on the local controller up to this value. This will draw 100% power.

7.1.14 When the system temperature reaches setpoint and stabilizes, turn program switch to "On" in Trendtrak curve follower. Depress control push button switch to "Program." The system temperature will now be controlled by the program curve on the Trendtrak unit.

7.2 <u>To Shut System Down After Completion of Run</u>

7.2.1 Run setpoint on local controller down to zero.

7.2.2 Switch control push button from "Program" to "Local."

7.2.3 Open the main breaker on the cabinet.

7.2.4 Depress control power push button to "Off."

7.2.5 The 24 volts remain on the control push buttons, and show control system status until cabinet is disconnected from the main 480-volt power.

APPENDIX E

Typical Procedure for Testing Instrumentation and Control

1. TITLE

Continuous Power Supply Battery Load Test Procedure

2. PURPOSE

To provide a standard procedure for a load test to determine the ampere-hour capacity of the batteries.

3. SUPPLEMENTARY PROCEDURES

3.1 EBR-II I & C Work Request

3.2 MCP No. 6, "Nickel-Cadmium Battery Maintenance and Charging Procedure"

3.3 MCP No. 36, "Procedure for Maintenance and Calibration of the Continuous Power Supply System and for Checking and Setting of the Various Interlocks"

4. HEALTH PHYSICS REQUIREMENTS

None.

5. INDUSTRIAL SAFETY REQUIREMENTS

None.

6. PLANT CONDITIONS

6.1 Reactor to be shut down.

6.2 Continuous power being supplied from maintenance transformer.

7. PREREQUISITES

7.1 Open breaker 1MCB and remove leads 101 and 107 from the breaker. These leads normally feed dc power to the M-G drive motor.

7.2 Install load bank to breaker in position left vacant from step 7.1.

7.3 Check each cell as per step 7.1.2 in MCP No. 6. Record data. If batteries are not at normal charge, charge the batteries and repeat step 7.1.2 of MCP No. 6.

7.4 Install digital voltmeter across points 30 and 31 in the CP panel for current measurement.

7.5 Install Weston standard dc voltmeter across voltmeter installed in the panel.

8. TEST

8.1 Close breaker 1MCB. Read and record current and voltage.

8.2 Open breaker RCB on CP panel. Immediately read voltage and current. Record data on attached sheet.

8.3 Read current and voltage at 10-minute intervals until the battery voltage drops to 150 volts.

8.4 Reduce rectifier output voltage to minimum.

8.5 Open breaker 1MCB, remove load bank, and reconnect leads 101 and 107.

8.6 Remove test instruments.

8.7 Close breaker RCB and recharge batteries as per step 7.2 in MCP No. 6.

DATA SHEET

Reading Number	Time	Current	Voltage
0			
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			
26			
27			
28			
29			
30			

Note: (1) Take reading 0 with rectifier on-line (step 8.1).
(2) Take reading 1 with rectifier off-line (step 8.2).