OAK RIDGE NATIONAL LABORATORY

operated by

UNION CARBIDE CORPORATION

for the

U.S. ATOMIC ENERGY COMMISSION

ORNL-TM-908,
Volume I

MSRE DESIGN AND OPERATIONS REPORT

PART VIII, OPERATING PROCEDURES

R. H. Guymon

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DECEMBER 1965

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PREFACE

The report on the Molten-Salt Reactor Experiment (MSRE) has been arranged into twelve major parts as shown below. Each of these covers a particular phase of the project, such as the design, safety analysis, operating procedures, etc. An attempt has thus been made to avoid much of the duplication of material that would result if separate and independent reports were prepared on each of these major aspects.

Detailed references to supporting documents, working drawings, and other information sources have been made throughout the report to make it of maximum value to ORNL personnel. Each of the major divisions of the report contains the bibliographical and other appendix information necessary for that part.

The final volumes of the report, Part XII, contain rather extensive listings of working drawings, specifications, schedules, tabulations, etc. These have been given a limited distribution.

Most of the reference material is available through the Division of Technical Information Extension, Atomic Energy Commission, P.O. Box 62, Oak Ridge, Tennessee. For material not available through this source, such as inter-Laboratory correspondence, etc., special arrangements can be made for those having a particular interest.

None of the information contained in this report is of a classified nature.

All the reports are listed below.

ORNL-TM-728*	MSRE Design and Operations Report, Part I, Description of Reactor Design, by R. C. Robertson
ORNL-TM-729	MSRE Design and Operations Report, Part II, Nuclear and Process Instrumentation, by J. R. Tallackson
ORNL-TM-730*	MSRE Design and Operations Report, Part III, Nuclear Analysis, by P. N. Haubenreich, J. R. Engel, B. E. Prince, and H. C. Claiborne
ORNL-TM-731	MSRE Design and Operations Report, Part IV, Chemistry and Materials, by F. F. Blankenship and A. Taboada

*Issued.

ORNL-TM-732*	MSRE Design and Operations Report, Part V, Reactor Safety Analysis Report, by S. E. Beall, P. N. Haubenreich, R. B. Lindauer, and J. R. Tallackson
ORNL-TM-733*	MSRE Design and Operations Report, Part VI, Operating Safety Limits for the Molten-Salt Reactor Experiment, by S. E. Beall and R. H. Guymon
ORNL-TM-907*	MSRE Design and Operations Report, Part VII, Fuel Handling and Processing Plant, by R. B. Lindauer
ORNL-TM-908	MSRE Design and Operations Report, Part VIII, Operating Procedures, by R. H. Guymon
ORNL-TM-909	MSRE Design and Operations Report, Part IX, Safety Procedures and Emergency Plans, by A. N. Smith
ORNL-TM-910	MSRE Design and Operations Report, Part X, Maintenance Equipment and Procedures, by E. C. Hise and R. Blumberg
ORNL-TM-911	MSRE Design and Operations Report, Part XI, Test Program, by R. H. Guymon and P. N. Haubenreich
	MSRE Design and Operations Report, Part XII, Lists: Drawings, Specifications, Line Schedules, Instrument Tabulations (Vol. 1 and 2)

Acknowledgement

The Operating Procedures were written primarily by members of the MSRE Operations Department of the ORNL Reactor Division. Substantial contributions were made by members of the Development Department of the Reactor Division and by members of the Instruments and Controls Division who wrote and reviewed various sections. All contributions are gratefully acknowledged.

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Volume I

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MSRE DESIGN AND OPERATIONS REPORT

Part VIII

OPERATING PROCEDURES

R. H. Guymon

1. Introduction

The first draft of the operating procedures was written during design and construction of the reactor as an aid in producing a complete, workable design. This draft was then used during operator training, for prenuclear shakedown of the reactor, and for the zero-power nuclear experiments. During this time, changes were made in the master copy as the need arose. The present issue is the result of a comprehensive review and updating, and incorporates all changes and additions found necessary up to the beginning of power operation.

1A EXPLANATION OF THE OPERATING PROCEDURES

The prime purpose of this part of the MSRE Design and Operations Report is to aid in the training of operating personnel and to provide readily available reference material needed for operation. Details which are not thought to be needed in normal operation are omitted. These can be found in the other parts of the Design and Operations report and in the material referenced in Section 1B.

Section 2, Nuclear Aspects of Operation, gives a simplified discussion of basic nuclear facts, explains the nuclear behavior of the MSRE and sets down the values of characteristic properties.

Section 3, Operation of the Auxiliary Systems, covers in detail the operation of each auxiliary system. In order to avoid repetition with section 4, not all line, valve, switch or instrument numbers are enumerated, but often they are referred to in general terms or as groups (such as "The cooling water is turned on to all space coolers.") However, when it adds to clarity the numbers are also given. In general, flow rates, temperatures, pressures, etc., are not given but are covered by the startup check lists, log sheets, run instructions, and daily shift instructions.

Section 4, Auxiliary Systems Startup Check Lists, covers the minute details necessary in getting the auxiliary systems ready for startup. The position of each valve and switch is listed, and a test for each instrument under actual or simulated operating conditions is described in detail. The check lists are written in logical order for each system; however, since there is an interdependence between systems, it may be necessary to do portions of one check list before portions of another. When logical sequence permits, all operations in a physical area are listed together in order to expedite completion of these lists. All items in this section must be completed before each startup unless the omission is approved by the operations chief.

Section 5, Reactor Start Up, covers the actual startup of the reactor and operation at power. Each step is outlined in detail. All instrument settings and switch and valve positions are given. This section is written in chronological sequence and tells what is to be done, when it can be done, why certain precautions are necessary, and suggests corrective action in case of difficulty.

Section 6, Sampling and Adaptations, describes all samples which are to be taken, frequency of sampling, analyses to be made and allowable limits. Details of sampling procedures are given. Salt additions, chemical additions, etc., are described.

Section 7, Heat Balance, describes the method used to determine the power being produced by the reactor.

Section 8, Instrument Calibrations and Operation, gives the procedure used to periodically check the safety circuits and other instrumentation and assure that they are functioning properly.

Section 9, Unusual Operating Conditions, attempts to anticipate possible difficulties and suggest corrective action to be taken.

Section 10, Reactor Shutdown, describes in detail normal and special shutdowns of the reactor and lists possible causes for a shutdown and actions to be taken by operating personnel.

Section 11, Shutdown Operations, provides procedures for operational activities involved while the reactor is shut down including graphite sampling.

Section 12, Routine Observations, describes the taking of data, marking of charts, storing of data, logging equipment, and other routine duties of the shift personnel.

Section 13, Maintenance and Changes, describes the methods used for getting maintenance done safely and for making modification to the system or to approved documents.

1B LIST OF OTHER MATERIAL AVAILABLE

The MSRE is well documented with drawings and reports to cover all phases of the design, development, and construction. Not all of this information is needed routinely for operation of the reactor. The following list has been compiled expressly as an aid to operating personnel.

1. MSRE Design and Operations Report

ORNL-TM-728	Part I	Description of Reactor Design
ORNL-TM-729	Part II	Nuclear and Process Instrumentation
ORNL-TM-730	Part III	Nuclear Analysis
ORNL-TM-731	Part IV	Chemistry and Materials
ORNL-TM-732	Part V	Reactor Safety Analysis Report
ORNL-TM-733	Part VI	Operating Limits
ORNL-TM-907	Part VII	Fuel Handling and Processing Plant
ORNL-TM-908	Part VIII	Operating Procedures
ORNL-TM-909	Part IX	Safety Procedures and Emergency Plans
ORNL-TM-910	Part X	Maintenance Equipment and Procedures
ORNL-TM-911	Part XI	Test Program
	Part XII	Lists: Drawings, Specifications, Line Schedules, Instrument Tabulations

2. Miscellaneous Reports and Literature

   MSRE Semi-Annual Reports
   MSR 63-36 Line Schedule
   CF 60-10-62 I and C Electrical Standards and Graphical Symbols
   CF 57-2-1 Instrumentation Flow Plan Symbols
   CF 63-6-30 Design Data Sheets
   Manufacturer's Literature (File)
   Valve Tabulation
   Instrument Application Tabulation (Book)
   Instrument Specification (Book)
   Test Reports (Book)

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ORNL Radiation Safety and Control Training Manual (Book)
ORNL Radiation Safety and Control (Book)
ORNL Health Physics Manual (Book)
ORNL Emergency Manual (Book)

3. Miscellaneous Unpublished Information

Facts Book
Run Instructions (Book)
Shift Instructions (Book)
Calibration Curves (Book)
Log Books Previous Operations (File)
Logger Data (File)
Building Log (File)
Recorder Charts (File)
Rough Data From Previous Tests (File)
Daily Reports (File)
Run Reports (File)
Test Memos (File)
Thermocouple Tabulation Logs (Book)
Photographs of Construction (File)

4. Drawings

Process Flow Sheets

Fuel System	D-AA-A-40880
Coolant System	D-AA-A-40881
Fuel Drain Tank System	D-AA-A-40882
Off Gas & Containment Ventilation Systems	D-AA-A-40883
Cover Gas System	D-AA-A-40884
Oil Systems for Fuel & Coolant Pumps	D-AA-A-40885
Fuel Processing System	D-AA-A-40887
Liquid Waste System	D-AA-A-40888
Cooling Water System	D-AA-A-40889
Leak Detector System	D-AA-A-40890

Instrument Air Distribution One Line D-HH-Z-41782 & 41783

Approved by R H Guymon

Instrument Application Diagrams

Fuel Salt System	D-AA-B-40500
Coolant Salt System	D-AA-B-40501
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Cover Gas System	D-AA-B-40503
Oil System for Fuel Salt Pump	D-AA-B-40504
Sampler-Enricher System	D-AA-B-40505
Liquid Waste System	D-AA-B-40506
Oil System for Coolant Salt Pump	D-AA-B-40508
Water System	D-AA-B-40509
Off Gas & Component Air Coolant Systems	D-AA-B-40510
Fuel Loading & Storage System	D-AA-B-40513
Chemical Processing System	D-AA-B-40514
Containment Air	D-AA-B-40515
Nuclear Instrument	D-AA-B-40523

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Sampler Enricher	D-HH-Z-55575
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Safety Circuits	D-HH-B-57372-3
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Rod Control Circuits	D-HH-B-57387-9
Fission Chamber Drives	D-HH-B-57390
I.A.C. #1, F.O.P. #1 & C. O. P. #1	D-HH-B-57357

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I.A.C. #1, F.O.P. #2 & C. O. P. #2	D-HH-B-57358
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Radiator Lead Control System	D-HH-B-57322
Rod Control Circuits	D-HH-B-57324-25
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Instrument Air Compressors	D-KK-C-41159
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Freeze Valve Control Circuits	D-HH-B-57300-305
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Master Control	D-HH-B-57330-1
Rod Control	D-HH-B-57332-3
Radiator Load Control System	D-HH-B-57334
Safety System	D-HH-B-57335

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Coolant Salt System	D-HH-B-57336
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Auxiliary Process Control Systems	D-HH-B-57339-41
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Electrical-Process Equipment--Locations	D-KK-C-41139
Process Equipment Distribution System (one line)	D-KK-C-41152
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Schematics Electrical

Electric Heating	E-MM-C-51620
Main Power-Electric Heating	E-MM-C-40850
Panels FP1, FP2 & RCH3 Reactor Cell Elec. Heating	E-MM-C-51618
Panels RCH-4, Hx1, Hx2 & Hx3 Reactor Cell Elec. Heating	E-MM-C-51619
Panels RCH-1, 2 & 7 Reactor Cell Elec. Heating	E-MM-C-51698
Panels RCH 5 & 6, H 102&2 Reactor Cell Elec. Heating	E-MM-C-51699
Elec. Heating Distribution Panels R1-2 & 3	E-MM-C-56234
Fuel Drain & Flush Tank Heating	E-MM-C-51655
Elec. Heating - Radiator Inlet & Outlet	E-MM-C-40818
Elec. Heating - Radiator	E-MM-C-40822
Elec Heating - Radiator	E-MM-C-40823
Elec. Heating Distribution Panels H200-13, H201-12, H202-2, Sp-1 & 16	E-MM-C-40840
Panel G5-2-Y	E-MM-C-40828
Distribution Panels G5-1A1 through G5-1-A5	E-MM-C-51653
Panel 65-B5 Radiator Heating	E-MM-C-40821
Distribution Panels G5-1-C1, C2, & C3	E-MM-C-51654
Distribution Panels G5-1D2, D3, & D4	E-MM-C-40844

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Panel T-1-A Elec. Heating	E-MM-C-40846
Panel T-1-B Elec. Heating	E-MM-C-40847
Panel T-1-C Elec. Heating	E-MM-C-40848
Distribution Panels T-2-V1, T-2-W1 & W2	E-MM-C-40841
Panel T-2-Y Elec. Heating	E-MM-C-40849
Elec. Heating Flush & Drain Tanks, Panels G5-1-A1 & A2	E-MM-C-51662
Panel G5-1-A5	E-MM-C-56236
Panel G5-1-C2 Elec. Heating	E-MM-C-51665
Panel G5-1-C3 and D2 Elec. Heating	E-MM-C-40845
Panel G5-1-D3 & D4 Elec. Heating	E-MM-C-51673
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Panel T-2-W2 Elec. Heating	E-MM-C-40842
Panel T-2-W1 Elec. Heating	E-MM-C-40843
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Coolant Cell - Fill Line 203	D-MM-A-57492
Coolant Salt System	E-MM-A-40832
Flush & Drain System - Drain Tank Cell	E-MM-A-51660
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Fuel Pump & Overflow Tank	D-HH-B-40525
Heat Exchanger	D-HH-B-40526
Fuel Storage Tank	D-HH-B-40527
Reactor Vessel	D-HH-B-40528
Coolant Salt Pump	D-HH-B-40529
Coolant Pump Float Level Indicator	Sk-JWK-2-16-64
Radiator	E-HH-B-56283-4
Radiator Cell	D-HH-B-40530

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Coolant Drain & Fill Tank	D-HH-B-40532
Fuel Fill & Drain Tank No. 1	D-HH-B-40533
Fuel Fill & Drain Tank No. 2	D-HH-B-40534
Fuel Flush Tank	D-HH-B-40535
Typical Freeze Flange	D-HH-B-40542
Typical Freeze Valve	GG-C-55509
Freeze Valves	D-HH-B-40543
Fuel & Coolant Salt Systems, Reactor Cell	E-HH-B-40536
Coolant Salt System, Coolant Cell	E-HH-B-40537
Flush & Drain System, Drain Tank Cell	E-HH-B-41771
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Chemical Processing System Gas Lines	E-HH-B-40554
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Reactor Cell	E-MM-A-48759
Coolant Cell	E-MM-A-48760
FD-1, FD-2, and FFT	E-MM-A-48762
Radiator	E-MM-A-48764
Reactor Vessel	E-MM-A-48765
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Console	E-HH-B-40568
Main Control Board	E-HH-B-40555
Auxiliary Control Board	D-HH-B-40644
Transmitter Panels	E-HH-B-40642
Sampler Enricher Panesl	D-HH-Z-41720
Water Panel	D-HH-B-40645
Oil Panels	D-HH-B-41722
Jumper Panel	E-HH-B-57400-3
T. C. Scanner Panel	D-HH-B-41648 & 61
Cover Gas System Panel	D-HH-B-41757 & 61

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Containment Air Panel	D-HH-Z-40621 & 55559
Diesel Panels - Local & Remote	D-KK-C-41178
Diesel Panels - Switch House	D-KK-C-55151
Diesel Panels _ Auxiliary Control Room	D-KK-C-55152
Heater Control Panels	E-MM-Z-51624
Motor Control Center T-1, G3 & T-2	D-KK-C-41160
Motor Control Center G5-1, G4 & G5-2.	D-KK-C-41161
MG Sets 2 & 3 Control Panel	D-KK-C-55108

Approved by [signature: P. N. Haubenreich] 7/23/65

SECTION 2

NUCLEAR ASPECTS OF OPERATION

Nuclear safety has been designed into the MSRE. Furthermore, qualified operators must have a working understanding of the considerations involved in nuclear operation, in order to operate the reactor in a manner which is both safe and efficient.

The purpose of this section is to provide information to which the operator can conveniently refer for a review of the nuclear aspects of the operation of the MSRE. First, there is a simplified explanation of how uranium can be made to produce heat in a controlled manner through a nuclear fission chain reaction. Then the specific characteristics of the MSRE are discussed briefly. This includes a discussion of how the nuclear instrumentation and controls work, how the nuclear power responds to the controls, and why precautions must be taken in the management of the fuel. The subject of radiation safety and control is not covered completely, since adequate treatment would be lengthy and is readily available to the operator in other publications.

2 A SIMPLIFIED REACTOR THEORY

This section, of necessity, gives only a very simplified and somewhat sketchy treatment of reactor theory and those areas of nuclear physics which are important in reactors. Convenient and fairly simple treatments of these fields are given in books by Glasstone[1,2] and Stephenson[3].

1 GLOSSARY

Words peculiar to nuclear physics or reactor theory which will be used are defined as follows:

age - a measure of the distance traveled by a neutron while slowing down by collisions with nuclei in a given material.

atom - the smallest particle of matter retaining its chemical identity, composed of a nucleus surrounded by orbital electrons.

atomic weight - the weight of an atom expressed in atomic mass units. The atomic weight is approximately equal to the combined number of protons and neutrons in the nucleus.

atomic mass unit (a.m.u.) - one-sixteenth the weight of an oxygen atom.

barn - a unit of area equal to 10^{-24} sq. cm. (This is the order of magnitude of the cross sectional area of a nucleus.)

beta particle - a high-speed electron emitted when a nucleus undergoes certain internal changes.

blanket - a region surrounding the core of a reactor, whose function is the useful absorption of neutrons.

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[1] S. Glasstone, Sourcebook on Atomic Energy, Van Nostrand, 2nd ed, 1958

[2] S. Glasstone, Principles of Nuclear Reactor Engineering, Van Nostrand, 1955.

[3] R. Stephenson, Introduction to Nuclear Engineering, McGraw-Hill, 2nd ed., 1958.

buckling - a factor in the spatial distribution of the neutron flux, characteristic of the size and geometry of a reactor.

capture - an event in which a neutron enters and remains in a nucleus.

Chain reaction - a reaction in which one event triggers or produces another similar event.

core - the heart of a reactor, in which the chain reaction is sustained.

cross section - a measure of the probability of a nuclear reaction.

criticality - a condition in which each fission produces exactly one other fission.

decay - radioactive disintegration.

diffusion length - a measure of the average distance a neutron moves from the time it reaches thermal energy until it is absorbed.

e-folding time - same as period.

electron - a particle with a unit negative charge and a mass of 0.00055 a.m.u.

electron volt (ev) - a quantity of energy equal to 1.52 x 10^{-22} Btu.

fission - a reaction in which a nucleus splits into two or more heavy fragments.

fission product - a nuclide produced by fission (most are radioactive).

flux - the product of the number of neutrons per unit volume and their speed.

fuel - fissionalbe material.

gamma ray - high-energy electromagnetic radiation.

generation time - the average time between sequential fissions in a chain reaction.

isotopes - nuclides having the same number of protons but different numbers of neutrons.

moderator - material used to slow down neutrons.

multiplication factor - the ratio of fissions in successive generations of a chain reaction.

neutrino - a neutral particle emitted in conjunction with a beta particle.

neutron - a neutral particle having a mass of about 1 a.m.u.

nucleus - the dense core of an atom, composed of protons and neutrons.

nuclide - a species of atom characterized by the numbers of neutrons and protons it contains.

period - when the neutron density is changing exponentially, the time to change by a factor of e (e = 2.72).

prompt neutron lifetime - the average time between the birth of a fission neutron and its ultimate absorption.

proton - a particle with a unit positive charge and a mass of about 1 a.m.u.

radioactive - subject to spontaneous change of the nucleus, usually by emission of a beta particle and gamma rays.

reactivity - the quantity $(k - 1)/k$ where k is the multiplication factor.

reflector - material added on the outside of a reactor to reflect neutrons.

resonance energy - a neutron energy range in which the probability of reaction is very high.

scattering - an event in which a neutron interacts with a nucleus to change its direction and speed.

2 ATOMIC STRUCTURE

The world around us is made up of a wide variety of substances. Each "chemically pure" substance is comprised of molecules, each identical with all others of that substance. The molecules in turn are combinations of atoms, an extremely small unit of matter ($\sim 10^{-8}$ cm). An atom contains a nucleus, whose diameter is only about 1/10,000 of that of the atom, but which contains nearly all of its mass. Around the nucleus are orbiting electrons, negatively charged particles with little mass. The nucleus, which is positively charged, contains protons and neutrons. The nuclear particles (nucleons) are about equal in mass, but the proton has a positive charge, equal in magnitude to the negative charge of the electron, while the neutron is uncharged. The atom is neutral, having as many negative electrons as positive protons.

A nuclide is comprised of all atoms having the same number of neutrons and the same number of protons. Naturally occurring nuclides range from normal hydrogen, whose nucleus is simply a proton, to uranium-238, which has 92 protons and 146 neutrons in its nucleus.

Atoms of any one element all have the same number of protons and orbital electrons. Because chemical properties are determined by the orbital electrons, all atoms of an element are chemically alike. But not all atoms of an element necessarily have the same number of neutrons. Nuclides of the same element with different numbers of neutrons are called isotopes of that element.

An example of isotopes is shown in Fig. 2A-1, which depicts schematically the two isotopes of lithium. Both have 3 protons and 3 electrons, and behave alike chemically. But Li^6 has 3 neutrons and Li^7 has 4. (The superscript number on the element symbol is the total number of nucleons or the atomic mass number.) This difference in the number of neutrons causes these isotopes to have quite different nuclear properties--Li^6 is 30,000 times more likely to absorb a neutron, and it is for this reason that separated Li^7 is used in the MSRE salt manufacture. (Natural lithium is comprised of 92.5% Li^7 and 7.5% Li^6.)

Li^6 atom. Li^7 atom.

Fig. 2A-1 Representation of Two Isotopes of Lithium.

The positively charged nucleus is held together by extremely strong short-range forces, while the electrons are much less tightly bound to the atom by attraction to the positive nucleus. In chemical reactions, which involve the orbital electrons, the energy for a reaction is on the order of a few electron volts (ev). Much more energy (on the order of millions of electron volts) is involved in changes in the nucleus because of the stronger forces of attraction. Indeed, so much energy is involved that a nuclear reaction can produce a significant change in mass of the reacting particles as mass is converted to energy, or vice versa. (The conversion follows Einstein's famous $E = mc^2$.)

Consider Figure 2A-2, which is a plot of the mass per nucleon (the ratio of nuclear mass to atomic number, or number of nucleons) against atomic number. It is seen that the average mass of nucleons in nuclides of intermediate number is significantly less than the averages at either end. A consequence of this is that if heavy nuclides can be split to form lighter fragments the total mass decreases. The difference appears in the form of energy. This is the basis of power from nuclear fission. (Fusion involves building up from the low-A end of the scale.)

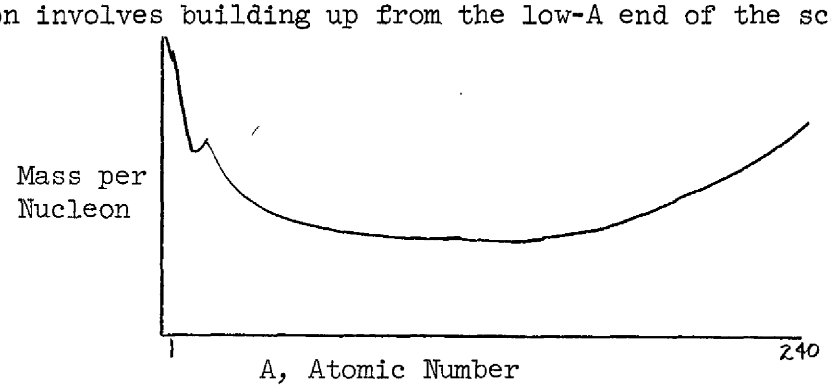

Fig. 2A-2 Average Mass per Nucleon

3 RADIOACTIVITY AND RADIATION

The number of nucleons in naturally occurring nuclides covers a wide range, from 1 to 238. But if one plots the number of neutrons against the number of protons in each naturally occurring nuclide, it is found that all of the points lie in a rather narrow band as shown in Fig. 2A-3.

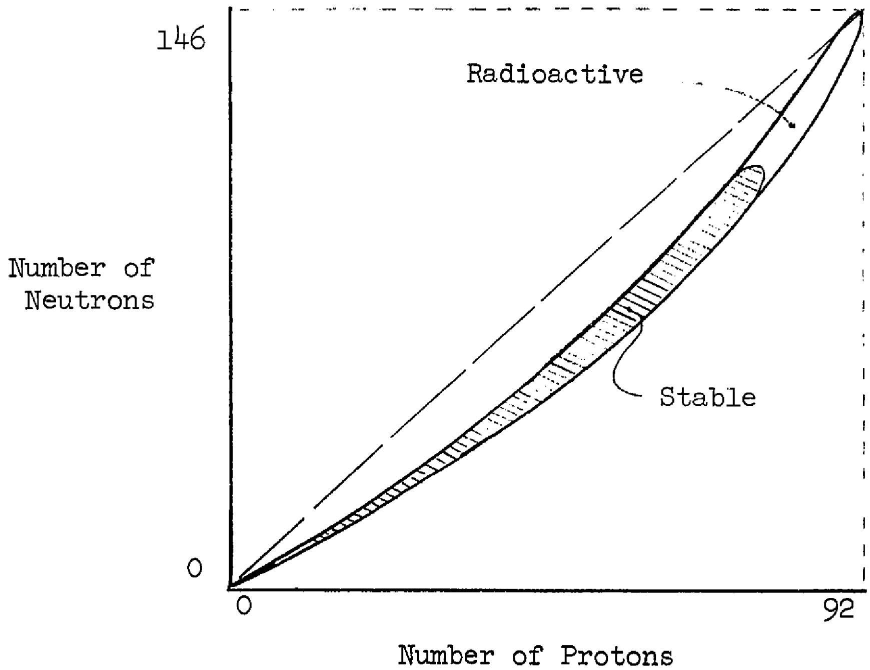

Fig. 2A-3 Nuclear Composition of Naturally Occurring Nuclides

Some nuclides found in nature are radioactive; that is, the nuclei may spontaneously change, or "decay." Nearly all of these naturally radioactive nuclides are at the heavy end of the band and decay by the emission of an alpha particle from the nucleus. An alpha particle consists of two protons and two neutrons (identical with a helium-4 nucleus), so this type of decay produces a nuclide nearer the stable band.

The fact that the band in Fig. 2A-3 is curved has an important implication. If a heavy nuclide is split, or fissioned, the fission fragment nuclei usually have a composition near the straight line joining the original point to the origin. Thus the primary fission products usually lie outside the stable band, on the side of too many neutrons, and are radioactive. The tendency is for change toward the stable band, sometimes by emission of a neutron from the nucleus but much more often by the process called beta decay. In this process a high-speed electron (beta particle) is emitted from the nucleus, reducing the number of neutrons by one and adding one to the number of protons.

Approved by R. H. Huymon

2A-7
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Another process (besides fission) which can produce radioactive nuclides is neutron absorption. A passing neutron may be absorbed in almost any nucleus (the probability of absorption varies widely, however). When this happens, a certain amount of energy, called the binding energy of the added neutron, is immediately released, usually in the form of gamma rays, called capture gammas. The new nucleus, containing the added neutron, may be stable or it may be radioactive. Radioactivity produced by neutron absorption is called induced radioactivity, or the material is said to be activated. Induced radioactivity is usually in the form of beta decay.

Beta decay is always accompanied by the emission of a neutrino. The neutrino is a particle with very small mass, which is so unlikely to interact with matter that it is extremely difficult to detect. Neutrinoes are important in a reactor only in that they carry away a significant amount of energy in a form which is not recoverable.

Most radioactive decay processes, whether they be alpha decay or beta decay, are accompanied by the emission of gamma rays, called decay gammas.

Radioactive decay is a statistical process, that is, the rate can be predicted only for large numbers of nuclei. The probability that a nucleus will decay in a given interval of time is called the decay constant, usually represented by λ. Thus, when there are N nuclei of a of a radioactive nuclide present, the rate of decay is $N\lambda$ disintegrations per unit time. If there are N_o nuclei at a particular time, then a time t later there will be $N_o e^{-\lambda t}$ nuclei remaining.

$$N = N_o e^{-\lambda t}$$

This formula means that the number of nuclei present (and the rate of disintegration) decreases by a certain fraction in any equal lengths of time. The time required to decrease by a factor of two is the half-life. Half-lives of fission products range from a fraction of a second to many years. Naturally occurring radioactive nuclides are usually very long lived. For example U^{235} decays by alpha emission with a half life of 700 million years.

Amounts of radioactive material are usually expressed in units of curies. A curie is defined as the amount of material which undergoes 3.7×10^{10} disintegrations per second.

Alpha particles, beta particles and gamma rays all deposit energy and cause local damage along their path through matter. This can cause problems of heating, changes in physical properties of materials and biological injury.

Charged particles give up energy as they move through matter by the process of ionization. The charged particles and the orbital electrons exert forces on each other which slow down the moving particle and draw many electrons from their atoms, leaving positively charged atoms or ions. Thousands of ion pairs must be formed in the course of stopping an alpha particle or a beta particle, but in ordinary matter this will occur in a short distance. Thus charged particles have a limited range. For example, a 1-Mev beta can travel 0.14 in. in water (or flesh). Alpha particles produce more dense ionization, and the range of a 1-Mev alpha in water is only 0.0002 in.

Gamma rays do not ionize directly since they are electromagnetic radiation with no charge. They interact through any of three processes to produce high-speed electrons which in turn ionize the medium. The gammas always travel at the speed of light, but their energy can be decreased, even to zero, by scattering collisions with electrons. (It is useful for some purposes to think of gammas as particles since they have direction, energy and momentum and can have collisions.) The linear rate of energy loss by gammas in matter is far less than that of charged particles. Consequently they do not have a definite range. Instead the intensity of a stream of gammas falls off exponentially with distance through matter.

$$I = I_o e^{-\mu x}$$

Shielding consists of absorbing the energy of radiation in material interposed between the source of the radiation and objects which are to be protected from the effects of the radiation.

4 THE FISSION PROCESS

There are some nuclides in which the nucleus will fission, or split into a number of smaller particles, when a neutron collides with it. Some nuclides, such as U^{238}, will fission only if the neutron is travelling at very high speed; neutrons of any energy will cause certain other nuclides to fission. U^{235}, which is fissionable with neutrons of any energy, is the fuel in the MSRE.

In the fission process, a neutron enters a nucleus, causing so much disturbance that the forces which hold the nucleus together are overcome and the nucleus splits into two or more smaller nuclei or fission fragments. The exact manner in which U^{235} nuclei split is not always the same, but in most fissions the nucleus (atomic mass 235) breaks up into two unequally-sized particles having atomic mass numbers around 95 and 140. In addition to the fission fragment nuclei, there are many other smaller particles resulting from the fission. These are beta particles, gamma rays, neutrinos and neutrons. On the average, the fission of a U^{235} nucleus gives off 2.5 neutrons and it is this fact which makes a chain reaction possible, since these new neutrons, if they are properly handled, can cause other fissions.

Nuclear fission is important because of the relatively large amount of energy released in the process, compared to the energy available from chemical reactions, which involve only the loosely bound orbital electrons. To illustrate, when a carbon atom burns, or combines chemically with an oxygen molecule, the energy released is 4 ev. In contrast, when a single U^{235} nucleus fissions, the total energy released is about 200,000,000 ev (200 Mev). The distribution of this energy is shown in Table 2A-1. All of this energy eventually appears as heat, but not all of it in places where it can be utilized. The fission fragments are all slowed down and stopped within a few thousandths of an inch, so their energy appears as heat essentially at the point of the fission. Beta particles have a range of only an inch or less. Neutrinoes, on the other hand, travel such great distances without creating heat (or leaving any trace) that as far as power production is concerned they might as well not even exist. A fission neutron usually gives up its energy in a series of collisions along a zigzag path a few feet long. A gamma ray may penetrate as much as several feet in a straight line before its energy is converted to heat. The available energy in Table 2A-1 is the estimated amount which produces useful heat in the MSRE*. The rest of the energy escapes and appears as heat in the shield or elsewhere outside the reactor.

Table 2A-1 Distribution of Fission Energy

	Energy, Mev	
	Total	Available
Kinetic energy of fission fragments	168	168
Kinetic energy of fission neutrons	5	4
Instantaneous gamma rays	7	7
Gamma rays from fission product decay	6	5
Beta particles from fission products	8	8
Neutrinos	11	0
	205	192

Although most of the fission heat is generated practically instantaneously, the beta particles and gamma rays from the fission products are

*Note that Table 2A-1 lists only the energy directly produced by fission. In a reactor there is also energy produced by non-fission capture of neutrons which produces gamma rays at the instant of capture and gamma and beta rays by the decay of the capture products. The ratio of captures to fissions depends on the reactor; in the MSRE this source releases about 6 Mev/fission, nearly all of which appears as useful heat.

liberated over a period of time by radioactive decay. The fission products are a mixture of nuclides with half lives ranging from a fraction of a second to many years. Thus, in a nuclear reactor the heat source from the fission product decay decreases after the fission reaction is stopped, rapidly at first, then more slowly and never completely dying out. The energy release after shutdown, called "afterheat", is a serious problem in high-power reactors.

Nearly all of the fission neutrons, are emitted almost instantaneously, but a few are liberated by the decay of certain short-lived fission product isotopes, called precursors. These delayed neutrons comprise only 0.64 per cent of the total neutrons, and they are nearly all emitted within the first minute after a fission, but they play an important part in making the fission chain reaction more easily controlled, as will be seen later.

Although the amount of energy produced per fission is large compared with that in chemical reactions, the absolute amount is so tiny that an extremely large number of fissions must occur to produce a useful amount of heat. (198 Mev is only 3.0×10^{-14} Btu. At 198 Mev/fission, the fission rate required to produce 1 watt is 3.16×10^{10} fissions/sec.) To illustrate, when the MSRE is operating at a nuclear power of one megawatt, about <u>one trillion</u> (10^{12}) fissions occur each second in each cubic inch of fuel salt. The important consequence of such high fission rates is that the laws of probability apply very well, so the analysis of the nuclear behavior of a reactor can be based upon probabilities.

5 CROSS SECTIONS AND REACTION RATES

In the calculation of rates of reaction between nuclei and neutrons, use is made of probabilities expressed in terms of nuclear cross sections. The following illustration is helpful in understanding the significance of the term "cross section". Consider a thin element of volume containing a number of spheres (nuclei) as shown in Fig. 2A-4. If a neutron, which can be pictured as a tiny projectile, enters perpendicularly to a face, the chance that it will collide with a sphere is equal to the fraction of the area of a face covered by the circles which are the projections of the spheres.

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This fraction is

$$\frac{N\ a^2\ dx\ \sigma}{a^2} = N\sigma\ dx$$

Since this is the probability that a neutron will suffer a collision while traveling a distance dx, the probability per unit distance traveled is found by dividing by dx. This probability of collision per unit neutron path length, $N\sigma$, is called the macroscopic cross section, symbolized by Σ, with dimensions of reciprocal length.

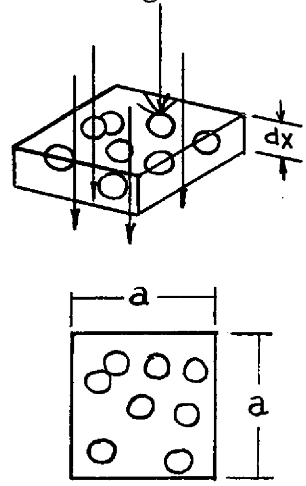
Fig. 2A-4

r = radius of sphere

$\sigma = \pi r^2$ = cross sectional area of sphere

N = number of spheres per unit volume

$Na^2\ dx$ = number of spheres in volume element



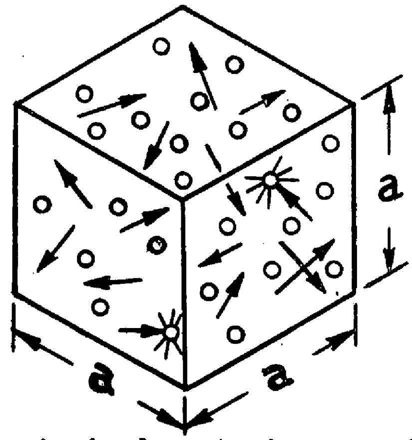
Now picture a box containing nuclei and randomly moving neutrons as shown in Fig. 2A-5. The combined distance traveled each second by all the neutrons in the box is a^3nv. (Assume the neutron density in the box is not changing, so if some of the original neutrons leave, others come in to take their place.) The path length per unit volume per second is a^3nv divided by the volume, a^3. This quantity is called the neutron flux, ϕ.

$$\phi = nv \left(\frac{\text{neutrons}}{\text{cm}^3}\right)\left(\frac{\text{cm}}{\text{sec}}\right) \text{or} \left(\frac{\text{neutrons}}{\text{cm}^2 - \text{sec}}\right)$$

Since the number of collisions per unit path length is Σ, the rate of collisions per unit volume is the product of the path length per unit volume per unit time and the probability of a collision per unit path length.

$$R\left(\frac{\text{collisions}}{\text{cm}^3 - \text{sec}}\right) = \phi\left(\frac{\text{neutron-cm}}{\text{cm}^3 - \text{sec}}\right) \times \Sigma\left(\frac{\text{collisions}}{\text{neutron - cm}}\right)$$

Fig. 2A-5



n = number of neutrons per unit volume

v = speed of neutrons

a^3n = number of neutrons in volume element

The foregoing picture of cross sections is inadequate in several respects.

In the first place, the experimentally determined cross sections show that for most isotopes the effective neutron target area, σ, is many times the actual πr^2 of the nucleus. Further more, σ varies with neutron speed, usually in such a way that the nucleus appears to present to passing neutrons a target which becomes larger the slower the neutron.

Another difficulty with the simple picture is that a neutron may undergo any of several different reactions with nuclei of a particular type. The fission reaction has already been mentioned. Another reaction is radiative capture, in which the neutron is absorbed and a gamma ray is emitted from the nucleus. A neutron may also undergo an elastic scattering or "billiard ball" collision with a nucleus. The nucleus has a different probability or cross section for each type of reaction, and in general all the cross sections vary with neutron velocity. Cross sections for different reactions are identified by subscripts; f for fission, c for radiative capture, a for absorption, s for scattering and t for total*.

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*Absorption includes both fission and radiative capture. Total includes absorption plus scattering. Thus $\sigma_a = \sigma_f + \sigma_c$ and $\sigma_t = \sigma_a + \sigma_s$.

In view of the inadequacy of the "hard sphere" picture of neutron-nucleus collisions, it is perhaps best to think purely in terms of probability. The probability that a neutron, while passing a unit distance through a region inhabited by N nuclei per unit volume, will undergo a particular reaction is $N\sigma$, where σ is a measure of probability whose magnitude depends upon the type of nuclei, the type of reaction and the neutron speed. The probabilities are additive, i. e., the probability that a reaction of some sort will occur is the sum of the probabilities for reactions of all the possible types. For example, in a region containing two types of nuclei identified by subscripts 1 and 2

$$\Sigma_a = \Sigma_{a1} + \Sigma_{a2} = N_1\sigma_{a1} + N_2\sigma_{a2}$$

$$\Sigma_t = N_1 (\sigma_{a1} + \sigma_{s1}) + N_2 (\sigma_{a2} + \sigma_{s2})$$

It follows that the fraction of the absorptions which occur in nuclei of type 1, say, is

$$\frac{\Sigma_{a1}}{\Sigma_a} = \frac{\Sigma_{a1}}{\Sigma_{a1} + \Sigma_{a2}}$$

6 THE FISSION CHAIN REACTION IN AN INFINITE REACTOR

Because each U^{235} fission releases, on the average, 2.5 neutrons the feasibility of a self-sustaining chain reaction would at first seem obvious, since to maintain such a reaction only one of the 2.5 neutrons need cause another fission. However, a practical reactor must contain materials other than fuel and these other materials absorb part of the available neutrons. Furthermore, a certain fraction of the neutrons will escape from the reactor without reacting. Therefore, the primary problem of reactor theory is the specification of materials and an arrangement which will conserve neutrons and result in a self-sustaining chain reaction. Such an assembly is a reactor.

The chances that a neutron will escape from a reactor decrease as the reactor is made larger, of course. The leakage probability is also reduced as the macroscopic cross section of the materials is increased. Thus a self-sustaining chain reaction is possible in a small reactor if the macroscopic cross section is adequately large. This requires either a high concentration of fuel or a large microscopic cross section. Because fission and absorption cross sections are much larger for slow neutrons than for fast, most reactors utilize slow neutrons.* This is done by including in the reactor a substance, having a low atomic weight, a large scattering cross section, and a small absorption cross section. This material, called the moderator, slows down (moderates) the fast neutrons by elastic scattering. It also helps to conserve neutrons by diverting those that are headed out of the reactor. (Sometimes material with a high scattering cross section is added around the outside of a reactor for the sole purpose of scattering back or "reflecting" neutrons which would otherwise escape. This is then called a reflector.)

In order to see how the requirements for a self-sustaining chain reaction can be calculated, let us consider the various fates which may befall a neutron in a reactor which contains fuel, moderator and other neutron-absorbing material. There are several things that can happen and they all affect the chance that one of the neutrons emitted in a fission will survive to cause another fission. First, we will examine how the individual probabilities of the different events combine to give the overall probability of a fission neutron causing another fission. Then we will see how the probabilities are determined by the materials and geometry of the reactor.

For simplicity, first consider the case of a reactor which we imagine is so large that leakage can be neglected. (Infinite reactor case.) Suppose we begin with a large number, say x, neutrons which have just been born in U^{235} fissions caused by slow neutrons. (Refer to Fig. 2A-6) Some of these very fast neutrons will collide with uranium nuclei (either U^{235} or U^{238}) and result in fissions which produce more neutrons. Thus the total number of fast neutrons will be increased by a factor, ϵ, called

*Most reactors utilize "thermal" neutrons, i.e., neutrons which have been slowed down until they reach an energy range fixed by the temperature of the medium.

the fast fission factor. Now if neutrons which have suffered a few collisions so their energy is in the intermediate range pass near a U^{238} nucleus, the chances are they will be swallowed up in radiative capture.* The probability that neutrons will be slowed down past the resonance energy without being absorbed is called the resonance escape probability, p . After the neutrons have been slowed down to thermal energies, only a fraction are absorbed in U^{235}. This fraction is the thermal utilization factor, f . (In an infinite reactor the remainder of the neutrons are absorbed in other materials.) Some of the absorptions in U^{235} are radiative capture, while others result in fission with a production of ν neutrons per fission. Thus one cycle is completed. The ratio of the neutrons present after one cycle, or generation, to those present initially is called the infinite multiplication factor or reproduction factor. (It is called infinite because it applies only to a very large reactor where leakage is negligible.)

The average number of fission neutrons produced per neutron absorbed in U^{235} is called eta (η), and for the absorption of thermal neutrons it has a value of 2.08. The fast fission factor is a function of the ratio of moderator to fuel, approaching unity for large values of the ratio. The resonance escape probability also is a function of moderator-to-fuel ratio, increasing to unity as the ratio increases. The thermal utilization factor, in a homogeneous reactor, is just the ratio of the macroscopic absorption cross section of the fuel to the total cross section of all the components in the reactor. Even though only a very small fraction of the atoms in a reactor are U^{235}, the thermal utilization factor is usually greater than 0.8 because the cross section of U^{235} is so high compared with the other nuclides in the core. (Typical values are 690 barns for U^{235}; less than 0.01 barn for Be, C, or F.) Because in a heterogeneous reactor the fuel, moderator and structure are not exposed to exactly the same flux of neutrons, ϵ, p, and f are all dependent on the size and spacing of the fuel and moderator regions.

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*For neutrons of intermediate energy, U^{238} has a very high cross section for radiative capture. This is referred to as the resonance energy range.

x	fast neutrons from slow neutron fission of U-235
↓	increase due to fast fissions
$x\epsilon$	fast neutrons from both slow and fast fissions
↘ $x\epsilon(1-p)$	neutrons absorbed in U-238 in resonance energy range
$x\epsilon p$	neutrons slowed down to thermal energy range
↘ $x\epsilon p(1-f)$	thermal neutrons absorbed in materials other than U-235
$x\epsilon pf$	thermal neutrons absorbed in U-235
↘ $x\epsilon\ pf\ \sigma_c/\sigma_a$	radiative captures in U-235
$x\epsilon\ pf\ \sigma_f/\sigma_a$	fissions in U-235 caused by slow neutrons
$x\epsilon\ pf\ \nu\sigma_f/\sigma_a$	fast neutrons from slow neutron fission of U-235

$$k_\infty = \frac{x\epsilon pf\nu\sigma_f/\sigma_a}{x}$$

$$\eta = \nu\ \sigma_f/\sigma_a$$

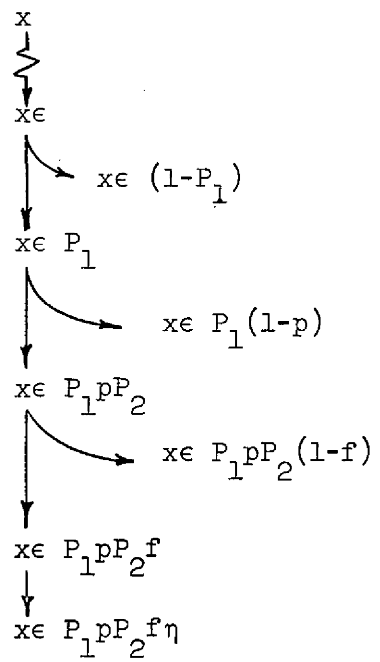
$$k_\infty = \eta\ \epsilon\ pf$$

Fig. 2A-6 Fission Chain in Infinite Reactor (No leakage)

7 EFFECT OF NEUTRON LEAKAGE

Because a significant fraction of the neutrons escape from even large reactors, the neutron leakage probabilities must be considered in calculating the multiplication factor which can actually be attained.

Let us suppose that $1-p_1$, is the probability that a fast neutron will leak out of the reactor before it is slowed down or absorbed. Then P_1 is the fast non-leakage probability. There is a probability that a neutron can escape from the reactor after it has become thermalized, and a slow non-leakage probability, P_2, can be defined. With the inclusion of leakage probabilities, the diagram of the chain reaction becomes as shown in Fig. 2A-7.



$$K = \frac{x\eta\epsilon p f\ P_1 P_2}{x} = k_\infty\ P_1 P_2$$

Fig. 2A-7 Fission Chain Reaction in a Finite Reactor

The non-leakage probabilities depend on the size and composition of the reactor. Two-group diffusion theory, a simplified mathematical description of neutron slowing down and diffusion, gives the following expressions for P_1 and P_2 in an unreflected (bare) reactor.

$$P_1 = \frac{1}{1 + B^2\tau}$$

$$P_2 = \frac{1}{1 + L^2B^2}$$

These will serve to illustrate the dependence of P_1 and P_2 on the physical dimensions and properties of the reactor.

The factor B^2, called the buckling, is a function of the reactor size and shape. For a bare, cylindrical reactor of radius R and height H.

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$$B^2 = \left(\frac{2.405}{R}\right)^2 + \left(\frac{\pi}{H}\right)^2$$

It can be seen that if the dimensions are made larger, B^2 decreases rapidly and P_1 and P_2 increase.

τ, called the age, is determined primarily by the moderator. It is equal to one-sixth the mean square of the distance traveled by a neutron while slowing down. L is called the thermal diffusion length, and L^2 is one-sixth the mean square of the (crow-flight) distance a neutron covers from the time it reaches thermal energy until it is captured. L^2 is given approximately by

$$L^2 = \frac{1}{3\Sigma_s\Sigma_a}$$

where Σ_s and Σ_a are the scattering and absorption cross sections of the reactor material. Reduction of τ by introduction of more efficient moderator material and L^2 by either better scattering or more absorber reduces P_1 and P_2.

8 CRITICALITY

In the preceding sections we followed a group of neutrons through one cycle, or generation, and derived a quantity, k, which is the ratio of neutron production in successive generations. It is clear that if k = 1, the fission chain reaction is self-sustaining and the neutron population, the flux, the fission rate, and all reaction rates will be stationary in time, without any contribution from neutron sources other than fission. The critical condition is defined as that in which k = 1. Note that criticality does not imply any particular power level, merely that the chain reaction is exactly self-sustaining.

9 EXTRANEOUS NEUTRON SOURCES AND SUBCRITICAL MULTIPLICATION

Besides the fission process, several other nuclear reactions lead to the emission of neutrons. Most important of these are the interaction of high-energy gamma rays or alpha particles with any of several materials, the most important of which is Be^9.

A neutron source may be constructed using gamma rays from some fission product, a neutron-activated material, or the natural radioactive element, radium. This is called a photoneutron source, and the most common form contains antimony-124 (60-day half-life, produced by neutron irradiation of

Sb^{123}) and beryllium. An alpha-n source may contain a mixture of beryllium with 138-day polonium-210 or long-lived radium or plutonium, all of which emit alpha particles in their decay.

The MSRE fuel salt contains an inherent neutron source resulting from interaction of alphas from uranium decay with the beryllium of the salt. In addition, after fission products have built up in the reactor, a strong photoneutron source will result from the fission product decay gammas interacting with the beryllium.

The importance of these extraneous sources of neutrons is that they can be used to maintain some neutron population or fission rate in a reactor even when the fission chain reaction is not self-sustaining.

Consider a reactor which is subcritical, i.e., $k < 1$. On the average, each fast neutron introduced by an extraneous source will produce in the first generation k neutrons; in the second k^2; and so on. Thus for each source neutron, there eventually appear a number of neutrons M given by

$$M = 1 + k + k^2 + k^3 + \cdots = \frac{1}{1 - k}$$

If source neutrons are being introduced at a rate S, then the total rate of neutron appearance in the reactor is SM. The population of neutrons in the reactor is the product of the birth rate and the average time a neutron spends in the reactor before being absorbed or leaking out. If the lifetime is a constant in a reactor with an extraneous source, the population and the flux will be proportional to M. For this reason M is called the subcritical multiplication factor.

M becomes very large as k approaches a value of 1. Thus, theoretically, if a source is present, any flux or power could be reached with the reactor slightly subcritical. Practically speaking, however, the source becomes insignificant when the power reaches a few watts or so, and the reactor behaves as if no source were present; i.e., the power rises when the reactor is supercritical ($k > 1$) and decreases when it is subcritical.

10 REACTOR KINETICS

Consider a hypothetical reactor in which all of the neutrons have the same generation time, ℓ. Neglecting any extraneous source, the fractional change in flux, or power in one generation is $k - 1$. Thus the rate of change of power is

$$\frac{\Delta P}{\Delta t} = \frac{P\ (k-1)}{\ell} \quad .$$

In this case, if k is constant, the power changes exponentially; i.e., for an initial power P_o, the power after a time t is

$$P = P_o\ e^{t\ (k-1)/\ell} \quad .$$

The quantity $\ell/(k - 1)$ is called the period, or the e-folding time since it is the period required for an e-fold change in power. Somewhat more generally, the period is defined as the instantaneous value of

$$\frac{1}{P}\ \frac{dP}{dt} = \frac{d\ (\ln P)}{dt}$$

In an actual reactor the generation time is not the same for all neutrons. The lifetime is about the same for all (typically less than a millisecond) but the generation time includes the "gestation period" for the delayed neutrons (on the order of several seconds). The delayed neutrons usually therefore exert a strong slowing down or damping influence on power changes. Although the mathematical expressions for the kinetics become complicated when delayed neutrons are included, the behavior is still basically exponential and an important characteristic of a reactor is the "inhour curve" which relates the inverse period to the reactivity. (Reactivity is defined as $(k - 1)/k$.)

The inverse period increases with reactivity and this increase becomes much sharper above the point where the reactivity equals β, the fraction of the neutrons which are delayed. This point is called prompt critical because at higher reactivity, the chain reaction can diverge with prompt neutrons alone, without waiting for the delayed neutrons. At a constant k above prompt critical the power behavior is approximately given by

$$P = P_o\ e^{(k - 1 - \beta)t/\ell^*}$$

where ℓ^* is here the prompt neutron lifetime. The reactivity is sometimes measured in "dollars", or multiples of β. (One dollar is prompt critical.)

In the normal operation of a reactor the reactivity is adjusted (by means to be described later) to hold to power steady or to go from one power level to another at a reasonable rate.

11 NUCLEAR INSTRUMENTATION

The most satisfactory means of continuously monitoring the nuclear power of a reactor is to follow the neutron flux at some point. The detector can be located outside of the reactor itself, because the flux produced by neutrons leaking from the reactor rises and falls with the power inside.

The most common form of neutron detector is the ionization chamber. In such a device, neutrons interact with some material to produce high-speed particles which ionize (strip electrons from atoms) in a gas in the chamber. An electric potential causes the electrons and positive ions to be drawn to opposite electrodes, and appropriate circuitry either counts the pulses of ions or measures the average current.

Boron-10, which emits an ionizing alpha particle upon absorption of a neutron, is commonly used in ion chambers, either as a coating or in the form of BF_3 gas. A form of ion chamber called a fission chamber contains U^{235}, and the fission fragments produce the ionization.

Gamma radiation interferes with the measurement of low fluxes of neutrons, because the gamma rays also produce ionization and contribute to the current in a neutron-sensitive chamber. This is no problem in a fission chamber because the counting circuit can be made to discriminate between the large pulses caused by fission fragments and the much smaller events caused by individual gamma photons. The compensated ion chamber was developed to provide a current proportional only to neutron flux even in high gamma fields. This type of detector has two chambers which produce equal ionization currents when exposed only to gamma rays. One of the chambers contains a boron coating so that it is sensitive to neutrons as well as to gammas. The desired signal is obtained by bucking or subtracting the currents from the two parts of the detector.

Because the reactor power may vary over many decades from sub-critical source multiplication to full power and because the time variation is often exponential, it is common to use circuitry to produce a signal proportional to the logarithm of the power. This may be a log count rate meter or a logarithmic current amplifier. In either case the time derivative is the inverse of the period, and, displayed on properly marked dials or charts, provides a useful indication of the period.

Note that the nuclear instruments give a signal which is only proportional to power. The proportionality factor must generally be determined by heat balance measurements and simultaneous nuclear instrument readings.

12 REACTOR CONTROL

The function of reactor control is to regulate the power and/or temperature in the desired ranges, to prevent excessive power or temperature, and to shut the fission chain reaction down to very low levels whenever necessary. To do this, the reactivity is varied, usually by the movement of neutron absorbing material (generally called a rod, regardless of shape) into and out of the core.

Small, fairly quick, variations in reactivity (less than a dollar) are required to maintain the power within a narrow band. This is the regulating function and a special rod for this is called a regulating rod.

Rods which can rapidly insert considerable poison if required to prevent power or temperature excursions are called safety rods.

There are several factors affecting reactivity which produce rather slow changes during an operating cycle (startup, power operation and shutdown). At some stages the net effect is a tendency to reduce k; at other times, k tends to increase. In order to keep k at or near 1, control rods may be occasionally or gradually adjusted. Rods performing this function are called shim rods.

An important effect on reactivity is that of core temperatures. As temperatures rise, materials grow less dense and microscopic cross sections change. The net effect is usually a negative temperature coefficient of reactivity, so that the reactivity must be increased by some other means if the operating temperature is to be raised. Distinct from shifts in the overall temperature distribution are the changes in temperature distribution accompanying power changes. As the power is raised, temperatures in various parts of the core diverge, and in order to hold some desired temperature (or temperature average) constant it is generally necessary to adjust the reactivity by shim rod movement. The power coefficient of reactivity is the amount of rod motion required to produce the desired effect.

Temperature coefficients of reactivity not only affect shim requirements but also have an important effect on kinetics, since negative reactivity coefficients tend to produce a stable, self-regulating system when the power is high enough to produce a feedback effect.

During power operation, consumption of U^{235} by fission and by radiative capture tends to reduce reactivity. This burnup effect is slow, since only a very small fraction of the inventory is consumed in a day. Shim rod movement and periodic additions of uranium compensate for this effect.

Another effect of power operation is the production of fission product poisons which tend to reduce k. Most of these poisons are stable and have relatively small cross sections, so they continue to build up. Shim rods compensate for these poisons. (In the MSRE the U^{235} inventory is increased.) A few poisons with high cross sections produce transient effects, with time constants on the order of hours, and these effects require the use of the shim rods.

In a circulating-fuel reactor one more effect on reactivity is observed: the loss of delayed neutrons by emission outside of the core. This causes a slight reduction in k (the effective value of ν is reduced) but more importantly it affects the kinetics (the value of the "dollar" is reduced).

13 XENON AND SAMARIUM

The most important single fission product nuclide is xenon-135. This radioactive nuclide (9-hour half life) has a thermal neutron cross section of about 3 million barns. Most Xe^{135} is produced by the decay of iodine-135, which has a half-life of 5 hours and a small cross section. When the reactor is operated at power, the I^{135} and then the Xe^{135} concentrations build up. The Xe^{135} concentration at power is limited by its natural radioactive decay and by transmutation by neutron absorption. Typically the equilibrium poisoning effect of Xe^{135} is about 2 to 3% in k. When the reactor power is reduced, the Xe^{135} concentration at first increases because the destruction by neutron capture decreases before the production by I^{135} decay changes appreciably. Radioactive decay of the Xe^{135} causes the concentration to begin to decrease after a few hours and eventually it would all disappear.

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Xenon is normally a gas, and in fluid-fuel reactors the Xe^{135} concentration may be significantly affected by mechanisms which remove xenon from the fuel.

Another fission product which has an important effect on the reactivity is samarium-149, a stable nuclide formed by decay of 53-hour promethium-149. Samarium-149 has a cross section of about 40,000 barns, so its concentration is held down by burnup when the reactor is at power. After the power is reduced, the burnup stops, but the Pm^{149} continues to decay, causing an increase in Sm^{149}. Being stable, the Sm^{149} remains high until the power is raised and it comes back to the equilibrium value at power. Typical values of the Sm^{149} reactivity effect are: equilibrium at full power, 0.9% $\delta k/k$; and increase at zero power 0.2% $\delta k/k$.

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2B MSRE NUCLEAR CHARACTERISTICS

The preceding general description of reactor theory is applicable to the MSRE, as it is to all reactors. This section describes the unusual features of the MSRE and provides quantitative information on its nuclear characteristics in a condensed form. A much more detailed treatment is given in MSRE Design and Operations Report – Part III, Nuclear Analysis, ORNL TM-730.

1. Core Reactivity Factors

The unique feature of the MSRE, which sets it apart from other reactors, is that the uranium fuel is contained in a molten mixture of fluoride salts which is circulated through a heat exchanger to remove the heat produced by the fission process in the core.

Although the fissionable material is dispersed throughout the fuel system, the fission chain reaction is confined to the core. The fuel is not chain-reacting in the piping because the neutron leakage probability is much too high because of the small dimensions. In the heat exchanger, the parasitic absorption of neutrons by the tubes combines with high leakage to rule out criticality. Even in the drain tanks, the leakage is too high for criticality. (Resonance capture in ^{238}U and absorption in the cooling thimbles also tend to reduce k.) The high leakage and resonance absorption are direct consequences of the poor moderation in the salt. In the core, on the other hand, there is graphite to slow the neutrons down with but little absorption, and with the slow neutrons the vessel is large enough to give a low probability of leakage.

The reactivity of the core is a function of several variables. These are:

1. the concentration of ^{235}U in the fuel salt,
2. the temperatures of the fuel and the graphite,
3. the presence of gas bubbles in the core,
4. the positions of the neutron-absorbing control rods,
5. the concentrations of neutron poisons in the fuel salt and in the graphite, and

6. the number of neutrons emitted in the core per fission (as affected by the loss of delayed neutrons during fuel circulation).

Each of these variables is discussed separately in this section.

1.1 Fuel Salt Concentration

The minimum amount of ^{235}U required for criticality in the MSRE is about 50 kg (in 73 ft^3 of salt) or a concentration in the fuel salt of 0.2 mole % of highly enriched uranium. For the first exploratory operation of the MSRE, a higher uranium concentration is desired for reasons of chemistry. (If fluorine loss from the salt should occur, more UF_4 could go to UF_3 before U precipitation would occur.) Therefore in the original charge of fuel salt the uranium concentration will first be brought up to 0.5 mole % by the addition of 150 kg of depleted uranium. (The ^{235}U fraction of this uranium is only 0.002.) Then, during the initial critical experiment, the ^{235}U concentration will be brought up by addition of highly enriched uranium (93% ^{235}U) to the "clean critical" concentration. This is the concentration required for criticality with no fission product poisons in the reactor, all control rods fully withdrawn, the fuel salt stationary, and the reactor at a uniform temperature of 1200°F. The predicted critical loading is 69 kg of ^{235}U, giving a total uranium concentration in the salt of 0.80 mole % U. This salt is sometimes referred to as fuel C, having a molar composition of 65 LiF-29.2 BeF_2-5.0 ZrF_4-0.8 UF_4. The values quoted later in this section for nuclear parameters apply when the reactor is fueled with this salt.

Addition of highly enriched uranium when the concentration is near the critical value causes an increase of 0.22% δk/k for each percent increase in ^{235}U concentration. Thus the addition of 85 g ^{235}U (the amount in an enriching capsule) would produce an increase of only 0.03% δk/k.

After the initial critical loading, about 7 kg of ^{235}U will be added as highly enriched uranium to bring the fuel salt up to the operating concentration (0.28 mole % ^{235}U, 0.83 mole % total U). The increase is required to compensate for effects which will appear when the reactor is operated at high power, namely:

1. elevation of fuel and graphite temperatures,
2. partial insertion of the control rods to permit power regulation,
3. fission product poisons,
4. loss of delayed neutrons due to emission outside the core,

Burnup – When the reactor is operated at power, ^{235}U is consumed by fission and by radiative capture. (The ratio of captures to fissions is 0.18.) The rate amounts to 1.25 g/Mwd, which means that the amount which can be added in one capsule would be consumed in about 7 days at 10 Mw. When the reactor is operated at full power, additions of enriched uranium will be made at intervals of 7 days or less so that not only is the loss due to burnup made up but the ^{235}U inventory is actually increased to compensate for the negative reactivity effects of fission products which are building up.

Non-uniform Uranium Distributions – The coefficient of reactivity for changes in ^{235}U concentration which was quoted above applies to uniform increases in the concentration. Although no significant non-uniformities in uranium concentration are anticipated in operation, the reactivity effects of localized uranium are worth noting. The reactivity effect of a given amount of ^{235}U could be much greater if it were all in the core than if it were evenly dispersed throughout the 75 cu ft of fuel salt. Uranium evenly distributed in the core is worth 3 times as much as the average over the entire loop. A small amount of uranium at the point of maximum importance (near the center of the core) would be worth 15 times as much as the loop average.

1.2 Temperature and Power

Changes in fuel temperature and in graphite temperature affect reactivity in different ways. The primary effect of graphite temperature is through its influence on the thermal neutron velocity distribution; an increase in temperature resulting in higher energies and lower cross sections. The reactivity is affected by fuel salt temperature mainly because thermal expansion of the salt reduces the amount of ^{235}U in the core. Other, less important effects are the decrease in moderation by Li, Be and F as the salt expands and the influence of salt temperature on thermal neutron energies.

If the temperature of the fuel and graphite is uniform throughout the core, an increase in the overall temperature would produce a decrease in reactivity; the ratio is the temperature coefficient of reactivity, $-7.0 \times 10^{-5}\ ^{\circ}F^{-1}$. (To illustrate, a $10^{\circ}F$ increase over the entire core would cause the reactivity to decrease by 0.07% $\delta k/k$.)

If a uniform change could be produced throughout the fuel in the core without changing the graphite temperature, the reactivity effect would be $-3.3 \times 10^{-5}\ ^{\circ}F^{-1}$. A uniform change in graphite temperature alone would give $-3.7 \times 10^{-5}\ ^{\circ}F^{-1}$. The sum of the fuel coefficient and the graphite coefficient is the total coefficient, $-7.0 \times 10^{-5}\ ^{\circ}F^{-1}$.

When the reactor is operated at power, temperature distributions are established in which the rate of fuel temperature increase as the salt rises along a channel is proportional to the heat generation at the point. The graphite temperature at any point is above that of the fuel by an amount proportional to the local heat generation. (See later section on fluxes, heat generation and temperatures.) As the power is raised and the temperatures depart from isothermal, the net reactivity effects of the change in fuel temperature can be regarded as the product of the fuel temperature coefficient of reactivity and the change in an average temperature which appropriately reflects the reactivity effect of the actual distribution of fuel temperatures. This is called the nuclear average temperature of the fuel (NAT). An NAT can be similarly defined for the graphite: Calculations indicate the fuel and graphite NATs (T^*_f and T^*_g) are related to the fuel temperatures entering and leaving the reactor vessel as follows:

$$T^*_f = \left(\frac{T_{out} + T_{in}}{2}\right) + 1.1\ P = T_{out} - 1.4\ P$$

$$T^*_g = \left(\frac{T_{out} + T_{in}}{2}\right) + 5.5\ P = T_{out} + 3.0\ P$$

where P is the power in megawatts.

The shapes of the temperature distributions at power are characteristics of the physical system. On the other hand, the entire temperature distribution can be shifted up or down simply by moving the control rods to obtain any desired relation of the temperatures at power to the isothermal temperature before the power was raised. (When the rods are moved the entire temperature distribution must shift to produce a compensating effect to keep the reactor just critical.) The amount of reactivity change which must be produced with the rods to obtain the desired temperature response is called the power coefficient of reactivity. The MSRE rod servo system holds the reactor outlet temperature constant. The power coefficient for this mode of operation is -6×10^{-5} Mw^{-1}.

1.3 Control Rod Positions

When the control rods are inserted in the core, they absorb neutrons which might otherwise cause fission, thereby reducing k_{eff}. Except when the nuclear power is shut down to practically zero, k_{eff} is always kept in the range 1.000 ± 0.001. This is done by adjusting the rods as required to compensate for other changes which tend to take k out of that range.

The change in reactivity per unit distance of rod movement is the sensitivity. The upper end of the poison section extends out the top of the core at all times, so the movement of a rod is equivalent to adding or removing a length of poison from the core at the lower end of the rod. The reactivity effect of adding poison in the core depends on where it is added, being approximately proportional to the square of the ratio of the local neutron flux to the average flux. The flux distribution from top to bottom of the core is approximately a sine curve. Thus the sensitivity of a control rod varies with the position of its lower end approximately as $(\sin \pi y/L)^2$, where L is the effective length of the core and y is the distance from the top of the "effective core" to the lower end of the poison. The effective limits of the core are where the flux distributions in the core extrapolate to zero.

The poisoning effect of a rod at any given position is the integral of its sensitivity from completely out to that position. Thus the poisoning effect is approximately proportional to

$$w(y) = \frac{2}{L}\int_0^y \sin^2\left(\frac{\pi y}{L}\right) dy$$

which is an s-shaped curve as shown in Fig. 2B-1. This expression is only approximate because the insertion of the rod depresses the flux in its vicinity so that the sensitivity does not follow exactly a $\sin^2$ curve. The relation of the actual worth curve to the simple approximation is shown in Fig. 2B-1.

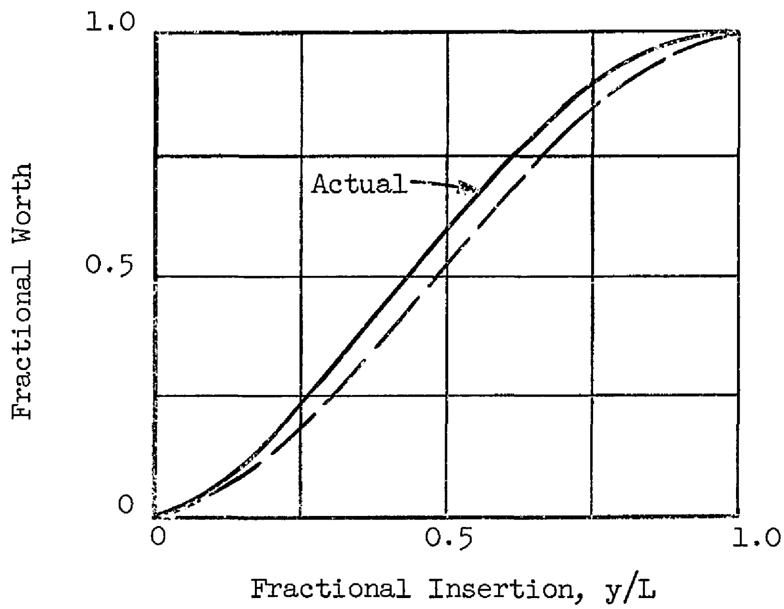

Fig. 2B-1 Shape of Rod Worth Curves

Table 2B-1 gives the predicted effect of configurations in which rods are either all the way out or all the way in. Rod numbers here identify rod positions in the core, and as indicated by the diagrams, rod 2 is the one diagonally opposite the core sample assembly. (The rod identification numbers on the console may not correspond; the "rod 1" instruments and controls on the console are connected to whichever rod is being used as the regulating rod.) The effective height of the core to which these total-worth values apply is about 78 in. Since the

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Table 2B-1

CONTROL ROD EFFECTIVENESS
(Initial Critical Conditions)

	Rod 1	Rod 2	Rod 3		Reactivity Effect (% δk/k)
a	Out	Out	Out	○ ○○	0
b	In	Out	Out	● ○○	−2.36
c	Out	In	Out	○ ●○	−2.26
d	Out	In	In	○ ●●	−4.03
e	In	Out	In	● ○●	−4.33
f	In	In	In	● ●●	−5.51

		Worth (% δk/k)
a − b	Rod 1 (rods 2 and 3 out)	2.36
d − f	Rod 1 (rods 2 and 3 in)	1.48
a − c	Rod 2 (rods 1 and 3 out)	2.26
e − f	Rod 2 (rods 1 and 3 in)	1.18
a − d	Rods 2 and 3 (rod 1 out)	4.03
b − f	Rods 2 and 3 (rod 1 in)	3.15

rod travel is only 51 in. between limit switches, the available worth of a rod is only 0.927 of the total. Application of this factor to the total predicted worth of rod 1 gives an available worth of 2.2% $\Delta k/k$. The first evaluation of the worth of rod 1 gave 2.18%.

Because of the core symmetry, rods 1 and 3 are identical in worth; rod 2 is somewhat less than either because it is more "shadowed" by the other rod thimbles or rods. The worths listed in this table were predicted for the initial, clean core. When fission product poisons build up and more ^{235}U is added to the fuel, the neutron diffusion length in the core is reduced, making the rods worth less. This effect is expected to reduce the figures in Table 2B-1 by about 6 percent.

Any rod can be designated as the regulating rod (rod 1 on the console) by wiring it in to the servo system which controls flux or reactor outlet temperature. The other two rods are the shim rods. Because it is an advantage to be able to shift the regulating function from one rod to another without changing either the regulating rod worth or the shim worth, Rod 1 will be designated as regulating rod initially and if a change is necessary, Rod 3 will become the regulating rod.

The effect of flux depression or "shadowing" which shows in Fig. 2B-1 and Table 2B-1 also causes the sensitivity of a rod to change sharply as its end moves by that of another rod. (Picture a rod moving up into or down out of the "shadow" around another rod.) For this reason the two rods used as shims are kept well above the regulating rod, so that its sensitivity does not change sharply. One reason for this is that the reactivity balance calculation uses approximations for rod worth which fit better when the rod tips are not too close. (See MSR-64-14, "On-Line Computation of Control Rod Effect for Reactivity Balance.")

1.4 Xenon-135

In the MSRE, ^{135}Xe is produced at a rate of 6.3 atoms per 100 fissions. About 97 percent appears first as ^{135}I which decays with a 6.7-hr half-life to ^{135}Xe. The other 3 percent is formed directly in fission. Iodine-135 is uniformly distributed throughout the fuel salt, giving a distributed source of ^{135}Xe. (Any uranium in the graphite gives rise to a localized source of iodine and xenon, but this is relatively unimportant.) Xenon-135 which appears in the circulating fuel salt may (1) decay to long-lived ^{135}Cs (2) capture a neutron and go to stable ^{136}Xe, (3) be transferred to the gas in the pump bowl or (4) be transferred into the gas-filled pores in the core graphite. Xenon-135 in the graphite may decay, be burned up by neutron capture or move back into the salt.

The time constants for the decay and burnup are well known. The half-life of ^{135}Xe for natural decay is 9.2 hrs., giving a decay constant of 0.075 hr^{-1}. The effective cross section (in the MSRE neutron energy spectrum) is 1.5 x 10^{6} barns, giving a burnup time constant for ^{135}Xe dispersed around the fuel system of 0.02 hr^{-1}. For ^{135}Xe evenly distributed throughout the graphite in the core, the burnup time constant would be 0.07 hr^{-1}. (These burnup time constants are at 10 Mw and are proportional to reactor power.) The rate constants for the other processes are not well known, and an important objective of the MSRE operation is to determine values for them. It is expected that the transfer to the pump bowl offgas will be relatively fast, resulting in low steady-state xenon-poisoning (only 0.1% $\delta k/k$ or less at 10 Mw).

1.5 Other Fission Products

If ^{135}Xe poisoning is kept low by gas stripping as expected, the individual fission product contributing most to the neutron poisoning in the MSRE will be ^{149}Sm. The steady state poisoning of ^{149}Sm in the MSRE at any significant power will be about 0.9% $\delta k/k$. (The steady-state level is independent of power because both the burnup time constant, $\phi\sigma$, and the production rate are proportional to power, and the steady-state level is the ratio.) The initial ingrowth of ^{149}Sm will be slow, so the reactor must be operated at high power for several months before the ^{149}Sm reaches steady state.

The transients in ^{149}Sm poisoning have a much shorter time constant, namely that of the decay of 53-h ^{149}Pm, the precursor of ^{149}Sm. When the power is shut down, the destruction of ^{149}Sm stops and the ^{149}Pm which is present soon decays into ^{149}Sm, increasing its poisoning effect on reactivity. The steady-state amount of ^{149}Pm is proportional to power, and hence so is the size of the ^{149}Sm poisoning transient following a shutdown. When the power is shut down from 10 Mw, the ^{149}Sm transient will be about 0.03% δk/k.

There are a few other high-cross-section fission products which saturate in roughly the same length of time as ^{149}Sm, and some exhibit similar transients. The combined effect of these will be about 0.2 that of ^{149}Sm.

The large majority of fission products (all those except ^{136}Xe and the "Samarium" group) contribute to a poisoning effect which will grow approximately linearly with integrated power in the MSRE. The rate will be about 1×10^{-4}% δk/k per Mw-day.

1.6 Delayed Neutrons

When the fuel salt is stationary all of the delayed neutron precursors decay in the core. When the fuel is circulating, part of the precursors decay outside of the core and these delayed neutrons are lost to the chain reaction.

The delayed neutrons comprise 0.0064 of the total neutrons released by fission. Because their initial energies are lower than the average for all fission neutrons, the delayed neutrons are less apt to leak during slowing down, and the effective fraction of delayed neutrons in the non-circulating case is 0.0067. When the fuel is circulating, the delayed neutrons emitted in the main part of the core are 0.0039 of the total. But because many of the delayed neutrons are now emitted in the reactor-vessel heads, from which some reach the core, the effective fraction is 0.0046. Thus circulation causes an effective loss of 0.0021 of the neutrons, or a decrease in reactivity of 0.21% δk/k.

The changes in reactivity associated with the delayed neutron precursor transport reach steady state within a minute or two after circulation is stopped or started. When the pump is stopped, the reactivity increases as precursors are no longer swept out of the core. Time constants are those associated with coastdown of the flow and the half-lives for precursor decay which govern the concentration transients. When fuel circulation is first started, the concentrations of precursors will immediately drop below the steady-state values as salt with practically no precursors flows into the core. There will be some small perturbations as the salt which was in the core comes back, but this effect is smeared out by mixing. Of course when circulation is first started the reactivity changes are unimportant because the reactor is well subcritical. (The rods are inserted before the fuel pump is started.)

1.7 Entrained Gas in Fuel

Development testing of the prototype of the fuel circulating pump indicated that undissolved helium bubbles to the extent of 0.5-1% by colume could be expected to circulate with the fuel salt. These bubbles were introduced by the action of the spray ring in the pump bowl. Operation at the MSRE has showed that essentially no bubbles circulate with the salt if the level in the pump bowl is at the normal operating point or higher (>60%). However a bubble fraction of 2-3% was observed at an abnormally low salt level.

When gas bubbles appear in the fuel salt in the core, the density of the salt-gas mixture decreases, the neutron diffusion length increases and as a result, reactivity decreases. The fuel density coefficient of reactivity was calculated to be 0.18. Thus, a bubble fraction of 1% would result in a reactivity decrease of 0.18% $\delta k/k$. The presence of bubbles causes the fuel density, and hence the reactivity to respond to pressure changes. With ~ 2 1/2% bubbles, the pressure coefficient of reactivity was 3×10^{-6} $\delta k/k$ per psi for slow pressure changes and 1.4×10^{-4} for rapid changes.

Since the MSRE will normally operate with no bubbles circulating, the effects described above will not be observable. However, they may appear under abnormal circumstances (low pump-bowl level).

2. Heat Generation and Temperature Distributions

About 93% of the heat associated with the fission process in the MSRE is produced within the fuel by fission fragments and the various radiation scattering and capture processes. About 6.5% is generated in the graphite and transferred to the fuel in the core. This leaves only about 0.5% to be absorbed in the thermal shield, biological shield, and structural material in the cells. (About 5% of the energy of fission escapes in the form of neutrinos and never produces any heat; this energy is not included in the above balance.)

2.1 Overall Temperature Distribution

The overall temperature distribution in the fuel is determined by the spatial distribution of the power and the flow rate of the salt. At 10 Mw the nominal temperature rise of the fuel from reactor inlet to outlet is 50°F. Since about 14% of the power is generated in the upper and lower heads and other peripheral regions of the reactor vessel, the average temperature rise as the fuel passes through the graphite channels is only 43°F. The fuel undergoes a 3.5° temperature rise before it reaches the graphite and another 3.5° rise between the time it leaves the graphite and the time it leaves the core. The temperatures in the upper and lower heads are expected to be more-or-less uniform because of fluid mixing.

Since most of the heat of fission comes from the fission fragments, the heat-source distribution is essentially the same as the fission distribution which, in turn, has about the same shape as the thermal-neutron flux. The fuel velocity is relatively unifrom over most of the core, with a region of high velocity near the center. Since the neutron flux is depressed near the center of the core by the control rods and thimbles, the temperature rise of the fuel in the central channels is much lower than that in channels some distance out from the center. The maximum temperature rise (~ 86°F) occurs in the channels about 8 in. from the core center line. The temperature of fuel in any channel increases continuously from the inlet to the outlet. The rate of increase is proportional to the heat production, or flux; low at the ends and high in the middle. Since the shape of the power distribution along a channel follows approximately a sine curve, the axial temperature distribution of the fuel (proportional to the integral of the flux distribution) has the shape of the general curve (1 - cos x).

The temperature of the graphite at any point in the core is higher than that of the adjacent fuel because the heat produced in the graphite must flow into the fuel. The maximum difference between the mean transverse temperature in a graphite stringer and the mean transverse temperature in a fuel channel is 61°F near the midplane of the core. Because of the continuously rising fuel temperature, the absolute maximum graphite temperature (~ 1300°F) occurs considerably above the core midplane.

2.2 Local Temperature Effects

Local overheating is not likely in the MSRE because of the relatively low power density. However, there are some areas in the reactor vessel where local heating must be considered.

The INOR-8 structural parts of the reactor are subject to radiation heating by gamma rays and fast neutrons. For the most part, this heat is efficiently removed by the salt flowing past the surfaces. However, if solids were deposited from the salt, they could inhibit such heat removal (and produce more heat if the deposits contain ^{235}U) and lead to locally high temperatures. The reactor-vessel lower head and the core-support ring above the inlet volute are areas where solids could accumulate if they form in the fuel salt. The temperatures in these areas are continuously monitored for evidence of local overheating.

The control-rod thimbles are subject to substantial radiation heating because of their location near the center of the core. Under normal conditions they are adequately cooled by the combination of salt on the outside and rod-cooling air on the inside.

Blockage of a fuel channel would require that the heat produced in that channel be transferred through the graphite stringers to the fuel in adjacent channels. The temperatures resulting from this condition would not damage the reactor.

3. Instrumentation

The nuclear instrumentation is described in detail in the MSRE Design and Operations Report - Part II, Nuclear and Process Instrumentation, ORNL - TM - 729. A brief summary is given here of the operating principles and functions of those instruments which respond to neutrons or the nuclear power of the reactor.

3.1 Non-fission Neutron Sources

Neutrons are of course produced by the fission process at a rate proportional to the power-level. But neutrons are also produced in the reactor by other processes. The strength of this fission-independent neutron source is related to safety. It is also closely related to the neutron instruments because whenever the fission rate is very low, it provides most of the neutrons that are counted by the detectors. Thus the selection of the source and detectors must be coordinated to provide the necessary information for reactor operation.

The prime safety function of a neutron source is to guarantee a sufficiently high neutron population so the statistical nature of the neutronic processes is maintained. In addition the source supports a certain minimum fission rate, or power level, in the subcritical reactor. Since the size of the power excursion for a given reactivity ramp generally increases as the initial power decreases, this minimum level tends to limit the severity of some accidents. Another useful, but not safety, function of an independent neutron source is that it permits monitoring the subcritical multiplication in the reactor as criticality is approached. This is particularly important in the MSRE where keff in the empty reactor starts at zero and each fill with fuel salt is essentailly a new critical experiment.

Three types of non-fission neutron sources are important in the MSRE: 1) the inherent alpha-n source in the fuel salt, 2) the external (Am-Cm-Be) source in the thermal-shield source tube, and 3) the photo-neutron (r,n) source which results from the interaction of fission product gammas with beryllium.

3.1.1 Inherent Source

The alpha particles emitted by the various uranium isotopes in the fuel interact with the Li, Be, and F to produce neutrons. The alpha particles from ^{234}U acting on Be and F produce about 96% of these neutrons. With the reactor full of fuel salt at the normal operating concentration, the internal source releases about 4×10^5 n/sec in the core. This source is adequate for all the safety requirements of the system. However, since the source is absent when the reactor is empty, it does not meet the requirement for monitoring subcritical multiplication during a fill.

3.1.2 External Source

Neutrons are produced in this source by the action of alpha particles from ^{241}Am and ^{242}Cm on ^{9}Be. The source was produced by mixing 0.6g of ^{241}Am with Be and irradiating the mixture in the

ORR to transmute some of the Am to ^{242}Cm. When fresh, this source emitted about 1.2 x 10^8 n/sec but, since it is installed in the thermal shield, only a fraction (<25%) of these neutrons actually enter the core. More than 99% of the external-source neutrons come from the Cm alphas so the effective half-life of the source is that of ^{242}Cm, 160 days. Thus the intensity of the external source will decrease with time unless the neutron flux from the operating reactor is high enough to keep the Cm concentration high.

Since the external source is independent of the fuel location, these neutrons and their progeny are counted when the reactor is empty and during the initial stages of a fill when the internal source is insignificant.

3.1.3 Photoneutron Source

Gamma rays with energies greater than 1.7 Mev are capable of producing neutrons from ^9Be. Since a number of ^{235}U fission products emit gammas with energies above this threshold, the MSRE will have a substantial internal photoneutron source after an inventory of fission products has been established. This mechanism will provide at least 10^7 n/sec in the core for 100 days after the reactor has operated at 10 Mw for 30 days. The photoneutron source is subject to decay and is not very effective after long shutdowns. Furthermore, it has the same disadvantage as the (α, n) source - it is observable only when the fuel is in the reactor.

3.2 Neutron Detectors

Radiation detectors in general consist of a chamber filled with an ionizable gas and devices for collecting the ionic charges. When a particle of ionizing radiation passes through the gas, positive ions and electrons are formed which flow to oppositely charged electrodes producing a small electric current. These small pulses of current can be amplified and registered as discrete events or can be "smeared out" and measured as an average current.

Since neutrons are uncharged, they do not produce any direct ionization in passing through matter. Thus, neutrons as such cannot be detected by ionization chambers. To circumvent this, neutron chambers contain a material that will interact with neutrons and produce ionizing radiation. This secondary radiation then produces ionization in the chamber which is detected and registered as a neutron event.

The neutron detectors in the MSRE are located in the nuclear instrument shaft some distance from the reactor core. However, the neutrons that leak out of the operating reactor produce a significant neutron flux in and around the various detectors. Since the shape of the neutron flux in the core of the critical reactor is essentially independent of power level, a nearly constant fraction of all the neutrons produced by fissions in the reactor escapes. The fraction of escaped (leakage) neutrons that reaches a given location in the instrument shaft is also independent of the neutron population density. Thus, a neutron detector with a fixed detection efficiency at a fixed location will register neutron events at a rate that is directly proportional to the neutron level (or fission rate, or power level) in the reactor. The conversion factor between neutron-chamber output and reactor power can be established only if the absolute reactor power can be measured by an independent method. The method that is used to measure absolute reactor power is a system heat balance. Thus, once accurate heat balances have been obtained, it will be possible to read absolute power directly from the nuclear instruments.

Four types of neutron detectors are in use in the MSRE. These are fission chambers, BF_3 pulse counters, compensated ion chambers, and boron-coated safety chambers. The basic features of each are described below.

3.2.1 Fission Chambers

A fission chamber makes use of the very intense ionization produced by fission fragments to register the passage of neutrons. Some of the interior surfaces of the MSRE fission chambers are coated with ^{235}U (other fissionable materials may be used in other applications) which undergoes fission in a neutron flux. Most of the time at least one of the primary fission fragments escapes from the surfaces and produces a very large pulse of ionization. These pulses are amplified and counted as individual events. Alpha particles from the radioactive decay of the uranium in the chamber and gamma rays from outside also produce ionization in a fission chamber but the associated pulses are very much smaller than those from fission fragments. Thus with an electronic circuit which counts only the largest pulses, a fission chamber can be made to discriminate against nearly all radiation effects other than from neutrons.

The two fission chambers in use in the MSRE will produce a counting rate of about 0.4 counts/sec in a neutron flux of 1 n/cm^2-sec. The normal useful range of a fission chamber is about 4 decades in counting rate. Below about 2 c/s the time response of the count-rate circuitry is too slow to be very useful; above about 20,000 c/s coincidence losses begin to be observable. The useful range of the MSRE chambers has been greatly extended by equipping them with servo-operated positioning devices. Since the neutron flux in the instrument shaft decreases approximately exponentially with distance from the reactor, the logarithm of the ratio of the flux at one point to that at some reference point (say, the bottom of the shaft) is proportional to the distance between the points. That is

$$\log \left[\frac{\phi(x)}{\phi(x_o)}\right] = -\alpha\left[x - x_o\right].$$

Or

$$\log \phi(x_o) = \log \phi(x) + \alpha(x - x_o).$$

Thus, the log of the count rate or flux (and hence the actual count rate) at some reference point, where it is too high to be measured accurately, can be obtained from the log of the count rate at some other point by adding to it a number proportional to the distance between the points. If the correlation between flux at the reference point and reactor power is known, this approach can be used to indicate the log of the reactor power directly.

The above principle is used to extend the useful range of the MSRE fission chambers to about 10 decades. The chamber travel to accomplish this is about 90 in. This allows them to cover a power range from well below critical (0.01w) to well above full power (100 Mw). Since the exponential decrease of flux with distance is only approximate, electronic corrections are applied to improve the correlation between log power and the sum of log count rate and position. Even so, these instruments do not give the most precise indication of nuclear power that is available.

3.2.2 BF_3 Pulse Counters

A BF_3 chamber is simply a vessel equipped to collect ionization pulses and filled with boron trifluoride gas. This gas, in addition to being ionizable, contains ^{10}B which interacts with neutrons to produce alpha particles. Since the ionization pulses from alphas are large, this chamber can be made relatively insensitive to gamma radiation (but less so than a fission chamber). It also has a high neutron-detection efficiency.

It was originally expected that the fission chambers described above would have sufficient sensitivity to give significant counting rates (>2c/s) with the reactor vessel empty and only the external source present. This was not achieved because of physical limitations on the source intensity and the unfavorable location of the source with respect to the detectors. Therefore, detectors with higher sensitivity were provided for this condition and to monitor the early stages of a reactor fill. (The fission chambers provide a useful indication before the reactor is completely filled with fuel salt.) The chambers used in this application are two BF_3 chambers with sensitivities of 14 c/sec per unit neutron flux (1 n/cm^2-sec). Because of their high sensitivity, these chambers are subject to rapid depletion of the ^{10}B in high neutron fluxes and must be retracted to a low-flux region when the reactor is in operation.

3.2.3 Compensated Ion Chambers

This type of device measures the average current produced by ionizing radiation rather than discrete pulses. The neutron-sensitive portion of a compensated ion chamber is a vessel, fitted with charge-collecting electrodes, filled with an ionizable gas, and coated on the inside with boron enriched in ^{10}B. Since the gas is ionized by gamma rays as well as by the alphas from the ^{10}B (n,α) ^{7}Li reaction, the output of this subchamber is proportional to the total radiation level. When a reactor is operating at power, the contribution to the chamber current from gamma radiation is relatively low and the output of the boron-coated chamber is essentially proportional to the neutron flux (power level). However, when the reactor is shut down, the neutron flux drops to a very low level while the gamma radiation from the fission products remains high. Thus, the indicated current is high relative to the actual power level. In order to compensate for this high reading at low power, a second subchamber is used that is sensitive to gamma rays only; that is, no boron coating is used. If this second chamber has the same characteristics (volume, gas pressure, collection voltage, etc.) as the boron-coated chamber, the currents induced in the two chambers by gamma radiation will be equal. The outputs of these two chambers are connected with opposing polarities (bucking each other) so that the two gamma-induced currents cancel each other and the net current flow is due to neutron-induced ionization. The combination of two subchambers and connecting wiring constitute a single compensated ion chamber. In practice the two subchambers rarely have identical characteristics so one of the chamber volumes is made adjustable so the degree of compensation can be tailored to exactly cancel the gamma ionization currents.

The two compensated ion chambers are used to provide linear indications of the power level. The chamber that feeds the linear power recorder also supplies the flux signal for the control-rod servo mechanism. These chambers have a useful range of about 6 decades and indicate power from a few watts up to 150% of full power (15 Mw). Linear output over this span is achieved by 15 stages of range switching in the output amplifier. The position of the chambers is selected to provide maximum accuracy in the normal power range, 1-10 Mw.

3.2.4 Safety Chambers

The principal requirement of neutron detectors in the safety system is high reliability so a relatively simple device is indicated. The chambers in use on the MSRE are uncompensated, ionization chambers utilizing boron for neutron sensitivity. A chamber consists of several concentric cylinders with some of the internal surfaces coated with boron enriched in ^{10}B. The ionizable gas is dry nitrogen at 1 atm pressure. Each chamber is equipped with two high-voltage leads and two independent signal leads. The chamber output is read as a continuous current rather than individual pulses.

The output from these chambers has a useful range of about 2 decades and the normal readout is 1-20 Mw. The MSRE installations have a special switching arrangement that increases the amplifier output by a factor of 10^3 when the fuel pump is off. Under these conditions the instrument range is 1-20 Kw. Since the safety chambers are uncompensated, they are not highly accurate at very low powers, but accuracy at low power is not a requirement of the safety system.

4. Kinetics and Safety

There are several facets to the interest in the kinetics of the MSRE. Is it stable, i.e., do small disturbances cause oscillations which don't die out? Does it respond quickly and smoothly to the controls? Could damaging nuclear excursions result from any conceivable incident?

The dynamic behavior of the MSRE is shaped largely by 1) circulating fuel, 2) separate moderator, 3) negative temperature coefficients of reactivity, 4) relatively low heat generation rate, and 5) loose coupling to the heat sink (air). Circulation of the fuel reduces the delayed neutron fraction, which makes the reactivity-period relation significantly different. This effect is important in the "zero-power" kinetics (where temperature feedback is negligible) and in rapid nuclear excursions. In power excursions, the negative temperature coefficient of the fuel acts promptly as an inherent shutdown mechanism, but the graphite contributes little. Normal power operation reflects primarily the rather sluggish temperature response. The graphite responds slowly to power changes: a 1-Mw change in reactor power changes the graphite heat generation by only 0.06 Mw and the heat capacity of the graphite is 3.6 Mw-sec/^{o}F, giving an initial rate of change of 1^{o}F/min. Furthermore the heat transfer to the fuel takes effect slowly: the transfer amounts to 0.02 Mw/^{o}F, giving a time constant for the graphite of 3.6/0.02 = 180 sec. The transfer of heat through a considerable resistance to a low-temperature heat sink makes for sluggish response. Some indication of this is the time constant which is the ratio of reactor heat capacity, 12 Mw-sec/^{o}F, to the heat transfer in the radiator. At 10 Mw the heat transfer is 10 Mw/1000^{o}F = 0.010 Mw/^{o}F and the time constant is 1200 sec. (20 min.). At 1 Mw, the heat transfer area is reduced, giving a time constant of almost 3 hours.

4.1 Stability and Transient Response

The MSRE is stable under all conditions. At low power, however, the margin of stability is not great and low-frequency oscillations tend to die out slowly if no external reactivity control is applied. This "wallowing" has a characteristic period of several minutes, so it is easily flattened out by movements of the regulating rod.

Without any rod control, the negative temperature coefficient of reactivity causes the nuclear power to follow changes in heat removal rate and eventually level off at the same value. The servo control system "tightens up" the response causing the nuclear power to follow more quickly with little or no overshoot or undershoot.

4.2 Potential Accidents

There are several more or less conceivable incidents in which nuclear heating could produce undesirably high temperatures and pressures inside the fuel salt system. These are described and discussed in detail in ORNL TM-732, The MSRE Safety Analysis Report.

4.2.1 Uncontrolled Rod Withdrawal

Perhaps the most severe reactivity excursion which could be considered credible is simultaneous and continued withdrawal of all three rods past the critical positions. If this happened under the worst conditions and there were no corrective action, the power would surge to between 400 and 500 Mw for a fraction of a second, then drop back to around 50-100 Mw. The fuel temperature would rise very rapidly; within 6 sec. after the peak power, the maximum fuel temperature in the core would be above 1800°F. The core would see a pressure surge of about 20 psi. Rod scram on either 1-sec. period or 15-Mw power would limit the excursion to tolerable proportions even if one of the three rods failed to drop.

4.2.2 "Cold-Slug"

This is a postulated accident in which the mean temperature of the core decreases rapidly because fuel is injected at an abnormally low temperature, creating a reactivity excursion by virtue of the negative temperature coefficient of reactivity. The most likely way in which such an accident could happen would be for the fuel external to the reactor vessel to be cooled off while the fuel pump is stopped; starting the fuel pump would then inject the cooler fuel. All concern over this kind of cold-slug accident was eliminated by requiring that the control rods be fully inserted before the fuel pump can be started. With the rods down, no possible cold slug could make the reactor critical, much less cause an excursion.

4.2.3 Filling Accident

The reactor could go critical with the core only part full of fuel if: (1) the control rods were withdrawn too far, (2) the core temperature were too low, or (3) the fuel were abnormally concentrated in uranium. The position of the control rods will be prescribed for each fill, and it is up to the operator to see they are not withdrawn too far. Administrative control is also used to assure that the temperature is high enough. A control interlock requires that the rods be withdrawn part way before a fill starts. Should the reactor go supercritical during a fill, the rods would scram either on a 1-sec. period or at 15 Kw. This will stop the excursion and if the reason for criticality was either high rods or low temperature, the reactor will not go critical again. Abnormal concentration of uranium is extremely unlikely, but separation by selective freezing in the drain tank is theoretically possible even to a degree that would make the reactor critical with the rods in. Thus in order to prevent undesirably high core temperatures in the third type of filling accident, safety interlocks stop the fill when the rods drop.

4.2.4 UO_2 Precipitation

Separation of uranium from the circulating fuel could lead to local overheating under deposits or reactivity disturbances if the uranium shifts position. The only known way for uranium to become concentrated in the loop is by gross contamination of the salt with moisture to form UO_2. Precautions against moisture, backed by the presence of ZrF_4, make UO_2 precipitation extremely unlikely. Nevertheless, the operation will be watched carefully for possible signs of such a condition: temperature differences between the reactor vessel and incoming salt is one indication, another is the reactivity balance which would show the loss of uranium. Rod scram at 15 Mw would protect against excursions caused by fast recovery of up to 700 g of uranium or more. The 1-sec. scram gives protection against even larger excursions by starting the rods dropping earlier in the excursion.

4.2.5 Others

If the fuel pump stops, the reactivity tends to increase, but the change is slow and is easily controlled by the temperature interlocks and the 15-Kw scram with the pump off. Afterheat problems are moderate in the MSRE because the power density in the fuel is low. If the fuel were stopped in the core the temperature rise would increase only 150°F over about 20 hours. Fuel in the drain tanks could increase much more, were it not for the heat removal by the thimbles. Criticality in the drain tanks could occur only if the uranium were concentrated near the center of the tank by more than a factor of four. This is very unlikely, if not impossible. However, should such occur, the chain reaction would level off at heat-loss power without causing damage.

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SECTION 3

OPERATION OF AUXILIARY SYSTEMS

In the normal operation of the MSRE practically all of the installed equipment must function in an integrated manner, with a high degree of interdependence. It is convenient, however, to regard the reactor complex as an assembly of individual systems. The central part of the MSRE operation consists of transferring the fuel salt, circulating it through the core, sustaining a fission chain reaction in the core and removing the heat from the fuel — all under controlled conditions. This part of the operation requires not only the primary components, but absolutely depends upon the operation of the so-called "auxiliary" systems. (These are auxiliary in the sense of being subservient to, or supporting, the primary systems, not in the sense of substitute or reserve. Only a few components are auxiliary in the latter sense.)

The startup and operation of each of these systems are described in this section.

3A ELECTRICAL SYSTEM

The 7503 Area is supplied from the ORNL substation by either of two 13.8 kv TVA power lines, a preferred line or an alternate. These are separated by two interlocked pole mounted motor operated line switches. Automatic transfer is provided from the preferred line to the alternate line. Both transfer switches can be operated remotely from the auxiliary control room.

The normal AC power enters the 7503 area from the 13.8 kv feeder (between the transfer switches) through two transformer substations. A 1500 kva, 480v, 3-phase substation serves the process equipment, and a 750 kva, 480v, 3-phase auxiliary station is for building services, that is, lighting, ventilation, etc. The auxiliary substation has no emergency source, but the process station has three diesel-generators for emergency AC use. Some of the process area lights can be supplied from either substation.

There are two separate area DC systems, 250v system and a 48v system. These are normally operated by AC-DC motor-generator sets and have battery supplies for emergency use.

This section will cover operation of all equipment from the two 13.8 kv power supply lines to, but not including, the breakers for individual equipment. These breakers will be covered with the equipment involved.

1 SYSTEM STARTUP

1.1 Alternating Current System

Normal power is supplied to the area by closing motor-operated pole line switch 129 in the preferred feeder, ORNL Circuit 234. This switch can be closed remotely from ACR Panel 11 in the auxiliary control room or manually at Pole B - north of Building 7503. An indicating light on ACR Panel 11 indicates when voltage is available on ORNL Circuit 234, and lights above the control switch indicate whether switch 129 is open or closed. The manual-automatic selector switch should be placed in the automatic position.

1.1 (continued)

Power is supplied to the 750-kva auxiliary power substation for building services by closing the manual pole switch located at the sub-station east of Building 7503.

Next, close the manual breakers to the 480v, 3-phase Distribution Panels 1 and 2, which are located at Column D4 on the 840-ft level of the building, this will bring service power into the building. Distribution Panels 1 and 2 breakers can then be closed as required to put equipment in service as indicated in Tables I, II, & III.

Power is supplied to the 1500 kva process power switchgear by closing the manual primary disconnect switch located at the substation west of Building 7503.

The process equipment switchgear and motor control centers are located in the switch house which is west of the main building and south of the process power substation. This room contains most of the breakers for energizing the process equipment. The buses for the process equipment are energized by closing the following breakers from the 1500 kva switchgear in the switch house except as noted below:

1.1.1 Breaker R brings power from the substation to 1500 kva switchgear bus. (TVA BUS)

1.1.2 Breakers S and Breaker A-1 energizes Bus No. 3. Close Breaker A-1 from DP-3 or DMP-3. (A-1 is interlocked not to close before S.)

1.1.3 Breaker T and Breaker A-2 energizes Bus No. 4. Close Breaker A-2 from DP-4 or DMP-4. (A-2 is interlocked not to close before T.)

1.1.4 Breaker Z energizes Bus No. 5. (Close Breaker from DP-5.)

The motor control centers (MCC) can be energized by closing the following breakers:

1.1.5 Breaker L for MCC-G3.

1.1.6 Breaker F for MCC-G4.

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TABLE I

DISTRIBUTION PANEL NO. 1

Circuit	Equipment	Breaker Fuse	Load (HP)	Remarks
	10-ton crane	70A/90A	15	Both cranes on same fuse and breaker
	3-tone crane		7 1/2	
1	Spare	70A		Two 30A fused switches
2	Fused Sw., 852 L	25A		Two 30A fused switches
3	Spare	25A		
4	Change House Vent Fan & 840 level htr. fan	15A	1/2, 3/4	Vent fan interlocked with Circuit 5
5	852' Htr. Fan	15A	1-1/2	
6	Spare	15A		
7	Two 3 Φ Receptacles	70A		(1) High Bay A-4 (2) North ESA
8	C. R. Air Cond	100/60A	15	Time delay and two pressure switches
9	225 KVA Lighting Transformers (See Table III)	400A		ΔY, 480/120/208v, 3Φ, 4W
10	Spare	400A		
11	Spare	400A		

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TABLE II

DISTRIBUTION PANEL NO. 2

Circuit	Equipment	Breaker Fuse	Load (HP)	Remarks
1	Two, 480v, 3φ Receptacles	50A		In Service Area
2	Spare	50A		
3	Spare	100A		
4	Spare	100A		
5	Spare	100A		
6	Spare	100A		
7	Two, 480v, 3φ Receptacles	70A		Switch house, Blower House
8	Spare	100A		
9	Spare	70A		
10	Spare	100A		
11	Rollup doors	30A	2	Top, bottom limit switch
12	Spare	30A(F)		
13	Two fans, 1 heater	30A(F)		South high bay
14	Spare	30A(F)		
15	Spare	30A(F)		
16	Spare	30A(F)		

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TABLE III

BUILDING LIGHTING FROM DISTRIBUTION PANEL 1 - CIRCUIT 9

Circuit	Light Pan.	Location	Emergency*	Lighting Area
Distribution Panel 1A located 840' level, Col. 4, 5-C				
0	Pnl. 1 Pnl. 2	MCR-852 MCR-852	No Yes	Maint. Control Room & RC & DTC Recept.
1	K	TR	Yes	TR-S. ESA, W. Tunnel, Blower House, Vent House, Switch house, C.D. Cell, Waste Fan.
2	C	Comp. R	No	Spare
3	H B	840, Col. 1-C 852, Col. 4-D	No Yes	840' heater distribution area, No ESA 852' hall, Hi Bay, outside E & SE of Building
4	D	840, Col. 4, 5C	No	Spare
5	J	852, Col. 2D	Yes	Locker room, Instrument Office & Shop, Hi Bay
6	A	852, Col. 2D	Yes	Computer Room, CR, Offices, Outside No. & West
7	G	Hi Bay Col. 5C	No	Hi Bay
8	AB	840, Col. 4, 5-C	Yes	Bat. Room, 840' Maintenance Area, East of TR
Distribution Panel 1A1 - located 840' - outside NE door to TR				
1-6	Spare			
7	Comp House	Comp H	Yes	Store Room (Comp House)
	T	Diesel H	Yes	Diesel H.
8	S	SR	No	Service Room & Tunnel

*Emergency Supply from Breaker M - Gen. Bus No. 3, through lighting transformer and "B" position switch at each light. panel.

1.1.7 Breaker CC for MCC-G5-1. (This breaker also can be operated from Panel DPM-5, ACR.)

1.1.8 Breaker AA for MCC-G5-2. (This breaker also can be operated from Panel DPM-5, ACR.)

1.1.9 Breaker X for MCC-T-1.

1.1.10 Breaker Y for MCC-T-2.

These additional breakers should be closed.

1.1.11 Breaker BB for Heater Distribution Panel G5-BB.

1.1.12 Breaker M should be closed to supply power for emergency AC lighting. This includes Maintenance Control Room Panel No.2, Lighting Panels K, A, AB, B, and T. Each of these has a selector switch with an A and B position. The A position powers the lights from the auxiliary substation, and the B position powers lights from DG No. 3 Bus. These lighting panels should be operated in the B position.

1.2 Direct Current System

Before starting the DC systems, turn on the battery room ventilating fan. Check to be sure that all battery cells are filled with electrolyte to the top of the stippled windows. Measure the specific gravity of each cell. The specific gravity of a fully charged cell is 1.210.

1.2.1 To start the 250v DC system:

1.2.1.1 Close Switchgear Breaker W, from switch gear panel, to supply power to MG-1. Start MG-1 from MG-1 control panel as follows:

1.2.1.2 Set auto-manual voltage switch in auto position.

1.2.1.3 Push "AC" start button.

1.2.1.4 Adjust generator voltage to 260v (floating voltage) if batteries are charged, or to 280v (recharge voltage) if batteries need charging, by use of the auto field rheostat. (Left side) After completing Step 1.2.1.5 and 1.2.1.6 adjust charging rate. Charging rate should not exceed 56 amperes. After batteries are recharged, adjust generator voltage to 260 v.

1.2.1.5 Close the reverse power trip breaker.

1.2.1.6 Push "DC" start button.

1.2.1.7 Close the 250v distribution switches. (840-ft level north)

(a) emergency lights

(b) breaker trip power

(c) MG-4

(d) 13.8 kv transfer control power.

1.2.1.8 Start the 25 kw DC to AC MG-4 from control panel in MG room as follows: Note; MG-4 will not start if MG-1 voltage is above 270v.

(a) Set auto-manual selector switch in "auto" position.

(b) Press "start" button.

(c) Set the generator voltage to 120v by adjusting the "generator" voltage rheostat.

(d) Set the AC frequency to 60 cycles by adjusting motor rheostat. Any change made in MG-1 voltage also changes frequency of MG-4. Note: After loading, readjust frequency to 60 cycles.

(e) Set MG-4 main contactor in "on" position.

(f) Push reset on throwover switch to transfer instrument power from TVA to MG-4.

1.2.1.9 Close breaker MCC G4-31 to energize the alternate power supply for AC instruments.

1.2.2 <u>To start the 48v DC system and charge batteries</u>

In Switch Room:

1.2.2.1 Close MCC G3 Breaker 9 to MG-2.

1.2.2.2 Close MCC G4 Breaker 9 to MG-3.

At 48v DC Panel, 840-ft level:

1.2.2.3 Open generator output contactors for Generator No. 2 and Generator No. 3.

1.2.2.4 Push motor start buttons to start MG-2 and MG-3.

1.2.2.5 Adjust both generators to 51.6v with field rheostat. (Large dial is for coarse adjustment; small dial is for fine adjustment.)

1.2.2.6 Close equalizer contactor and both Generator No. 2 and No. 3 output contactors.

1.2.2.7 Adjust battery charging rate not to exceed 69 amps with field rheostats.

1.2.2.8 After batteries have been recharged (i.e., when specific gravity of each cell is $\geq$ 1.210), open equalizer contactors and standby generator output contactors. Stop standby MG-2.

1.2.2.9 If necessary, adjust operating generator voltage to 51.6v, using field rheostat. The charging rate of each generator is limited to 54 amperes.

1.2.3 Startup 48v DC System with Batteries Charged

In Switch Room:

1.2.3.1 Close breakers MCC G3-9 (or G4-9) at 48v DC Panel on 840-ft level.

1.2.3.2 Push start button for MG-2 (or 3).

1.2.3.3 Adjust operating generator voltage to 51.6v.

1.2.3.4 Close the operating generator output contactors.

1.3 Heater System Preparation

Before starting the reactor or a section of the reactor system, the heater power supply must be checked to be sure all breakers are closed and the heaters are ready to be turned on.

The general procedure will be as follows:

1.3.1 Tabulate all heaters already in service. Have shift supervisor approve this list before proceeding.

1.3.2 All manual powerstats that are not in service should be set at zero.

1.3.3 Regulator motor power and control circuit power should be turned on. (See section 4A.3.1.)

1.3.4 All motor-operated powerstats that are not in service should be set at zero.

1.3.5 All induction regulators that are not in service should be lowered to minimum setting and turned off.

1.3.6 All heater breakers except breakers tagged open for repairs should be closed. (See section 4A.3.1.) The breakers are:

1.3.6.1 Heater panel breakers, north end 840-ft level.

1.3.6.2 Transformer breakers on transformer platform, over 830-ft pit.

1.3.6.3 Distribution panel breakers, north end 840-ft level.

1.3.6.4 Heater switch gear and MCC breakers in switch house.

1.3.7 All ten induction regulator blowers should be on. Switches are at each blower.

During and for two hours following the heater startup, a periodic check of all system heater temperatures should be made to ensure that no operating heaters were turned off and no heaters not needed were turned on. The heaters will be turned on as part of the reactor startup, Section 5C and 5F. This can be accomplished from the heater control panels.

2 NORMAL OPERATION

2.1 Alternating Current and Direct Current Systems

Normal operation of the AC system involves the occasional use of the switchgear and MCC breakers for testing the emergency equipment (Section 3A.3), which is not normally in operation, or for isolating sections of the electrical system for maintenance.

Periodically the 48v and 250v DC battery banks should be checked for dead cells by checking the liquid specific gravity and proper liquid level.

After excessive use of the 48v DC battery, or when a cell unbalance is indicated by variation in specific gravity of the cells, the battery will be given an equalizing charge as follows:

2.1.1 Using the field rheostat, slowly increase the operating generator voltage to 55.9 volts (2.33v/cell) and hold for eight hours, or until successive readings of specific gravity (over two-hour periods) show no increase.

2.1.2 If generator amps exceed 54, operate both generators in parallel per Battery Charging Procedure given below: At 48v DC Panel, 840-ft level:

2.1.2.1 Push motor "start" buttons to start both MG-2 and 3.

2.1.2.2 Adjust both generators to 55.9 with field rheostat. (Large dial is coarse adjustment; small dial is for fine adjustment.)

2.1.2.3 Close equalizer contactor and both generator No. 2 and No.3 output contactors.

2.1.2.4 Adjust battery-charging rate not to exceed 69 amps with field rheostats.

2.1.2.5 After battery has been recharged (i.e., when specific gravity of each cell is $\geqq$ 1.210), open equalizer contactors and open standby generator output contactors. Stop standby MG set No. 2.

2.1.2.6 If necessary, adjust operating generator voltage to 51.6v, using field rheostat.

2.1.3 If only one generator is used, upon completion of equalizing, slowly lower voltage to 51.6v.

2.2 Heater System - Normal Operation

Except during reactor system heatup when a higher load is required, most of the heaters will be operated at system heat-loss power.

Periodic checks will be made of the current drawn by each heater circuit to be sure there are no heater failures. When circulating salt, pipe temperatures will not indicate heater conditions. Ground detection meters will be checked once per shift on the normally ungrounded induction regulator circuits.

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3 EMERGENCY AND SPECIAL OPERATIONS

3.1 Alternate Feeder Operation

In the event that electrical power is lost on the preferred feeder, ORNL Circuit 234, and if there is still voltage on the alternate line, ORNL Circuit 294, after a preset time of 1 to 10 sec, switch 129 will open and 229 will close. Switch 129 will not open during an outage of <6 sec. Table IV lists breakers and starters which need to be reclosed after a momentary power outage that cannot be closed from the main control board. Start Equipment listed in Tables V and VI that was operating before the momentary loss of TVA power. Note: Use control room and walking logs to determine equipment to be restarted. The starters and breakers will have to be reclosed after momentary outages, or when TVA power is resumed.

Since there is no automatic feature for transferring from the alternate feeder back to the preferred line, this becomes a manual procedure, and should be done as soon as Circuit 234 has been restored. (See section 3A.3.3.2.)

3.2 Complete Loss of TVA Power

When voltage is lost on both TVA feeders or if the fault is between switch 129 and 229, switch 129 will open and 229 will not close. Alternating current must then be supplied by the diesel generators. Switch 129 will have to be closed manually when TVA power is restored.

3.2.1 Diesel Startup Procedure

3.2.1.1 Dispatch an operator to the diesel house to start at step 3.2.1.8 below, meanwhile:

3.2.1.2 Push "start" button for Diesel Generator No. 3 on DPM-3. Generator voltage increase on DPM-3 will indicate when unit starts. The diesel will crank for 10 seconds and if not started will repeat after 10 seconds for up to 3 attempts. If diesel fails to start, open fuel ignitor valve and turn on fuel ignitor pump motor switch (both located on west side of diesel) and repeat start.

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Table IV

BREAKERS AND STARTERS NOT OPERATED
from
MAIN CONTROL BOARD

BREAKER-STARTER	EQUIPMENT CONTROLLED	BREAKER/STARTER LOC.	TVA or DG
Reverse Power Breaker	250 v DC MG-1	MG-1 in MG Room	TVA
Starters	MG-1	MG-1 in MG Room	TVA
Starters	H-200-13, H-201-12, H-202-2 Htrs.	HCP-1, 840' level	TVA-MCC-T-1
Starters	RCH-1, RCH-2, RCH-3, RCH-4 Htrs.	HCP-6, 840' level	TVA-MCC-T-1
Starters	RCH-5, RCH-6, RCH-7, H 102-2 Htrs. HX-1, HX-2, HX-3, FP-1, FP-2 Htrs.	HCP-7, 840' level	TVA-MCC-T-1
Starters	R-1, R-2, R-3 Htrs.	HCP-7, 840' level	TVA-MCC-T-2
Starters	FFT-2, FD1-2, FD2-2 Htrs.	HCP-8, 840' level	TVA-MCC-T-1
Starters	MG-2, MG-3 Motor	48v Panel, 840' level	DG-3, DG-4
Starters	MG-2, MG-3 Gen. Output	48v Panel, 840' level	DG-3, DG-4
Starters	Waste Tank Vent Fan	Switch in Remote Maint. Processing Cell	DG-4
Breaker AA	MCC G5-2	DPM-5 in Aux. C.R.	DG-5, Bus #5
Breaker CC	MCC G5-1	DPM-5 in Aux. C.R.	DG-5, Bus #5
Starters	H-103 Htr.	HCP-8, 840' level	DG-5, MCC G5-2
Starters	FFT-1, FD1-1, FD2-1 Htrs.	HCP-8, 840' level	DG-5, Bus #5

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Table V

EQUIPMENT SUPPLIED FROM DIESEL GENERATOR No. 3

Equipment	Description	Motor Rating (hp)	Operating Load (hp)	Operating Load (kw)	TVA Load (kw)	MCC-G3 Breaker** No	MCC-G3 Breaker** Size Amps	Switch-gear Breaker
	Inst. Power Panel #5	30 kva		15	15	1	70	
C1*	30-ton Crane	40	37	31.5		2	100	
SP	Sump Pump	5	5	4.6		3	30	
PP	Pit Pump	5	5	4.6				
DCC*	Drain Tk Cell Cooler	10	?	?	?	5	?	
	Be Sampling #1	.5	.5	.5		7	15	
	Exhauster #2	.5	.5	.5				
CCP-3	Aux. FV Blower	7.5	7.5	4.6	4.6	8	30	
MG-2	48v DC generator	5	5	4.6		9	15	
RCC-1	Reactor Cell Cooler	10	?	?	?	10	?	
FOP-1	FP Lube Oil Pump	5	3.5	4	4	11	20	
TF-1	Cooling Tower Fan	5	5	4.6	4.6	12	15	
HCV-930A	Vent Valve	0.75	.75	.66		13	30	
HCV-930B	Vent Valve	0.75	.75	.66		14	30	
AC-1	Inst. Air Compressor	40	40	33.4	33.4	15	100	
*	Diesel Aux. Power	12.2kw		12.2		16	100	
CCC-1	Coolant Cell Cooler	2	2	1.8	1.8	17	15	
	Inst. Power Panel #4	10 kw		6		13	30	
TWP-1	Treated Water Pump	20	20	15	15	19	50	
CTP-1	Cooling Tower Pump	20	20	17.2	17.2	20	50	
MB-4	Annulus Blower	10	10	8.8	8.8	23	30	
SF-1	Stack Fan	50	50	41.8	41.8	24	100	
CCP-1	Component Cooling Pump	75	70	58				H
CP	Coolant Pump	75	46	39	39			K
	Lighting Transformer	100 kva	33	33	33			M
Total				344.32	252.6			

*Transfer switch to DG No. 4

**Breakers No. 4, 6, 21, 22 are spares.

Approved by [signature]

TABLE VI

EQUIPMENT SUPPLIED FROM DIESEL GENERATOR No. 4

Equipment	Description	Motor Rating (hp)	Operating Load (hp)	Operating Load (kw)	TVA Load (kw)	MCC-G4*** Breaker No	MCC-G4*** Breaker Size Amps	Switch-gear Breaker
C1*	30-ton crane	40	37	31.5	31.5	2	100	
DCC*	Drain Tk cell cooler	1.5	1.5	1.4	1.4	5	15	
MG-3	48v DC power	5	5	4.6	4.6	9	15	
COP-1	CP lube oil pump	5	3.5	4	4	11	20	
TF-2	Cooling tower fan	5	5	4.6	4.6	12	15	
DR-1	He O_2 Remover			1.		13	30	
	Preheater			.6				
	Dryer			.6				
*	Diesel Aux. Power	12.2		12.2		16	100	
CCC	Coolant Cell cooler	2	2	1.8	1.8	17	15	
CTP-2	Cooling tower pump	20	20	17.2		20	50	
TWP-2	Treated water pump	20	20	15		21	50	
WP	Waste Pump	10	10	7.5	7.5	23	50	
RCC-2	Reactor cell cooler	10	?	?	?	24	?	
MB-2	Annulus	10	10	8.8	8.8	26	30	
DR-2	He O_2 remover			1	1	27	30	
	Preheater			.6	.6			
	Dryer			.6	.6			
	Trnsfrmr. Spect. Rm	25 kva		15	15	29	30	
**	Inst Panel #2 & 3	25 kva		13		31	100	
AC-2	Inst air compressor	40	40	33.4		32	100	
AC-3	Ser. air compressor	40	40	33.4	33.4	33	100	
FP	Fuel Pump	75	45	38.2	38.2			D
CCP-2	Comp. cooling pump	75	70	58	58			E
SF-2	Stack Fan	50	50	41.8				
Total					212.7			

*Transfer switch from DC No. 3
**Transfer from MG No. 4 (250v DC supply)
***Breakers #1, 3, 4, 6, 7, 8, 10, 14, 15, 18, 19, 22, 25, 28, 30 are spares

3.2.1.3 After diesel starts and voltage reaches 480v, open Breaker A-1 and with key close Breaker A-5 from DPM-3. Get OK from technician at diesel generator unit before adding load.

3.2.1.4 Start diesel generator No. 4 by Step 2, observing generator volts on DPM-4.

3.2.1.5 When generator No. 4 voltage reaches 480v, open Breaker A-2 and with key close Breaker A-3 from DPM-4. Get OK from technician at diesel generator before adding load.

3.2.1.6 Start diesel generator No. 5 by pushing "start" button on DPM-5, observing generator No. 5 voltage on DPM-5. Start switch automatically opens after 10 sec; release to reset.

3.2.1.7 When generator No. 5 voltage on DPM No. 5 reaches 480v, open Breaker Z and with key close Breaker A-4 from DPM-5. Breaker BB load is on line. Get OK from technician at diesel generator before adding load. (See section 3A.3.2.2.)

3.2.1.8 After each diesel starts, check the following items in the diesel house and switch house area.

(a) Louvers are open to each unit;

(b) No obstructions are in cooling air path to diesels;

(c) No unusual noises from DG sets;

(d) Annunciators on Diesel panels are clear;

(e) Fuel oil level in day tank "50%;

<u>DIESEL GENERATOR 3 or 4</u>

(f) Lube oil pressure >20 psi (normal is 30-40 psi);

(g) Check that diesel generator 3 and 4 fuel ignitor motor switch is off and fuel ignitor valve is closed;

(h) Water temperature <180°F;

DIESEL GENERATOR 5

(i) Lube oil pressure - normal operating range;

(j) Water temperature - normal operating range;

(k) Fuel pressure - normal operating range;

(l) Speed - 1200 rpm;

(m) Starting air pressure - 225 psig;

(n) Items "e" through "l" should be checked every 30 minutes.

(o) Keep each generator at 480 volts and 60 cps.

3.2.1.9 After diesel generators 3 and 4 reach speed, check load limit at 5 and diesel generator 5 load limit at 10.

NOTE: If diesel 3 or 4 is heavily loaded or starts to decrease in speed, set load limit at 10. Reduce to 5 when diesel is shut down.

After diesels are started, close the following breakers:

(a) Breaker AA on DPM-5, Auxiliary Control Room;

(b) Breaker CC on DPM-5, Auxiliary Control Room.

Restart the following heaters supplied from DG-5:

(c) Heaters FFT-1, FD1-1, FD2-1, H-103 on HCP No. 8;

Start the motorized equipment listed on Tables V and VI, using the following guide:

With both diesel generators 3 and 4 running, start equipment with loads listed under column "TVA Load" in Tables V and VI. If diesel generator 3, 4, or 5 cannot be started or fails during operation, the operator should proceed as outlined in section 9A.

3.2.1.10 Call a power house operator to operate diesel units until they are shut down.

After TVA power has been re-established, the power supply should be returned to normal as described under Section 3A.3.3.1.

3.2.2 Heater System - Emergency Operation - Complete Loss of TVA Power

When diesel generator No. 5 is started and switched on to Bus 5 by opening Breaker Z and closing Breaker A-4, the

3.2.2 (continued)

radiator circuits CR-1 through 4 are automatically energized through Breaker BB. Power is on to the heater control circuits and the radiator induction regulator blower for CR-1 through 4.

When Breaker AA from the auxiliary control room is closed, the radiator circuits CR-5 through 8 and the induction regulator blower for CR-5 through 8 on the same circuit are on. When Breaker CC is closed, heaters on all freeze valves, drain lines, except L-103 are in operation.

To turn on heaters FFT-1, FD1-1, FD2-1, the three drain tank lower heaters, push the start buttons. Line 103 heater can be turned on by pushing its start button.

3.2.3 Emergency Lighting, 250v DC

There is 4 kw of emergency DC lighting located throughout Building 7503. There are twenty-eight 250v DC lights varying from 100w to 300w capacity, distributed as follows:

No.	Location	Watts/bulb
13	840-ft level and ESA	100
3	High-Bay Area	300
3	Control Room	200
5	852-ft level, offices and hall	100
1	Service Tunnel	200
1	Vent House	100
1	Switch House	100
1	Diesel House	100

These lights are supplied from the 250v DC panel Breaker 21 on the 840-ft level through a switch and an AC operated relay. Loss of AC power to the relay automatically energizes the DC lights.

The AC relay is fed from the switch adjacent Lighting Panel H on the north end of the 840-ft level.

3.2.3 (continued)

After the emergency AC lights, which are supplied from diesel generator No. 3 come on (see Section 3A1.1), the DC lights should be turned off at the 250v DC distribution panel to lower the load on the 250v battery.

3.3 Special Operations

3.3.1 Return from Diesel to TVA Power Supply

3.3.1.1 As soon as TVA power is restored, start up the 250v DC system by the Startup Procedure, (Section 3A.1.2).

3.3.1.2 Start up equipment from MCC T-1 and T-2 as required. See Table IV for heater induction regulator starter.

3.3.1.3 Parallel diesel generator 3 (or 4) with TVA, and transfer load without interrupting operations as outlined below.

NOTE: Never operate with generator 3 and 4 in parallel with TVA at the same time.

Make transfer in switch house as follows:

Generator No. 4 items are listed in parentheses.

(a) Breakers A-1 (A-2) opened, green lights indicating on Panel DP-3 (DP-4);

(b) Breaker A-5 (A-3) closed, red light indicating on Panel DP-3 (DP-4).

(c) With removable handle, close A1-SS (A2-SS) on DP-3 (DP-4).

(d) Set governor speed droop at 50 on DG-3 (DG-4).

(e) Adjust "running voltage" (generator) to agree with "incoming voltage" (TVA) on Panel DPS by raising or lowering VAR-3 (4) on DP-3 (4) with regulator transfer switch in automatic position. If on manual, use EFR-3 (4).

(f) Adjust generator speed with GS-3 (GS-4) switch until synchroscope pointer is rotating clockwise at 3 to 10 sec per revolution.

(g) Close Breaker A-1 (A-2) when synchroscope pointer is 5 degrees before "12 o'clock." Red light will come on, and the green light will go off.

(h) Turn GS-3 (GS-4) to lower and hold until generator wattmeter on DP-3 (DP-4) drops to a low value.

(i) Open A-5 (A-3). Green light will come on and red light will go off.

(j) Turn off A1-SS (A2-SS). Operate diesel unloaded for 5 min before stopping.

(k) Press diesel stop button, DP-3 (DP-4), and hold until diesel stops.

(l) Go through startup check list. (Section 4A.2).

3.3.1.4 Transfer the load from generator 5 to TVA as outlined below.

NOTE: Generator 5 cannot be paralleled with TVA. Therefore, during the transfer from generator 5 to TVA, the heaters supplied by generator 5 have to be off for a short time. Also, all induction regulators will be off because their control voltage is supplied from BUS No. 5.

<u>Transfer load from Generator 5 to TVA as follows</u>:

(a) Open AA and CC, on DPM-5, to partially unload diesel.

(b) Open A-4 to disconnect diesel from Bus 5. Operate diesel for 5 min. at no load before stopping.

(c) Stop Diesel No. 5. Push button on DP-5 or DPM-5.

(d) After shutdown of diesel, check that governor has reset. Reset marker should be at white mark. use mirror mounted on manifold.

(e) Close Breaker Z to tie Bus 5 to TVA bus.

(f) Close Breaker AA and CC on DPM-5 to restore heater voltage.

(g) Close all induction regulator heater starters (see Table IV) and reset to walking log settings prior to power outage.

(h) Go through startup Check List (Section 4A.2).

3.3.2 Return to Preferred Feeder from Alternate Feeder Without Loss of Power to Bus No. 3 and No. 4

3.3.2.1 If load on either Bus No. 3 or No. 4 exceeds 300 kw as indicated on bus wattmeter on DPM-3 and 4, adjust loads by starting up some standby equipment on the least loaded bus and by stopping the duplicated equipment on the more loaded bus. See Table V and VI for rating of duplicate equipment and supply bus.

NOTE: The diesels can stand 10% overload for two hours.

3.3.2.2 Start up Diesel No. 3 per Emergency Startup Procedure, Steps 3.2.1.1, 3.2.1.2, and 1.2.1.8.

3.3.2.3 Synchronize, parallel, and transfer load from alternate TVA feeder to generator No. 3 in the switch house as follows:

(a) Breakers S and A1 are closed, red lights indicating on DP-3.

(b) Breaker A-5 is opened, green light indicating on DP-3.

(c) With removable handle, close switch A5-SS on DP-3.

(d) Set governor speed droop to 50 on DG-3.

(e) Adjust "incoming voltage" (generator) to agree with "running voltage" (TVA) by raising or lowering VAR-3 (4) on DP-3 (4), with regulator transfer switch in automatic position. If on manual, use EFR-3 (4).

(f) Adjust generator speed with GS-3 switch until synchroscope pointer is rotating clockwise at 3 to 10 sec per revolution.

(g) With key, close breaker A-5 when synchroscope pointer is 5 degrees before "12 o'clock." Red light will come on and the green light will go off.

(h) Turn GS-3 to "raise" and hold until wattmeter TVA-A1 on DP-1 drops to a low value. Set load limit on governor to 10 if required.

(i) Open A1; green light will come on, red light will go off.

(j) Turn off A5-SS on DP-3.

3.3.2.4 Start up Diesel No. 4 per Emergency Startup Procedure, Steps 3.2.1.1, 3.2.1.4, and 3.2.1.8.

3.3.2.5 Synchronize, parallel, and transfer load from alternate TVA feeder to Generator No. 4 in the switch house as follows:

(a) Breakers T and A-2 are closed, red lights indicating on DP-4.

(b) Breaker A-3 open, green light indicating on DP-4.

(c) With removable handle, close switch A3-SS on DP-4.

(d) Set governor speed droop at 50 on DG-4.

(e) Adjust "incoming voltage" (Generator) to agree with "running voltage" (TVA) on panel DPS by raising or lowering VAR-3 (4) on DP-3 (4) with regulator transfer switch in automatic position. If on manual use EFR-3 (4).

(f) Adjust generator speed with GS-4 switch until synchroscope pointer is rotating clockwise at 3 to 10 sec per revolution.

(g) With key, close breaker A-3 when synchroscope pointer is 5 degrees before "12 o'clock." Red light will come on and the green light will go off.

(h) Turn GS-4 to "raise" and hold until wattmeter TVA-A2 on DP-1 drops to a low value. Set load limit on governor to 10 if required.

(i) Open A-2; green light will come on, red light will go off.

(j) Turn off A3-SS on DP-4.

NOTE: Never operate with generator 3 and 4 in parallel with TVA at the same time.

3.3.2.6 Transfer from alternate TVA bus to preferred TVA bus as follows:

(a) Turn the manual-automatic selector switch to the manual position, ACR Panel 11.

(b) Open switch 229 and close switch 129 from ACR Panel 11 to transfer to preferred feeder.

(c) Turn the manual-automatic selector switch to the automatic position ACR Panel 11.

(d) Close the following breakers to restore TVA power to Bus 5:

Breaker AA on DPM-5
Breaker CC on DPM-5

(e) Start MG set #1 per section 3A.1.2.1.

(f) Transfer load from generator No. 3 to TVA by special operations, Section 3A.3.3.1.

(g) Transfer load from generator No. 4 to TVA by special operations, Section 3A.3.3.1.

NOTE: The equipment on the following buses will be without power during the switching from ORNL Circuit 294, alternate, to 234, preferred:

TVA Switchgear Bus
Switchgear Bus No. 5
TVA MCC-T1 and T2
MCC G5-1 and G5-2
Auxiliary Substation

(h) Restart all equipment as required having combination starters on the buses noted in the above note. (See Table IV)

3.3.3 <u>Weekly Test Loading of Diesel Generators</u>

3.3.3.1 Diesel Generators No. 3

NOTE: <u>Generator No. 4 items are listed in parentheses</u>.

(a) Start up Diesel Generator No. 3 (4) as follows:

1. Follow steps 3.2.1.1, 3.2.1.2 (3.2.1.4) and 3.2.1.8 of this procedure.

3.3.3.1 (continued)

2. After unit starts, run at half throttle for 15 min by setting governor load limit to 5 (located at diesel).
3. Notify Shift Supervisor before paralleling with TVA.
4. Set load limits on governor to 10 if required.

(b) Parallel diesel generator 3 (4) with TVA and transfer load to diesel generator 3 (4) without interrupting operations as outlined below. Transfer must be made in switch house.

1. Breaker S(T) and A-1 (A-2) closed, red light indicating on DP-3 (DP-4).
2. Breaker A-5 (A-3) opened, green light indicating on DP-3 (DP-4).
3. With removable handle, close switch A5-SS (A3-SS) on DP-3 (DP-4).
4. Set governor speed droop at 50 on DG-3 (DG-4) (located on diesel).
5. Adjust "incoming voltage" (generator) to agree with "running voltage," (TVA) on panel DPS by raising or lowering VAR 3 (4) on DP-3 (4) with regulator transfer switch in automatic position. If on manual use EFR 3 (4).
6. Adjust generator speed with GS-3 (4) switch until synchroscope pointer is rotating clockwise at 3 to 10 sec per revolution.
7. With key, close breaker A-5 (A-3) when synchroscope pointer is 5 degrees before "12 o'clock." Red light will come on and the green light will go off.
8. Turn GS-3 (GS-4) to "raise" and hold until wattmeter TVA-A1 (TVA-A2) on DP-1 drops to a low value. Set load limit to 10 if required.

3.3.3.1 (continued)

9. Open A-5 (A-3); green light will come on, red light will go off.
10. Turn off A1-SS (A2-SS) on DP-3 (DP-4)

Operate Diesel Generator 3 (4) under load for 30 minutes, then return to TVA power as follows:

(c) Parallel Diesel Generator 3 (4) with TVA, and transfer load without interrupting operations as outlined below.

NOTE: Never operate with Gen. 3 and 4 in parallel with TVA at the same time.

Make transfer in switch house as follows:

Generator No. 4 items are listed in parentheses.

1. Breakers A-1 (A-2) opened, green lights indicating on Panel DP-3 (DP-4).
2. Breaker A-5 (A-3) closed, red light indicating on Panel DP-3 (DP-4).
3. With removable handle, close A1-SS (A2-SS) on DP-3 (DP-4).
4. Set turbine governor speed droop at 50 on DG-3 (DG-4).
5. Adjust "running voltage" (generator) to agree with "incoming voltage" (TVA) on Panel DPS by raising or lowering VAR-3 (4) on DP-3 (4) with regulator transfer switch in automatic position. If on manual, use EFR-3 (4).
6. Adjust generator speed with GS-3 (GS-4) switch until synchroscope pointer is rotating clockwise at 3 to 10 sec per revolution.
7. Close Breaker A-1 (A-2) when synchroscope pointer is 5 degrees before "12 o'clock." Red light will come on, and the green light will go off.
8. Turn GS-3 (GS-4) to lower and hold until generator wattmeter on DP-3 (DP-4) drops to a low value.

3.3.3.1 (continued)

9. Open A-5 (A-3). Green light will come on and red light will go off.
10. Turn off A1-SS (A2-SS). Operate diesel unloaded for 5 min before stopping.
11. Press diesel stop button, DP-3 (DP-4) and hold until diesel stops.
12. Complete Diesel Startup Check List. (Section 4A.2)

3.3.3.2 Diesel Generator No. 4

Repeat 3.3.3.1 using values in parentheses.

3.3.3.3 Diesel Generator No. 5

(a) Check that the governor load limit knob is set at 10.

(b) Start diesel generator No. 5 as follows:

1. Check that the starting air supply is normal.
2. Crank the engine by pushing the start button on DPM-5 in Auxiliary Control Room.
3. Check to see that there is oil pressure indicated on the lubricating oil pressure gauge.

(c) Allow the engine to run for five minutes without changing the control settings.

(d) Vary the engine speed by turning the governor synchronizer knob clockwise until the engine runs at approximately full governed speed. This will be when the frequency meter indicator on the control panel starts to move.

(e) Turn the governor switch control handle to vary the engine speed to obtain a 60-cycle reading on the frequency meter.

NOTE: The governor speed droop knob will never be used in a single unit application, so the indicator on this knob should remain pointing at "0".

The governor synchronizer indicator merely indicates how many turns of the synchronizer knob have been made.

3.3.3.3 (continued)

(f) The control panel voltmeter must indicate correct generator terminal voltage (480v) with the engine operating at rated speed. To establish the correct voltage reading, turn the adjusting rheostat control knob to left of the voltage regulator. Do not change this setting or the position of the exciter field rheostat after the proper voltage (480 volts) reading is obtained.

(g) Open Breaker Z and with key close Breaker A-4 to tie Diesel No. 5 to Bus No. 5.

(h) Close Breakers AA and CC (DPM-5) to restore power to heater, MCC's G5-1 and G5-2.

(i) Close all induction regulator heater starters (see Table IV) and reset to walking log setting.

(j) Operate Generator No. 5 under load for 30 min.

(k) Transfer back to TVA as follows:

1. Open Breaker AA, CC, and A-4 in this order.
2. Close Breaker Z.

(l) Repeat Steps (i) and (j) to restart heaters.

(m) Stop the engine by pushing the stop push button in and holding it in until the engine has stopped.

(n) After shutdown of diesel, check that governor has reset. Reset marker should be at white mark. Use mirror mounted on manifold.

3.3.3.4 After the weekly test loading has been completed recheck startup list to be sure diesels are ready for emergency start. (see Section 4A.2)

3.3.4 Test of 13.8 KV Automatic Transfer

These tests can be made without interrupting operation. However, a power failure during the test would require that the switch 229 be closed manually at the pole to put the alternate line in operation. Switch 129 should be opened manually and a check be made to insure that there was no fault in the area before closing Switch 229.

Each month P & E Electrical Department will be requested to perform the tests outlined below. The schematic diagram, #C-47278 shows the switch identification.

Approved by [signature]

3.3.4.1 Routine Testing Procedure, Automatic Operation

(a) Decouple motor operators #129 and 229 from line switches by means of decoupler assembly between mechanism and vertical operating pipe at each pole.

(b) To simulate loss of potential on preferred line (Emergency line energized):

1. Open Switch A and B on TD-1 with S-1 set on automatic.
2. Automatic operation -- preferred line switch opens after time delay, emergency line switch closes.
3. Reclose Switch A, B, on TD-1
4. Set S-1 to manual.
5. Open Switch 229. Close Switch 129.
6. Switch S-1 to auto.

(c) To simulate loss of potential of preferred line, (Emergency line Not energized):

1. Open Switches A, B, and J on TD-1 and A on TD-2 with S-1 on automatic.
2. Automatic operation -- none.
3. Reclose Switches A, B, J, on TD-1 and A on TD-2.

(d) To simulate overload through CT's, followed by loss of potential on preferred line: (Emergency line energized).

1. Open switch poles D, E, F, G, H, and I on TD-1 with S-1 on automatic.
2. Manually close overcurrent relay 50-1, 50-2, or 50-3.
3. Immediately open Switches A and B on TD-1. Automatic operation -- preferred-line switch opens, lockout light remains illuminated.
4. Reclose all switches A through I on TD-1.

3.3.4.1 (continued)

(e) To simulate loss of potential on emergency line after transfer to emergency line:

1. Repeat step (2A)·(b)-1
2. Open switch poles J on (TD-1) and A on (TD-2) only.
3. Automatic operation -- emergency line switch opens after time delay.
4. Reclose J on TD-1 and A on TD-2.
5. Repeat steps (2D)(b)-4 close switch 129, 6.T.

(f) To simulate overcurrent surge through CT's without subsequent potential loss on preferred line:

1. Open switch poles D, E, F, G, H, and I on TD-1 with S-1 on automatic.
2. Manually close overcurrent relay 50-1, 50-2, or 50-3. Automatic operation: no operation - lockout resets after time delay.
3. Close switch D, E, F, G, H, and I on TD-1.

(g) Recouple motor operators 129 and 229 after completion of the above tests.

Approximately every 12 months, P & E Electrical Department will test the overcurrent relay settings of 50-1, 50-2, and 50-3 and the undervoltage relay settings of 27-1, 27-2, 27-3, and 27-4. These will be set by standard ORNL procedures. When these relays are being tested, the automatic transfer system will be deenergized by opening switch 108 on ACP #11 and opening 250v DC supply breaker (13.8Kv transfer control) in the 250 v DC supply panel (840' level). If possible the test should be made when the reactor is not in operation.

4 NORMAL SHUTDOWN

4.1 Alternating Current System

4.1.1 Shut off load on electrical bus to be shut down — see Process Distribution Drawing D-KK-C-41152.

4.1.1 (continued)

NOTE: If this is a shutdown of MCC No. G-3 or MCC G-4, or Bus No. 3 or 4, start up duplicate equipment on bus to be left in operation, see Table V and VI, Section 3A.3.2. Equipment which can be operated from either bus should be transferred to the operating bus.

4.1.2 Open breaker supplying bus (or buses) being shut down. Tag breakers that are opened on the supply side of equipment to be repaired to prevent them from being closed by others during maintenance.

4.2 Direct Current Systems

A shutdown of either the 48v DC systems or 250v DC systems requires that emergency loads supplied from these systems are not required during the shutdown.

4.2.1 48v System

To shut down the 48v system, first open the generator load breaker at the 48v panel outside the battery room. Second, open the battery bank safety switch in the battery room. Then turn off the operating MG set, and open Breakers MCC G3-9 and MCC G4-9 to isolate the supply system. Either 48v MG set can be shut down for normal maintenance by using the alternate unit to keep the control circuits in operation.

4.2.2 250v DC System

To shut down the 250v DC system, open the load switches in the 250 v distribution panel outside the battery room; turn off the 250v MG set No. 1 and then open breaker W in the switch house.

The 250v battery has a two-hour life at full load, but without any other 250v emergency supply this is just sufficient capacity to shut down the reactor any time the MG No. 1 set is off.

4.3 Heater System Normal Shutdown

Normal shutdown of all heaters can be made at the heater control panels.

Manual powerstats on the panels are turned to zero. The heater ammeter should read zero amps. Motor-operated powerstats are turned off by holding the "lower" push button until the ammeter reads zero and then 10 additional seconds. The induction regulators are turned off by holding "lower" push button until the minimum ammeter reading and then are turned off by pushing the "off" button. Fill line heater H-103 is turned off by turning manual powerstat to zero and then pushing the "off" push button.

Induction regulator blowers and control power to the panels should not be turned off on a normal shutdown.

3B INSTRUMENT AIR AND SERVICE AIR SYSTEMS

The instrument air system supplies clean, dry, compressed air for pneumatic instruments and other special uses. Two Joy compressors AC1 and AC2 are used to compress the air, which then passes through an aftercooler and entrainment separator to a common line supplying two parallel receiving tanks. From the receiving tanks, the air passes through one of two parallel drying stations containing Trinity heatless dryers. The dry air is distributed through headers to locally mounted filter and reducing stations. Two nitrogen cylinder banks provide emergency gas pressure to headers serving the more important equipment.

The service air system supplies air for pneumatic tools, etc. One Joy air compressor and receiver tank are provided. The compressed air without drying is distributed to stations located in various parts of the building. Service air can also be used for emergency cooling of freeze valves normally supplied by component cooling pump No. 3 (see 3D) and can be valved into the instrument air system upstream at the receiver tanks if required.

1 STARTUP

1.1 Instrument Air Compressors

1.1.1 Check that the cooling tower water system is in operation and water flow is adequate to each compressor head and after-cooler.

1.1.2 Check the oil level in each air compressor crank case.

1.1.3 Check that the electrical and control power is on to each compressor.

1.1.4 Check the air valving. Open the valves in the compressor discharge lines and the supply and discharge lines to both receiver tanks. (Both instrument air receiver tanks will be left on-stream.)

1.1.5 Check the drain valves. Open valves in the drain lines from the entrainment separator, receiver tanks, and line filters downstream of the receiver tanks. Close valves in the lines, bypassing the drain line traps.

1.1.6 To start compressors AC1 or AC2, set compressor selector switch (on MB12) to the compressor being started, and push start button for the selected compressor. (The standby compressor will start automatically if the instrument air pressure drops below the setpoint.)

1.2 Instrument Air Dryer

1.2.1 Close the discharge valve and discharge filter drain valves of both dryers.

1.2.2 Open dryer purge valves and humidity indicator bleed valves.

1.2.3 Turn on power to dryers and slowly open valves in air supply lines to dryers.

1.2.4 Adjust purge flows and moisture indicator bleeds to both dryers.

1.2.5 Let dryers operate until desiccant in indicator window turns blue or through one complete cycle.

1.2.6 Close the inlet and filter drain valves of the standby dryer.

1.2.7 Slowly open the valve in the discharge line from the dryer which is to be operated.

1.2.8 Check the instrument air header moisture analyzer. It should read <10% of scale.

1.3 Instrument Air Headers

1.3.1 Open all header block valves and set all pressure-reducing valves to the proper discharge pressure. At the reducing stations which have duplicate reducing valves, the valves must be closed which isolate the standby-reducing valves.

1.3.2 Open all valves to instruments, and close all spare valves to prevent excessive use of air.

1.4 Emergency Instrument Air Supply

1.4.1 Check that both banks of 6 nitrogen cylinders are full and all cylinder valves are open.

1.4.2 Set PIC 9006-1 at 65 psig, so that nitrogen will be used only on loss of normal instrument air pressure.

1.4.3 Open the block valve for one bank and close the block valve in the standby bank.

1.5 Service Air Compressor

1.5.1 Check the cooling water flow.

1.5.2 Check the oil level in the crank case.

1.5.3 Check the air valving.

1.5.4 To start the motor, switch the electro-pneumatic selector switch to the "hand" position. The compressor will load up and will subsequently unload and load automatically to maintain the set pressure. If usage is small it may be desirable to set the selector switch to "Auto." The compressor will then start and stop to maintain the desired pressure.

2 NORMAL OPERATION

2.1 Instrument Air Compressors

One instrument air compressor is normally in operation with the other in standby. Periodic checks should be made to assure that there is adequate cooling water flow to the compressors and aftercoolers, and that the water traps are operating properly. Any abnormal vibration or noise should be investigated.

2.2 Instrument Air Dryers

One of the instrument air dryers is normally in operation. The other should be in standby with the power off and valves closed. Periodic checks should be made to see that the purge and dryer bleed flows are adequate, the dryers are cycling, and the air is dry.

2.3 Instrument Air Distribution

Periodic checks should be made of the air flow rate and header pressures. The filters will be periodically blown down.

2.4 Emergency Instrument Air Supply

The two six cylinder banks of nitrogen cylinders will be full at all times. One bank will be connected to the emergency air headers through PCV 9006, which will be set to open at 65

2.4 (continued)

psig. The other will be valved off and in standby. All cylinder valves on both banks will be open.

2.5 Service Air Compressor

The service air compressor is not normally in operation unless needed for pneumatic tools or emergency cooling for freeze valves in the coolant cell or fuel processing cell. When in service, periodic checks should be made as described in 2.1 above.

3 EMERGENCY OR SPECIAL OPERATIONS

3.1 Loss of Instrument Air Pressure

Abnormal air usage or compressor troubles could cause the instrument air pressure to drop. Alarms will occur and the standby compressor will start. If the pressure continues to drop, the critical air headers will be supplied with nitrogen from the emergency nitrogen banks. When the on-stream bank pressure drops to approximately 100 psig, this bank should be isolated and the standby bank put on stream. Cylinders should be replaced as used. Any unnecessary usage should be reduced while operating on emergency supply. When the compressors are put back on stream, normal usage can be resumed. Pipes and valves are provided for cross-tieing the service air compressor with the instrument air compressors upstream of the dryers.

3.2 Loss of Cooling Tower Water to the Compressors

Cooling tower water is normally used to cool the compressors and aftercoolers. However, connections are provided for the emergency use of process water. Hand valve 880 must be closed and 872 opened.

4 SHUTDOWN

4.1 Header Shutdown

Shutdown of any header can be accomplished by closing the header supply valve. The equipment affected should be checked prior to shutdown to be sure that a needed air supply is not

4.1 (continued)

terminated.

4.2 Shutdown of Entire Instrument Air System

A shutdown of the instrument air system should be made in the following order:

4.2.1 Shut off emergency header block valves if emergency air is not needed during the down period.

4.2.2 Stop air compressors. Open electrical supply breakers if maintenance work is to be performed on the compressors.

4.2.3 Close supply discharge and filter drain valves to air dryers to keep desiccant dry during down period. Allow dryers to operate through one complete drying cycle to remove pressure from both drying columns, and then close dryer purge block valve and indicator bleed valve. Turn off the electrical power to both dryers.

3C WATER SYSTEM

Potable water as supplied to the MSRE from the X-10 water system is used for drinking and sanitary purposes and for fire protection. After passing through a backflow preventer, the water is called process water and is used in the liquid waste system, in the vapor-condensing system, for general clean-up of equipment, as makeup for the cooling tower water system, and for cooling of the charcoal beds. Two 520-gpm centrifugal pumps are provided for circulating cooling tower water, which is cooled by a two-fan induced draft cooling tower. The cooling tower water is used for air compressors, air conditioners, in the chemical plant, for the lube-oil systems, in the charcoal beds, and for condensing steam from the drain tank steam domes. (Process water can also be used for this.) Cooling tower water is also used in a shell-and-tube heat exchanger to provide cooling for the treated water system. Two 230-gpm centrifugal pumps circulate treated water in a closed loop to cool in-cell components. Makeup water is supplied by condensing building steam in a shell and tube heat exchanger using cooling tower water as the coolant. Treated water is also used to fill the Nuclear Instrument penetration. This water is continuously recirculated through a closed loop by a 5-gpm pump to maintain uniformity of the water condition throughout the penetration. The water is treated with 2000 ppm of a mixture of 25% potassium tetraborate and 75% potassium nitrite to minimize corrosion. Steam condensate is also used to supply water to the feedwater tanks. This untreated water is used in the drain tank bayonets to remove decay heat from the reactor fuel after the reactor has been drained.

1 STARTUP

1.1 Potable Water System

This system is started by opening the main supply valve located north of the 7503 building.

1.2 Process Water System

1.2.1 Open the main supply valve.

1.2.2 Put the process water backflow preventer into service and check that it is functioning properly as indicated by little or no leakage from the drain line. Every six months

1.2.2 (continued)
a complete checkout of the backflow preventer should be made by Inspection Engineering per ORNL Standard Practice Procedure No. 14.

1.2.3 Put the liquid waste backflow preventer into service and check that it is functioning properly as indicated by little or no leakage from the drain line. Every six months a complete checkout of the backflow preventer should be made by Inspection Engineering.

1.2.4 Check that the cooling tower makeup valve is operating properly.

1.3 Cooling Tower Water System

1.3.1 Check that the cooling tower basin is full of water and is clean.

1.3.2 Open the supply and discharge valves from both cooling tower pumps.

1.3.3 Start each pump individually and check for leaking packing or hot bearings. Leave one pump running.

1.3.4 Start the cooling tower fans.

1.3.5 Adjust all flows and set the temperature controller as indicated on the building log.

1.4 Treated Water System

1.4.1 Check that the level in both condensate storage tanks, and the surge tank are as indicated in the building log.

1.4.2 Open the supply and discharge valve from both treated water pumps.

1.4.3 Start each pump individually and check for leaking packing or hot bearings. Leave one pump running.

1.4.4 Open the valves at the treated water cooler, and adjust all flows as indicated on the building log.

NOTE: The design pressure of the thermal shield is <40 psig. Extreme caution should be taken to avoid overpressurizing it. Before opening the inlet valve, all valves in the outlet lines must be tagged open.

1.4.5 Check that pressure drop across the filter in the diesel house is less than 10 psi.

1.4 Treated Water System (con't)

1.4.6 Check that the pressure drop across the strainer in the water room is less than 8 psig. Switch to other side of the strainer and check that pressure drop is less than 8 psig.

1.5 Condensate Makeup

Condensate is made up by opening the steam and cooling water supply valves to the makeup condenser and by opening the valve to the desired condensate storage tank.

1.6 Decay Heat Removal System

1.6.1 Add condensate to each feedwater tank (FWT-1 and FWT-2) until the total volume in each system is approx. 40 gal.

1.6.2 After a fuel drain the heat removal will start automatically by opening ESV 806 or ESV 807 if the fuel drain tank temperature reaches 1300°F.

2 NORMAL OPERATION

2.1 Potable Water System

No operator action is required for the normal operation of the potable water system other than to prevent freezing. It should be noted that this system is never to be connected to equipment which might be contaminated or which might contain chemicals. Process water should be used for this purpose and for all cleaning and flushing operations.

2.2 Process Water System

During normal operation, a periodic check should be made to determine that the main backflow preventer and the waste system backflow preventer are operating properly. Water flow from the drains greater than 1 cc/min would indicate malfunctioning of the backflow preventers.

2.3 Cooling Tower Water System

In normal operation the supply and discharge valves from both cooling tower pumps should be open. One pump should be in operation with the other in standby. The operating pump should be checked periodically for leaking packing. The flow and temperature

2.3 Cooling Tower Water System (con't)

controller should be set as indicated on the building log. Both cooling tower fans will be operated in the summer; however, in cold weather only one may be needed. Alternating the fans will help prevent excessive icing of the towers.

2.4 Treated Water System

In normal operation the supply and discharge valves from both treated water pumps should be open. One pump should be in operation with the other in standby. The operating pump should be checked periodically for leaking packing. The flows should be set as indicated on the building log.

To avoid rupture of the thermal shield, the pressure should not exceed 20 psig. This is equivalent to 12 psig in the water room (PI 844) with no flow or 13 psig on PI 844 at design flow. The treated water filter in the diesel house should be bypassed and cleaned when the pressure drop exceeds 5 psig. The strainer in the water room should be switched to the clean side when the inlet pressure exceeds 8 psig. The treated water should be sampled periodically, and a mixture of 25% potassium tetraborate and 75% potassium nitrite added to keep the concentration greater than 2000 ppm.

2.5 Condensate Makeup

After each condensate storage tank has been filled, it should be sampled. If analysis indicates that it is not within limits specified in Section 6C, it should not be used in the treated water system or the steam drums. Water from the alternate tanks should be used while waiting for analytical results.

2.6 Decay Heat Removal System

During normal operation of the reactor, the steam drum level and drain tank temperatures should be checked periodically to insure that there is no water leakage to the steam drums.

To remove decay heat from fuel salt, this system will be operated intermittently. The block valves (ESV 806 and 807) in the water supply to the steam drums will open when the drain

2.6 Decay Heat Removal System (con't)

tank temperature rises to 1300°F and will close when the temperature drops to 950°F. The water level must be kept above the top water inlet to the bayonets, approx. 5 in., and below the steam outlet at 7-in. elevation. Other water levels can be used by controlling the water inlet flow using the LCV 806 or LCV 807. However, this increases the stresses and might shorten the life of the bayonets. If the LCV's are used the water flow must be stopped manually when the fuel temperature reaches approx. 950°F.

3 EMERGENCY OPERATION

3.1 Potable and Process Water

No emergency operations are anticipated for these systems.

3.2 Cooling Tower System

Low cooling tower water pressure will switch the supply to the drain tank steam drum condensers from the cooling tower water to process water (HCV 882C1). Process water can be turned on manually to the instrument air compressors by opening V 872 and closing V880.

3.3 Treated Water System.

Nuclear contamination of the treated water system, monitored by RIA 827, will close block valves in all the discharge water lines from the reactor and drain tank cells. Then high pressure will close HSV 844 in the supply line to the thermal shield. All inlet water lines into the reactor cell and drain tank cell contain check valves which prevent backleakage of activity.

If activity in the cooling water is the only (or most critical) incident at the time, dispatch an operator and H. P. representative to the water room to survey the water piping for activity. Check the common return lines. If radioactive, check the return lines from the RC and DTC space coolers. If one or more are free of activity, close HV's in the supply to and the return from all other in-cell equipment. Then raise the setpoint on the activity monitor (RIA 827) to open the block valve in this line, which will allow space coolers to be operated and prevent buildup

3.3 Treated Water System (con't)

of cell pressure.

Expansion of water after the block valves close is released through 100 psi pressure relief valves which discharge to the waste tank except in the case of the thermal shield. Rupture disks in L855 from the thermal shield water lines 844 and 845 relieve at 18 psi to the vapor-condensing system. Also, to prevent damage to the thermal shield if the inlet block valve (FSV 844) leaks, a flow-limiting orifice in L 844 has sufficient ΔP to carry the entire water capacity at full pump head.

3.4 Winterization

All water lines which can be exposed to subfreezing temperatures will be winterized and insulated. This winterizing will consist of tracing pipes with either electric heaters or steam lines.

3.5 Decay Heat Removal System

If loss of water from the system indicates a steam or water leak, the fuel can be transferred to the other drain tank where heat removal can be continued.

4 NORMAL SHUTDOWN

4.1 Cooling Water Systems

Normal shutdown of an entire cooling water system requires that there be no demand on that system during the down time. The circulation of either the CTW system or the TW system can be stopped by stopping the circulating pump on MB No. 2. The cooling tower fans can also be shut off from MB-2.

Any of the parallel paths of the cooling water systems can be isolated by closing supply and discharge hand valves. This allows the rest of the system to continue operation.

4.2 Decay Heat Removal System

When the fuel drain tank temperature drops to approx. 950°F, the water control valve, ESV 806 or ESV 807, will close automatically and remain closed until the fuel temperature increases to 1300°F. The water in the steam dome will then be boiled out and

4.2 Decay Heat Removal System (Con't)

stored in the feedwater tank until needed. The fuel drain tank temperature should be observed to insure that it does not continue to cool and to freeze the fuel salt.

3D COMPONENT COOLING SYSTEMS

Cooling is needed to prevent overheating of the reactor neck, control rods, and fuel pump, and for freezing the freeze valves.

Components located in the reactor and drain tank cells are cooled by the primary component coolant system which circulates reactor and drain tank cell air, using rotary type positive displacement blowers. Two blowers (CCP No. 1 and No. 2) are installed, but only one is used at a time. The other serves as an emergency standby unit.

Freeze valves located in the coolant drain tank cell and fuel processing cell are cooled by a secondary system using atomspheric air. The prime mover is another rotary type positive displacement blower (CCP No. 3). Emergency backup is provided by air from the auxiliary air compressor.

1 STARTUP

1.1 Primary System

1.1.1 Check that the treated water system is in operation and cooling water flow is adequate on the gas cooler and oil coolers.

1.1.2 Check that the instrument air system is in operation and air is on to the control valves in the component cooling system.

1.1.3 Open the large suction and discharge valves to both blowers and backseat each of them. This forms part of the reactor cell containment.

1.1.4 Open the valves which allow gas circulation past the cell radiation monitor and O_2 analyzer.

1.1.5 Close the valves in the cell evacuation lines and sample lines.

1.1.6 Start CCP No. 1 or No. 2 by pushing "start" button on MB No. 3. Observe that the system pressure increases and is controlled by PdIC 960A, @ 8.1 psig.

1.1.7 Leak check the bonnets of the blower discharge valves. These must not leak.

1.1.8 Start flows to components to be cooled as required and evacuate cells through line 565.

1.2 Secondary System

1.2.1 Check the oil level in the blower (CCP No. 3) and add oil if necessary.

1.2.2 Visually check the suction filter and replace the element if necessary.

1.2.3 Set PICA 906B to zero. Open V-906A.

1.2.4 Start CCP No. 3 by pushing the button on MB 12.

1.2.5 Adjust PICA 906B to 8 psig and observe that PCV 906B controls properly.

1.2.6 Adjust flows to freeze valves as required for their operation.

1.2.7 Start the service air compressor.

1.2.8 Set PCV 967 to control at 8 psig and close the valve upstream from PCV 967.

1.2.9 Stop the service air compressor if it is not needed for other purposes.

2 NORMAL OPERATION

2.1 Primary System

Normal operation consists of periodic observation of the temperatures at the gas cooler, water flows, and the differential pressure as indicated by PdIC 960A. A low oil pressure alarm, PA 791 (or 795) monitors the blower lubricating system. During an extended run, when one blower has operated for 4000 hr, it should be put in standby service, and the other blower should be put into operation until the end of the run.

2.2 Secondary System

The secondary system blower, CCP No. 3, should be checked periodically for proper oil level, unusual noise, and hot bearing housings. PIC 906 should be checked for proper pressure control.

3 EMERGENCY OPERATIONS

3.1 Primary System

Upon annunciation of low oil pressure (PA 791 or 795) on either CCP No. 1 or No. 2, low system pressure (PdA 960A) or low cooling water flow (PA 875) to the oil cooler, the condition should be immediately remedied, or the operating blower should be stopped

3.1 Primary System (continued)

(if still running). The standby unit should be started by pushing the start button on MB No. 3. It is then an administrative decision whether the reactor should continue to operate without a standby blower available.

3.2 Secondary System

Loss of CCP No. 3 for any reason is indicated by a low pressure alarm, PICA 906B. Emergency cooling can be provided to the freeze valves by starting the service air compressor and opening hand valves V-967A and V-967C and closing HV-906A in the blower hourse. PCV-967 should be checked and adjusted to 8 psig if necessary.

4 SPECIAL OPERATIONS

4.1 Reactor Cell Evacuation

4.1.1 Initial or Periodic Cell Evacuation - The reactor and drain tank cells can be evacuated at ~100 cfm using CCP No. 1 or CCP No. 2 by opening V-565C in the vent house. The periodic evacuation should be started when the cell pressure is −1.8 psi (3.6 in. Hg vacuum), and should be stopped at a −2.2 psi (4.4 in. Hg). If the component cooling system pressure starts to drop during evacuation, throttle V-565C to get PdIC-960A to control. To stop evacuation, close V-565C.

4.1.2 Continuous Cell Evacuation - If desired, the reactor cell can be kept at a constant vacuum by continually bleeding off gas through line 569. Open V-569A and throttle V-569B until FI 569 indicates a flow equal to the inleakage to the reactor cell plus the N_2 purge rate into the cell through the reactor cell and drain tank cell sump bubbler lines, FI RCC-A and FI DTC-A. FqI 569 will summarize the flow.

4.1.3 Inspection of Primary System Blowers - Since CCP No. 1 and CCP No. 2 are located inside tanks which are part of the reactor cell containment, routine inspection of these blowers should only be made when the reactor is shut down. Valves are provided for isolating each tank and minor repairs can be made under administrative control.

Plugging of the oil filter appears to be the most likely failure in the system. However, with a clean gas system the oil filter should last >4000 hr. At this time the oil level should be checked and oil should be added if necessary. The filter element and oil should be changed if the blower has operated >2000 hr since the last change, or if an extended run is planned. Inspection and maintenance of the oil system can be made by opening the 12-in. flanged inspection port on the blower containment tanks. The drive belts should also be examined at this time.

5 NORMAL SHUTDOWN

When cooling air is no longer needed, the operating blowers can be shut down by pushing the "stop" button on MB No. 3.

If maintenance is to be performed on part of the system, valves should be closed to isolate that part of the system.

3E SHIELD AND CONTAINMENT

The detailed steps in getting the reactor shield ready for operation and checking containment are covered in the Startup Check List, Section 4E. However, the general plan to be followed, reasons for actions taken, etc., are given below for each area.

The maximum credible accident for the MSRE consists of a simultaneous rupture of a molten-salt line or vessel and the presence of the proper amount of water, presumable due to a rupture of one of the cooling-water lines or the thermal shield. In this case the pressure could rise to 110 psig if it were not for the vapor condensing system, which will limit the rise to 39 psig. The maximum allowable leak rate from the reactor and drain tank cells when they are pressurized to 39 psig is 1% of their volume in 24 hours (180 ft^3/day). This is checked at a positive pressure (20 psig) after each time the reactor or drain tank cells have been opened for maintenance or inspection. Vapor condensing system is tested simultaneously, but separately, with reactor and drain tank cells. The cells are operated at 12.7 psia, and the leak rate is continuously monitored while the reactor is in operation.

Since any line in the cell could rupture during the maximum credible accident, containment must be provided for each. These are checked periodically as indicated in the Startup Check List, Section 4E.

1 REACTOR AND DRAIN TANK CELL

1.1 Startup

After all maintenance in the cells is finished, install all lower blocks, weld the seal pans in place, check the seal pans with the cells at 2 psig, and alternate top blocks in place. Maximum spacing between blocks is 24 inches.

Since the air line block valves close at a cell pressure of 2 psig, careful consideration should be given to the condition of the reactor and drain tank system before starting the cell pressurization. If there are no leaks in the air lines to the air operated valves, they will not change position during the period that the block valves are closed. Therefore, all vent valves from, and equalizing valves between, the reactor and drain tanks should be opened at the time the block valves close. The drain tank and reactor systems should be vented to atmospheric pressure before closing the block valves. Jumpers in Circuits 33, 34, and 35 will prevent the block valves from closing.

As an added precaution against unintentional transferring of salt, the transfer and fill freeze valves should be frozen. Since the component coolant pump will not be in operation, power to the heaters on the freeze valves should be shut off, and the power to the adjacent line heaters should be reduced so that the freeze valves remain frozen without coolant air.

When no pan leaks are visible at 2 psig, install all top blocks and pressurize the cell to 20 psig, hold the cell temperature constant, and check the leak rate by observing the cell pressure. (For calculation of leak rate, see Section 3E.1.2., Part VIII, MSRE Operating Procedures). The space coolers should be on at this time if possible.

If the leak rate is above the specified limit (see Table 3E-1 this section), all block and check valves and rupture disks in the lines connecting the cell atmosphere will need to be tested. It may be necessary to retest the seal pans.

When the leak rate is satisfactory, reduce the pressure in the cells to -2 psig, and again check the leak rate. The pressure should not normally be reduced lower than -2 1/2 psig. An alarm will occur at -3 psig, and the block valve (HCV-565) will close. At -4 psig the component coolant pump will automatically be shut off. (The space coolers and component coolant pump should be in operation).

If this leak rate is satisfactory, the pressure will be maintained at -2 psig, and the cell will be purged with nitrogen until the oxygen content is less than 5%.

The procedure outlined above tests only the containment of penetrations directly into the cell atmosphere. It is also necessary to test each line which connects with the reactor or drain-tank system and extends outside of containment. Also since during an accident any of the service lines entering the reactor or the drain tank cell could be ruptured, it is necessary to provide containment for these lines and to periodically check the adequacy of each of these. The general method of containment is described below. Details of the methods used for checking the containment are given in Section 4E.

TABLE 3E-1

ALLOWABLE LEAK RATE
at
VARIOUS PRESSURES AND TEMPERATURES

Cell Pressure		Cell Temperature		Allowable Leak Rate (Ft^3/Day)	
Psig	(Psia)	°F	°R	STP*	At Cell Pressure and Temperature
39	53.7	285	745	434	180
20	34.7	70	530	222	101
5	19.7	70	530	55.5	44.6
-2	12.7	70	530	22	27.4
-2	12.7	150	610	22	31.6

*The allowable leak rate at standard condition of temperature and pressure is assumed to be directly proportional to the pressure differential. Standard T & P are 32°F and 14.7 psia.

All cover gas lines which enter the system contain a minimum of one soft-seated check valve to prevent backflow. Also, the supply header pressure is maintained higher than could conceivably be developed in the system. These are tested by gas pressurization.

All the off-gas lines are blocked by a common block valve which is closed on high activity in the line upstream of the absolute filters in the ventilation system. In addition, those lines which normally contain fission gases are jacketed (double pipe) upstream of the charcoal beds. This is tested by gas pressurization.

The cell evacuation line contains a radiation block valve prior to the absolute filters. This is tested by gas pressurization (see Section 4E, Part VIII, MSRE Operating Procedures).

All cooling water lines which enter the cell have soft-seated check valves to prevent backflow. The cooling water lines which leave the cell contain radiation block valves. Taps are provided to enable pressurization of the in-cell equipment to test the check valves and block valves.

The surge tank also contains a block valve on the vent and a spring closed valve on the chemical addition line. These are tested by air pressurization.

The oil systems are closed systems. They are checked leak-tight periodically by pressurizing the entire systems, and administrative control is used to assure that no changes are made during operation which might violate containment.

The steam condensing system for the drain tank coolers is a closed system except for the water supply lines which contain soft-seated check valves and the vent line which goes to the vapor condensing system. These check valves are tested during testing of the vapor condensing system.

The coolant salt system is a closed system. Auxiliary lines connected to this system have similar containment to the fuel system. These are tested in place by gas pressurization wherever possible; otherwise, they are removed from the system and bench tested.

The cell sump jet supply lines contain soft-seated check valves, and the discharge lines contain two valves in series which close on high cell pressure. The check valves are tested when the cell is at pressure. A test line is provided for testing the block valves.

All lines to the fuel sampler contain soft-seated check valves, and the supply header pressure is maintained higher than the pressure which could be developed in the sampler. These are tested by gas pressurization.

The leak detector system is a closed system which is operated at a higher pressure than could conceivably be developed in the reactor. Administrative control is used to assure safe operation and maintenance.

The helium supply lines to the fuel pump, fuel overflow tank and fuel and flush salt drain tanks are provided with secondary containment to a point upstream of the check valves in these lines. The containment enclosures are connected to the RC or DTC but sealed off from them. These are leak tested by gas pressurization.

All instrument air lines and valve operator vent lines contain block valves which close on high cell pressure. These are tested by gas pressurization.

When the containment of all the penetrations is known to be satisfactory, the cell leak rate is below permissible limits, and the O_2 content of the RC and DTC atmosphere is less than 5%, the RC and DTC are ready for operation.

1.2 Normal Operation

The reactor and drain tank cell will be operated at -2 psig. This is accomplished by throttling V 569A. The evacuation rate is measured by F_qI 569 downstream of V 569A. A nitrogen purge will be maintained at a rate such that the oxygen content of the cell does not exceed 5%, as indicated by sampling cell air or use of a continuous O_2 analyzer. The purge nitrogen enters the cells at the sumps and provides the gas for the bubbler level indicator. A probe type level alarm is also installed in each sump. These are tied into a common annunciator. Water cannot be tolerated in either cell and should be jetted immediately. Continued buildup of water will necessitate shutting down and repairing the leak. The procedure for sampling and jetting the sump is given in Section 3J.

The cell leakage should not exceed 1% of the cell volume in 24 hr at 39 psig and 285°F. The rate of inleakage to the cell can be calculated from (1) the change in cell pressure and temperature or (2) the change in oxygen content. Several temperature-compensating-reference-volume tanks are located in the cells which when used as references for differential-pressure-measuring instruments eliminate the need for adjusting indicated-cell-pressure changes due to temperature changes.

The leak rate formulas are as follows:

F_1 and F_2 = O_2 analyzer readings at beginning and end of test (fraction of O_2 in containment atmosphere).

N = Nitrogen purge rate (SCFH).

L_R = Leak rate (standard cu ft per day).

P_1 and P_2 = Absolute pressure in containment at the beginning and end of the test (psia).

ΔP = Change in pressure during the test (in of H_2O).

t = Time duration of test (hrs).

T_1 and T_2 = Average cell temperature at beginning and end of test (°R).

Tare = Average cell temperature during test

$$\frac{(T_1 + T_2)}{2} \ (^\circ R).$$

V = Volume of containment (ft^3) (18000 cu ft).

W = Gas evacuated at F_qI 569 (SCF).

A - <u>When pressure testing the cell,</u> there will be no evacuation and no nitrogen purge.

(1) The leak-rate out of the cell in standard cu ft per day based on pressure and temperature measurements would be:

$$L_R = \frac{14.5 \times 10^6}{t} \left(\frac{P_1}{T_1} - \frac{P_2}{T_2}\right)$$

(2) When the temperature-compensating drum is used and the time is short, the leak-rate out of the cell in standard cu ft per day based on the differential-pressure instrument would be:

$$L_R = \frac{5.25 \times 10^5}{t} \left(\frac{\Delta P}{Tare}\right)$$

B - When the cell is less than atmospheric pressure, there may be a nitrogen purge and/or evacuation at F_qI 569.

(1) The leak-rate into the cell in standard cu ft per day based on pressure and temperature measurements would be:

$$L_R = \frac{14.5 \times 10^6}{t} \left(\frac{P_2}{T_2} - {}^{P_1}/_{T_1}\right) + \frac{24W}{t} - 24N$$

(2) When the temperature compensating volume is used and the time is short, the leak-rate into the cell is standard cu ft per day based on the differential pressure instrument would be:

$$L_R = \frac{5.25 \times 10^5}{t} \frac{\Delta P}{Tare} + \frac{24W}{t} - 24N$$

(3) If the leak rate is constant and the evacuation rate at F_qI 569 is constant, then the leak-rate into the cell in standard cu ft/day based on oxygen analysis readings would be:

$$L_R = \frac{538 \frac{T_1}{P_1} (F_2 - F_1) + 12 \, WF_1}{t \, (.2 - F_2)}$$

(4) If there is no evacuation at F_qI 569, the leak-rate into the cell in standard cu ft/day based on oxygen analysis readings would be:

$$L_R = \frac{538 \frac{T_1}{P_1} (F_2 - F_1)}{t \, (.2 - F_2)}$$

During operation the average temperature of the cells is maintained at 150°F or less by controlling the water flow to the three space coolers.

The cell air activity and oxygen concentration is monitored in the component coolant system, line 565, and therefore the pump must be in operation at all times.

1.3 Emergency or Special Operation

Cell air activity will stop the cell evacuation by closing HCV-565, and will give an emergency fuel drain. A rupture of in-cell piping or the loss of cooling water to the space coolers will cause the cell pressure to rise. When the pressure reaches 16.7 psia, all block valves will close. No automatic blocking action occurs on the valves in the cell ventilation lines, HCV-930A, HCV-930B, V-955A, or V-955B, and therefore these are tagged closed at the start of each run. It is highly important that they never be opened during operation.

If the pressure rises to 15 psig, the 3" rd ruptures and at ~ 20 psig the 12" rupture disc to the vapor condensing system will break, relieving the cell pressure.

Residual air activity in the cells can be purged through the auxiliary charcoal beds by opening V-571A and V-571B.

1.4 Shutdown

Shutdown of the reactor and drain tank cells consists essentially of shutting off the cell evacuation valves and venting the system to atmospheric pressure. This is best done by opening HV-955A and B, which bypass the 30 inch motor-operated valves (HCV-930A and B) in the cell ventilation line. When the cell has been vented, the motor-operated valves can be opened to provide ventilation for maintenance operations.

2. VAPOR-CONDENSING SYSTEM

2.1 Startup

Putting the vapor-condensing system in condition for operation consists of filling VT 1 two-thirds full of corrosion-inhibited water, checking that the rupture disk bypass valve, V-980, the vent valve, V-984, are tagged "closed".

2.2 Normal Operation

The vapor-condensing system should require little or no attention during operation. Should the water level in VT 1 drop below the lower intermediate probe, it should be replenished.. Approval of the operations chief should be obtained before filling. If the level continues to drop, it will be necessary to shut down the reactor and determine the source of leaks. (See Section 3E.2.4 Part VIII, MSRE Operating Procedures). If the system pressure rises above 15 psia as indicated by PIA VT 2, the system should be vented to the stack through HV-984. This valve should not be opened without the shift supervisor's permission and should be closed and tagged after venting.

2.3 Emergency and Special Operations

If the pressure in the reactor cell has increased to 15 psig, the 3" rupture disc will break, and at 20 psig the 12" rupture disc will break. Vapors from the reactor and drain tank cells will be discharged into VT 1, where the gases will be scrubbed and any steam condensed; the noncondensables will be retained in VT 2 and the vapor space of VT 1. The activity in the vicinity of the vapor condensing system may be as high as 100 rads/hr at this time.

As the reactor cell cools, its pressure will decrease, and the gases will be pulled back into the cell through CV's 980A and 980B. Any remaining pressure in VT-2 can be vented to the stack through V-984. However, any gas pressure remaining in VT-2 will be disposed of after the situation has been carefully reviewed. Special instructions will be issued at the time covering any other operations.

2.4 Shutdown Operation

A periodic leak test of this system will be performed and the leak-rate shall not exceed 1% of the volume in 24 hours at 39 psig and 140°F. The leak test when performed will be performed simultaneously with the RC and DTC leak test but as a separate test.

For this operation V-980 shall be opened when pressurizing the RC and DTC and then closed for the leak tests. The detailed steps for the leak test are given in Section 4E, Part VIII, MSRE Operating Procedures. The allowable leak rate is given in Table 3E-2.

Leak rate formulas are as follows:

L_R = Leak rate (scfd)

P_1 & P_2 = Absolute pressures at beginning and end of test (psia).

T_1 & T_2 = Absolute temperatures at beginning and end of test (°R).

t = Time duration of test (hrs)

$$L_R = \frac{3.725}{t} \times 10^6 \left(\frac{P_1}{T_1} - \frac{P_2}{T_2}\right)$$

TABLE 3E-2

VCS ALLOWABLE LEAK RATE

at

VARIOUS TEMPERATURES AND PRESSURES

System Pressure		System Temperature		Allowable Leak Rate	
Psig	Psia	°F	°R	STP*	At System Temperature & Pressure
39	53.7	140	600	139	46
20	34.7	70	530	71	32
5	19.7	70	530	18	17
-2	12.7	70	530	7	6.7

* The allowable leak rate at standard condition of temperature and pressure is assumed to be directly proportional to the pressure differential. Standard T & P are 32°F and 14.7 psia.

3 COOLANT CELL AND COOLANT DRAIN TANK CELL

3.1 Startup

Preparation for operation consists of installing blocks on the top of the penthouse; closing the doors between the coolant drain tank cell and the west tunnel, between the coolant drain tank cell and the blower house and between the coolant cell and the blower house (These doors should be locked and signs should be installed to prevent entry by personnel during operation.); putting the two coolant cell space coolers in operation; and providing adequate ventilation as described in 3F.

3.2 Normal Operation

In normal operation the radiation level in these areas will be too high for personnel entry. The cell temperature should be maintained at 150°F, or less, with the space coolers.

Water leaking into the cell will flow by gravity to the sump pump pit and will be automatically pumped to the catch basin.

3.3 Emergency or Special Operation

A leak of salt from the coolant or coolant drain tank systems into the cell would probably be detected by losses in coolant salt inventory. Air samples taken from the ventilation duct may show an increase in beryllium concentration. In case of a rupture of a salt line, it would be possible if water were present to develop a slight pressure and release some beryllium to the high bay, blower house, west tunnel or special equipment room. However, since these areas are vented to the containment stack, the amount of atmospheric contamination would be small. In case of an accident of this nature, gas masks should be worn until the conditions have been adequately analyzed.

3.4 Shutdown

After the reactor has been shut down for 15 minutes, access to the area is possible before the coolant salt is drained. Adequate health physics and beryllium surveys sould be made before entry.

4 SPECIAL EQUIPMENT ROOM

The special equipment room may be entered from the coolant drain tank cell or by removing blocks from above. During operation at power the radiation level is too high for continued occupancy; however, by entering through the top, short term operations or maintenance jobs can be done. A health physics survey is necessary before entry.

5 WEST TUNNEL AND SOUTH ELECTRICAL SERVICE AREA

These areas are not accessible during operation of the reactor, but they may be entered when the reactor is drained. Positive personnel barriers and warning signs must be provided before startup. A health physics survey is necessary before entry after shutdown.

6 CHARCOAL BED PIT

The shielding blocks on the charcoal bed pit should not be removed without administrative approval. Air leakage into this pit is vented to the ventilation stack. An inleakage will be limited by caulking around the blocks.

7 FILTER PIT

The ventilation system filters are installed in a pit south of the building. Top shielding is provided by means of concrete blocks, which are caulked to prevent air or rain leaking in.

Entry should be necessary only for maintenance and should be done with administrative approval.

8 AUXILIARY CELLS

The liquid waste cell, remote-maintenance practice cell, fuel storage cell, decontamination cell, equipment storage cell, and a spare cell are located below the 852 ft level in the high-bay area north of the drain tank cell.

The activity levels in these cells are independent of the reactor operation. Entry should be made only after a health physics survey.

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3F VENTILATION SYSTEM

The ventilation system provides ventilation to all areas where radioactive contamination or beryllium dust is likely to occur. The relative pressures are maintained so that the flow of air is from the less hazardous to the more hazardous areas. Dampers are provided in the discharge ducts from each area to enable balancing the flow for the specific operation in progress. Air flows from the ducts to a header which feeds three filter banks connected in parallel. Suction to the filter banks is provided by either of two parallel 19,000-cfm stack fans which discharge to a 100-ft high containment stack.

1 STARTUP

1.1 Stack Fans and Filters

1.1.1 Open all inlet and outlet dampers to the three filter banks.

1.1.2 Start stack fan No. 1 by pushing the start button in the control room.

1.1.3 Push the start button for the No. 2 stack fan. (The No. 2 stack fan will start automatically on high pressure at the suction of the filters.)

1.1.4 Check that the discharge damper from stack fan No. 1 is open and from No. 2 is closed.

1.2 Ventilation Distribution

1.2.1 Open the damper in the duct that supplies air to the high bay from the inlet air filter house.

1.2.2 Check that the supply air filters are in good condition.

1.2.3 Start steam to the coils in the supply air if heating is required.

1.2.4 Adjust dampers to the various areas to minimize possible spread of contamination and start waste blower. (See Normal Operation and Special Operations.)

2 NORMAL OPERATION

Normal operation of the ventilation is considered to be when the reactor and drain tank cells are closed and the reactor is in operation.

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2.1 Stack Fans and Filters

Stack fan No. 1 will normally be in service with No. 2 in standby ready for automatic startup. NOTE: Stack fan No. 1 will not start automatically. All three filters should be operated in parallel. Periodic checks should be made of the stack flow, suction pressure, filter pressure drop, and stack radiation monitor. Any abnormal vibration or noise should be investigated.

2.2 Ventilation Distribution

The reactor and drain cells will be sealed and held at a negative pressure (≈12.7 psia) using the component coolant pumps. The two block valves in the 30-in. reactor cell ventilation line will be closed. The coolant cell, coolant drain tank cell, special equipment room, south electric service area, fuel processing cell, and liquid waste cell will normally be closed and caulked. The decontamination cell, equipment storage cell, and spare cell may be open or closed depending upon conditions in that cell. The high-bay supply air damper should be open and doors to the high-bay closed. HCV 935A in the discharge from the high-bay area should be open. The high-bay area will be maintained at a negative pressure of -0.1 to -0.3 in. of water. The dampers in the exhaust lines from the coolant cell, coolant drain tank cell, special equipment room, fuel processing cell, and liquid waste cell will be open to maintain these at a lower pressure than the high bay. The waste blower should be in operation. The dampers to the decontamination cell, equipment storage cell, and spare cell will be adjusted to assure a flow of air from the high bay into these cells if they contain potentially hazardous material. Normally the dampers in the exhaust ducts from the transmitter room and north electric service area should be closed and the dampers in the duct from the south electric service area should be open. This will cause the air to flow from the 840-ft level to the transmitter room, then to the north electric service area, then to the south electric service area and subsequently to the stack. The dampers in the ducts from the service tunnel and vent house will be adjusted to keep them at a lower pressure than atmospheric. There are no dampers or valves in the ventilation lines from the off-gas containment boxes or charcoal beds.

Periodic checks should be made of the relative pressures and air flows. Due to possible cave-in of the high bay, the vacuum should not exceed −0.3 in. of water.

2.3 Other areas and equipment are ventilated by separate ventilating fans in the respective locations. They are as follows:

2.3.1 The "Sump Room" is ventilated by means of an exhaust blower. The on-off switch is located at the entrance to the sump on the 852 level. The blower should run continuously and should be checked on before entering sump room.

2.3.2 An exhaust fan mounted in the west wall of the MG #1 and #4 room provides ventilation for the motor generator sets. This fan should run at all times. The off-on switch is located at the fan.

2.3.3 The induction regulators of the salt piping heaters are ventilated by blowers which are to run continuously during operations. Groups of four or six induction regulators are each ventilated by a blower in conjunction with a small duct system. The on-off switches for these blowers are located at the respective blowers. There is a total of nine (9) blowers located in the induction regulator area just north of the "Heater Control Panel" on the 840 level.

2.3.4 The battery room is ventilated by an exhaust blower in the east wall. Continuous ventilation in this room is mandatory because of the evolution of hydrogen from the batteries. The on-off switch for this blower is located in Panel H switch #18 on the north wall of the 840 level.

2.3.5 The remote maintenance area is ventilated by a small exhaust blower in the west wall of the room. This blower should be operated when needed. The on-off switch is located at the blower.

2.3.6 The main disconnect panel in the motor control center is ventilated by means of an exhaust fan. The fan is located in the south wall of the motor control center room with the off-on switch located in the southwest corner of the room. This fan should be maintained running at all times.

3 OPERATION DURING MAINTENANCE

The flow of air should continue to be from the less hazardous to the more hazardous areas as described in 2.1 and 2.2 of this section. Many different damper settings may be required, depending upon the operating conditions. When increasing the air flow from one area, caution should be used not to decrease it below tolerance in another area. Several anticipated conditions are described below.

3.1 Maintenance in the Reactor and/or Drain Tank Cells

Before opening either cell a check should be made of the cell air activity, Monitor RE-565. During maintenance, both valves in the cell exhaust line 930 will be open, and the velocity through any opening will be maintained at no less than 100 ft/min. When the openings into the cell are large, the high bay exhaust valve HCV-935A will be closed. With smaller openings, it will be necessary to open HCV-935A to provide necessary ventilation in the high bay and maintain the high-bay pressure at −0.1 to −0.3 in. of water.

3.2 Maintenance in the Coolant or Coolant Drain Tank Cells

Direct maintenance is possible in equipment located in these cells. A check of the radioactivity should be made by the health physicist, and a check of beryllium contamination should be made by the industrial hygienist before entering the cell. The dampers in line 933 and 934 should be opened to provide maximum ventilation.

3.3 Maintenance in Auxiliary Cells, South Electric Service Area, and Special Equipment Room

Normally the dampers or valves in the exhaust lines from these areas will be fully opened before opening the area for entrance. A check must be made and approval given by the Health Physics group before anyone enters these areas.

4 SPECIAL OPERATIONS

4.1 Failure of Stack Fans

Should fan No. 1 stop due to mechanical or electrical failure, fan No. 2 controls are designed to start it automatically. The discharge damper from stack fan No. 1 will close and the damper from stack fan No. 2 will open. Should this fail or should No. 2 stack fan fail while running and before No. 1 has been repaired, all personnel will be evacuated from the high-bay area and other limited access areas until proper ventilation is restored. The areas should be kept closed as much as possible when the ventilation is lost. If both blowers stop, the waste blower will also stop and will have to be restarted after either fan is in operation.

4.2 Replacement of Exhaust Filters

Whenever the stack filter pressure drop exceeds 4 in. of water, the filters will be replaced one bank at a time while the fan continues to operate. The auxiliary cells and other limited access areas will be closed with their shield blocks and doors to assure sufficient exhaust from the high-bay area while replacing the filters. The inlet and outlet dampers of the bank to be replaced will be closed. The filter will be replaced with filters which have already been subjected to the Laboratory standard DOP smoke test, and the DOP smoke test will be repeated on the installation. See paragraph 4.4.

4.3 Excess Stack Activity

If the stack instrumentation indicates excess stack activity, the source of which is not indicated by other radiation detectors, a survey of each branch of the duct work and piping leading to the fans will be made with portable instruments to locate the source. Gas masks should be worn. Inlets to all areas should be closed to reduce the release of activity out of the stack.

4.4 Test of the Filters by the DOP Smoke Test

The filters will be tested to determine their efficiency for removing particulate matter by the ORNL standard DOP smoke test (see ORNL 3442, "Tests of High Efficiency Filters and Filter Installations at ORNL"). The test will be performed by the Inspection Engineering Department on replacement filters before they are installed in the system and the installation will be observed by Inspection Engineering personnel. The complete filter bank will be tested after each filter change and annually if the filters were not replaced during the preceding twelve months. They will also be tested at any time the efficiency of the filters is suspected to be less than 99.95%. The test on the system will be conducted with a flow of ~20,000 cfm with only one fan operating and the dampers to all filters open. This test will be performed by the Inspection Engineering Department and they will determine the amount of dioctyl phthalate required for the test. The smoke will be introduced into the system at the high-bay area exhaust duct. Samples will be taken from the sample ports in the three filter inlet ducts and the three filter outlet ducts. A photometer analysis will be performed on each filter bank and should indicate a filtering efficiency of $\geqq$99.95%.

5 SHUTDOWN

Depending on conditions at the time of shutdown, it may be necessary to close and caulk some of the auxiliary cells. After this is complete, the waste blower in the remote maintenance cell will be stopped and the stack fans stopped.

3G LEAK-DETECTOR SYSTEM

This system is a pressurized helium system consisting of eight valve manifolds or headers supplied from a common helium pressure-reducing station. Each header has from 4 up to 10 leak detector lines which serve in-cell flanges. Each leak detector line monitors from one to four pairs of ring-joint flanges.

A reference tank and sensitive DP cell are connected through appropriate valves to the eight headers so that small leaks from any one header can be measured.

Flange leakage can be tolerated at a rate of 6 cc/min for all inter-connected flanges (all headers connected). This is equivalent to a 0.66 psi per hour pressure drop (see Sect. 11.3 of the Design Report, Part I).

All data calculations and leak rates should be recorded in the leak-detector log.

1 STARTUP

As each leak-detector flange or group of flanges are tightened, the leak-detector line monitoring that flange, or group of flanges, should be purged of air and put into service by the following procedure:

Note: Leak detector line 420 serves two flanges in line 516 and it is used as an example (numbers in parenthesis).

1.1 Purging O_2 From Leak-Detector Headers

Headers containing oxygen should be purged as outlined below before being put into normal service.

1.1.1 Before opening the supply valves to the leak-detector lines, open the helium supply valves and the valve to the header to be purged.

1.1.2 Pressurize the header to 100 psi and close the valve upstream of O_2 contaminated section (V 514C or header supply valve).

1.1.3 Vent the header into the containment cell by opening a spare leak-detector line valve (L 430 on header 403 is a spare until the thermal shield water piping is cut and flanged).

1.1.4 After venting, close the valve in the spare leak-detector line.

1.1.5 To complete the purge, repeat the pressurizing and venting three times.

1.1.6 Then pressurize the header and, leaving the header supply valve open, open all leak-detector line valves except spares.

1.1.7 Open the supply valve to all other leak-detector headers, restoring them to normal service.

1.2 Purge Leak-Detector Lines as follows:

1.2.1 Make up all flanges served by the leak-detector, but do not tighten bolts. (On leak-detector line 420, this is two flanges in line 516.)

1.2.2 Close all "A" leak-detector valves on the header (420A through 429A).

1.2.3 Isolate all other headers from the pressurizing line (close V 401A and 403A through 408A).

1.2.4 Pressurize header being tested to 100 psig, then close header supply valve. (PI 402 reads 100 psig--V 514C, 514D open, and V 402A closed).

1.2.5 Open or check open the "B" (maintenance valve) to the flanges being made up (V 420B).

1.2.6 Slowly open the "A" valve to the flanges being made up until the header pressure drops 1 to 5 psi per min. This is equivalent to a purge of 100 to 55 cc/min.

1.2.7 Open header supply valve to purge line while all flanges are tightened (open V 402A while two flanges in line 516 are tightened).

1.3 Leak Check Flanges as Follows:

1.3.1 Close all "A" leak-detector valves on the header except for line to be checked. (Close V 421A through V 429A, and open V 420A)

1.3.2 Isolate all other headers from the leak test DP cell (Close V 401B and 403B through 408B).

1.3.3 Set valves to connect header to DP cell, and open equalizing valve (V 400) at DP cell. (Open V 402B)

1.3.4 Pressurize header (Open V 402A)

1.3.5 When header pressure is at 100 psig and steady, isolate header (Close V-402A).

1.3.6 Put DP cell in service by closing equalizing valve (V-400).

1.3.7 Unless gross leakage is indicated, record PdI 400 at 10-min intervals until leak rate is established. Record at least three 10 to 15 minute checks without equalizing. Acceptable leak rate is 10^{-3} cc/sec. which is approximately equivalent to a change in PdI 400 of 7% in 10 min.

1.3.8 If leak rate is not satisfactory, open the DP cell equalizing valve (V-400) and re-pressurize header (Open V-402A).

1.3.9 After retorquing flange, test as per 1.3.4 through 1.3.8.

1.3.10 If leak rate is satisfactory, open DP equalizing valve, V-400, and all "A" leak-detector valves on the header except spares. (Open V-420A and 422A through 429A and close V-421A).

1.3.11 Isolate header from DP cell (Close V-402B).

1.3.12 Repressurize header to 100 psig and put in normal operation. (Open V-402A until PI-402 indicates 100 psig.)

1.3.13 Close supply valve and tie all headers together. (Close V-514D and open V-401A through 408A.)

2 NORMAL OPERATION

During normal operation the DP equalizing valve (V-400) is open. All headers are isolated from the DP cell (V-401B through 408B closed). All headers are tied together (V-401A through 408A open). All "A" and "B" leak-detector-line valves 410 through 489 (except spares) are open. The pressure drop of PIA 514 is an indication of the leak rate of the total leak-detector system. PIA 514 annunciates at 90 and 110 psig.

When low annunciation occurs, the system pressure (PIA 514) should be recorded in the leak detector log and the leak rate calculated. If leak rate is normal (<0.66 psi/hr pressure drop) repressurize system (V-514D) and record time and pressure.

If calculated pressure drop is greater than 0.66 psi/hr, determine the location of leak as described in Section 3.

3 LOCATION OF LEAKING FLANGES

3.1 Pressurize all headers to 100 psig.

3.2 Open DP equalizing valve and open V 401B to connect header 401 to the DP cell.

3.3 Close all header supply valves (V 401A through 408A).

3.4 Close V 400 to put DP cell in service on header 401.

3.5 Record all header pressures.

3.6 Determine which header is leaking, based on decrease in header pressures or from DP cell measurements. (DP instrument can be switched from one header to another.)

3.7 When leaking header has been located, put other headers in normal service.

3.8 Close off half of the valves on the leaking header, and using DP cell determine which half the leaking flange is on.

3.9 Determine leaking flange by checking each individual line on the leaking half of the header.

3.10 Determine leak rate on the leaking flange using the DP cell. The corrective action which will be taken when a leaking flange is located will be an administrative decision, depending on the rate of leakage, and the system into which the leakage occurs. Until a decision is made, open all valves on the header and keep pressurized above 50 psig.

4. SHUTDOWN PROCEDURES

4.1 Reactor Shutdown

During a reactor shutdown the leak-detector system will remain in operation as described in Section 2.

4.2 Leak-Detector Header Shutdown

A header may need to be shut down to repair an item connecting directly to the header, that is, a damaged valve, leaking fitting, etc. To shut down and vent a header, proceed as follows:

4.2.1 With the system at pressure and the header supply valves open, close all valves to the header except the valve needing repairs.

4.2.2 Close the header supply valve if this will isolate the section to be maintained from the helium supply. If a header supply valve needs repairing, close all other header supply valves ("A" valves) and open the "B" valves to L 400 for all headers except the one to be repaired.

4.2.3 Close V 514B and C.

Note: If repairs are being made during reactor operation, they should be completed before L 400 pressure drops to the 90 psi alarm point.

4.2.4 Vent the header to be repaired by opening a spare leak-detector line into the contained cells. When the header pressure reaches zero, close the spare leak-detector line valve.

4.2.5 After repairs have been completed, flush the section contaminated by oxygen by procedure given in 1.1 & 1.2 of this section.

4.3 Shutdown of One Leak-Detector Line

To shut down one leak-detector line, close valve supplying that line. The leak-detector line will vent as the flanges being monitored are opened. Note: The maintenance personnel should be informed that there is pressure on the flange being disconnected. When the flange joint is reconnected, the lines should be purged and leak checked per 1.1 and 1.2 of this Section.

Approved by [signature]

3H INSTRUMENTATION

Many instruments at the MSRE are the same or similar to those used in other plants and loops. The operation of these is common knowledge of operating personnel and is not described here. This section describes the operation of the more complicated or less commonly used instruments.

3H INSTRUMENTATION

1 CONTROLLERS AND INDICATORS

There are a number of different types of recorder/indicator controllers at the MSRE. The maintenance and adjustment of these is the responsibility of the instrument department. Changing of control action settings will not normally be done by the operations personnel. If it is necessary to make changes these should be noted in the console log and punch listed for the instrument department to check.

The following is a brief description of the primary functions, means of adjustment and method of setting the variables. The Foxboro Company Consotrol Stabilog and Hyper-Reset Type as used on the drain tank recorders is used as an example.

1.1 Types of Control Action

Automatic process control functions may be enumerated as follows: 1) On-Off, 2) Proportional Band (throttling range), 3) Reset Action, and 4) Derivative Action (rate action). One or more of these functions may be combined in a single controller to produce a desired control action, and this action (input to output) may be reversed as required. Whether these functions are accomplished manually or automatically will depend upon the frequency of the process change and the speed and dexterity of the operator.

1.2 Reversal of Control Action

Item 1 of Fig. 2 indicates the desired controller output (V port) for a given controller input (E_1 port). As shown, for an increase in element (signal transmitter) pressure there will be a corresponding increase in controller output pressure. As an example, this mode known as "direct" action, is desired in the case of the pressurizer level control. As the level increases it is necessary to increase the pressure applied to the "air to open" letdown valve in order to reduce the sure applied to the "air to open" letdown valve in order to reduce the level. Likewise, the opposite mode (reverse action) is required to decrease the heater on-time when the fuel pressure increases.

Before describing the control actions, it is necessary to define an "error signal" as that change in relation between the pen (Item 1, Fig. 1, Input Signal) and the setting index (Item 3, Fig. 1).

1.3 ON-OFF

This action may be described as a 100% change in output for an incremental error signal either positive or negative.

1.4 Proportional Band

Items 2 and 3, Fig. 2, show the proportional band scale and adjustment lever, respectively. Proportional action may be defined as the change in controller OUTPUT air pressure proportional to the amplitude of the error signal within the limits of the measurement scale range.

Figure 3 shows graphically the relation between the INPUT signal and the OUTPUT pressure (valve position, Item 2, Fig. 1), assuming that the setting index is at 50% scale range and the action of the controller is "direct." The intersection of the curves at the output scale midpoint is attributable to the fundamental design of the proportioning mechanisms.

The 100% curve requires the pen to move over its entire range to produce a 100% change in output pressure. The 0% curve indicates that an infinitesimal error signal will produce a 100% change in output, i.e., on-off control. A study of the 200% curve indicates that the output pressure will not reach its minimum or maximum even with a 100% change in pen position. Observe the indicated range of the letdown valve. With a proportional band setting of >200%, the valve would never full close (or open) and with 50% the error signal need be only 1.5 psi (12.5%) to full close (or open) the valve.

Figure 4 shows the same relationship with the set point at 25% scale range. Note now, with a proportional band >100%, the valve would never full close even with the maximum negative error signal of 3 psi (25%).

Figure 7 indicates schematically the floating disk action of the controller proportional adjustment. An increasing back pressure on the nozzle, by closing the air gap, is amplified in the relay for

for final control element operation, and is also fed back to the proportional bellows. A total air gap change of .0006" is sufficient to produce the 3-15 psi change in output pressure. Assuming the controller to be in equilibrium with 9 psi set and input pressures with a 100% proportional band setting, the output and proportional bellows will be at 9 psi. The balance spring will be exerting a force equivalent to the 9 psi in the P bellows. If a sudden pressure increase in M occurs, the nozzle bleed will temporarily be restricted and the output will increase to meet the demand. However, the output pressure will increase along the 100% proportional band curve because of the feed back to P which is opposing the action of M about the fulcrum. A decreasing measurement signal will likewise cause a decrease in output. Note that if the proportional band setting were 0% any feed back to P would have a very limited effect on the back pressure at the nozzle. The converse is true if the band setting were 500%. Reversal of control action is accomplished by interchanging the signals to the set and measurement bellows.

The proportional band adjustment is made by moving the level horizontally to the desired point on the scale which is graduated from 0 to 500, indicating the proportional band width in percentage range of the recorder scale, Item 4, Fig. 1.

1.5 Reset Action (+ Proportional Band)

Items 4 and 5 of Fig. 2 show the reset scale and adjustment screw, respectively. Reset action may be described as a shift of the proportional band position with regards to the original set point and is a function of the elapsed time and amplitude of the error signal.

Figure 5 indicates graphically a specific action of the reset control. Again using the let down valve as an example, assume that the pumping rate has slowly increased to such a value as to require the valve to be some 92% open to maintain control and would thus stabilize the measurement pen at 60% of scale when following the original set point 50% proportional band curve. The addition of the reset action produces the effect of shifting the proportional band to such an extent that with the new requirement of valve position, the measurement pen will remain in alignment with the set point index. The opposite reset action will occur if the pumping rate were to decrease. The reset action is not a result of the fact that the valve requirement is now 92% open, but is a result of the amplitude of the error signal produced by the pen movement and the time required for this movement, which in turn produces the new valve position. If reset action is present during startup, while the measurement pen is at or near 0%, the proportional band will be shifted until it rests entirely above the 50% set point, and there will be no control action until the pen reaches set point. Excessive reset will cause an overshoot of the pen in the opposite direction. Reset action is considered a slow type action of control and will have little or no effect on rapid process oscillations.

Figure 8 shows the addition of the reset bellows to the floating disk mechanism along with the reset capacity tank and restrictor valve arrangement. The feed point of the reset network is in parallel with the proportional bellows but its action is in opposition. Assuming that there exists a pressure balance between the four bellows, the action may be described as follows for a specific measurement increase condition; an increase in M pressure will produce an increased output pressure which will follow the preset proportional band range but will be shifted to an even greater output by the RC time controlled increase in pressure in R. The resulting action of a pressure rise in R will produce the same proportional band shift as would a decrease of pressure in the set point bellows S. In some controllers the reset action is not automatic, but once a process is stable, the measurement may be brought into alignment with the set point by a mechanical adjustment of the balance spring, shown in Fig. 7.

The reset action adjustment screw is rotated CW for maximum control effect and CCW for minimum to the desired setting on the rotating scale which is graduated from .1 to 50, indicating the reset time constant in minutes. With a setting of .1 minutes (restrictor valve full open), the reset bellows will essentially cancel out the action of the proportional bellows, and the control will be on-off.

1.6 Derivative Action (+ Proportional Band)

Items 6 and 7 of Fig. 2 show the derivative scale and adjustment screw, respectively. Derivative action may be described as an automatic proportional band range adjustment which temporarily narrows the band and depends upon the rate of change of the error signal. This action may also be considered as maintaining a linear relationship between the first derivative of the error signal and the output signal.

Figure 6 shows graphically a transient condition for a specific derivative action. The 200% proportional band setting is chosen to show more clearly the resulting action when considering the letdown valve. If a positive error signal of 5% were to arise as a result of an increase in measurement, the valve would only open some 2% along the 200% curve with no derivative action. Introduction of the derivative action produces a fast response narrowing of the proportional band to some temporary range, which in this case will open the valve wide (+ 12 psi output), thus attempting to restore the process to normal by fast letdown before the error signal becomes excessive. The derivative control is sometimes called "anticipatory control." A loss of measurement signal will cause a like narrowing of the proportional band in an attempt to close the valve rapidly.

The above description concerns only "direct" derivative action which ismost often used with a relatively long process lag, and which allows the use of a wider proportional band for stability and still retains the advantage of narrow band control for sudden process upsets. "Inverse" derivative has the opposite action in that it automatically widens the throttling band in proportion to the rate of change of the error signal. It is most often used in a short time-constant process in allowing narrow proportional band action for good control and wide band action for stability.

The derivative action adjustment screw is rotated CCW for maximum control effect and CW for minimum to the desired setting on the rotating scale which is graduated from .1 to 50, indicating the derivative time constant in minutes. A setting of 50 will introduce such a long time lag into the proportional bellows that the control action will be essentially on-off.

Note that the error signals do not achieve the magnitude as depicted graphically in Figs. 5 and 6, but are limited immediately by the reset action sensing the amplitude and elapsed time and derivative action sensing the rate of change.

1.7 Foxboro Hyper-Reset Control Adjustment Procedure

1) Adjust the reset time to its maximum value and the derivative time to its minimum value.

2) Set the proportional band at some high value (+ 100%) and then reduce it in successive steps, leaving the pointer at each setting long enough to observe the resulting control. Continue to reduce the proportional band until cycling is just perceptible.

3) Increase the derivative time until this cycling is removed. Narrow the proportional band slightly, and again increase the derivative time until cycling is removed. Repeat until further increase of derivative time fails to eliminate the cycling introduced by the narrowing of the proportional band. Maintain this setting of derivative time and widen the proportional band until the cycling is removed.

4) Set the reset time to the same value as the derivative time.

For controllers with reset only, follow steps (1) and (2) but leave the proportional band position in a stable and not a cycling condition. Then reduce the reset time in steps, watching the error signal decrease to zero. Too much reset will cause a cycling action, and therefore should be set above this value.

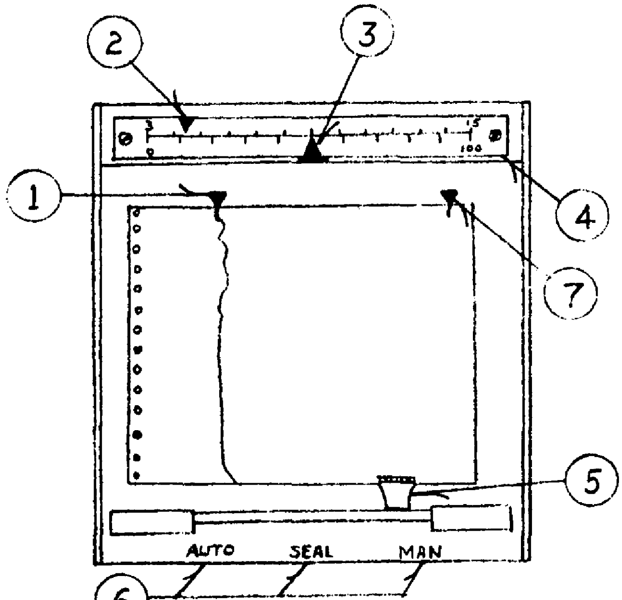
1.8 Frequency Response

Figure 10 shows graphically the theoretical frequency response of a typical controller. Curve "A" indicates the gain vs frequency of a proportional controller with a proportional band setting of 100%. The gain will be linear with frequency up to about 100 cycles/min. Curve "B" indicates the theoretical response of a proportional + reset + derivative controller with a proportional band setting of 50%, a reset time of .1 min and a derivative time of .01 min. The actual curve "C" follows the general slope of the reset and derivative, but changes slope about the intersecting time-constant points and follows the proportional band. The roll-off at high frequencies is a function of the limiting mechanical components of the controller.

Curve "A" of Fig. 11 shows the phase angle vs the frequency of a proportional controller. As would be expected, the output lags the input at the higher frequencies due to mechanical limitations. Curve "B" is a typical theoretical phase shift curve with a reset time of .1 min and a derivative time of .01 min. Curve "C" is a more likely actual phase shift picture in that the change of slope is not as sharply defined. The change in slope at the higher frequencies will finally achieve a 180° phase shift which will induce a positive feedback oscillation in the controller.

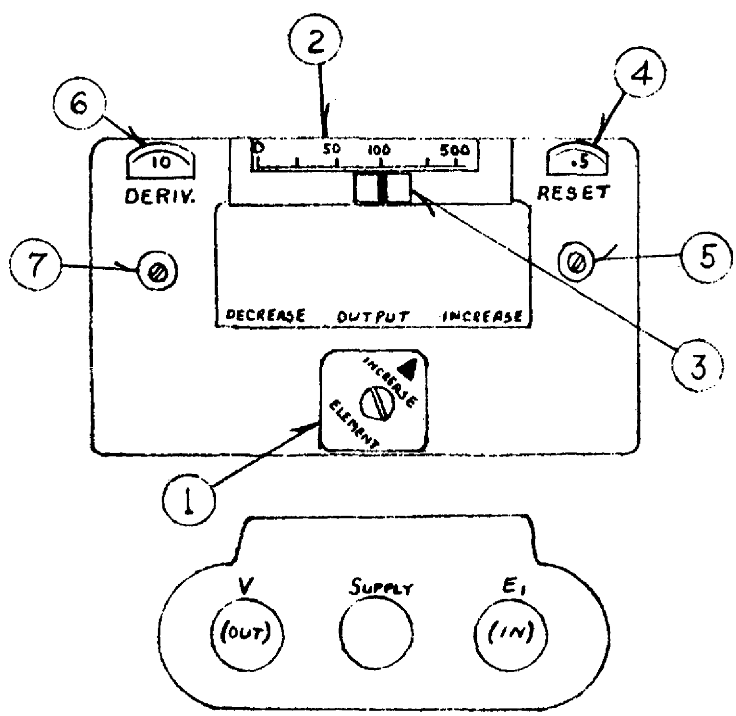
The response and phase shift curves shown here are, of course, for a controller only. In order to obtain a complete picture of automatic process control action, it is necessary to have the amplitude and phase characteristics of the process system, as well as the established response of the controller.

Approved by [signature]



MODEL 54 FOXBORO RECORDER

FIG. 1



FOXBORO MODEL 58PS
CONTROLLER

FIG. 2

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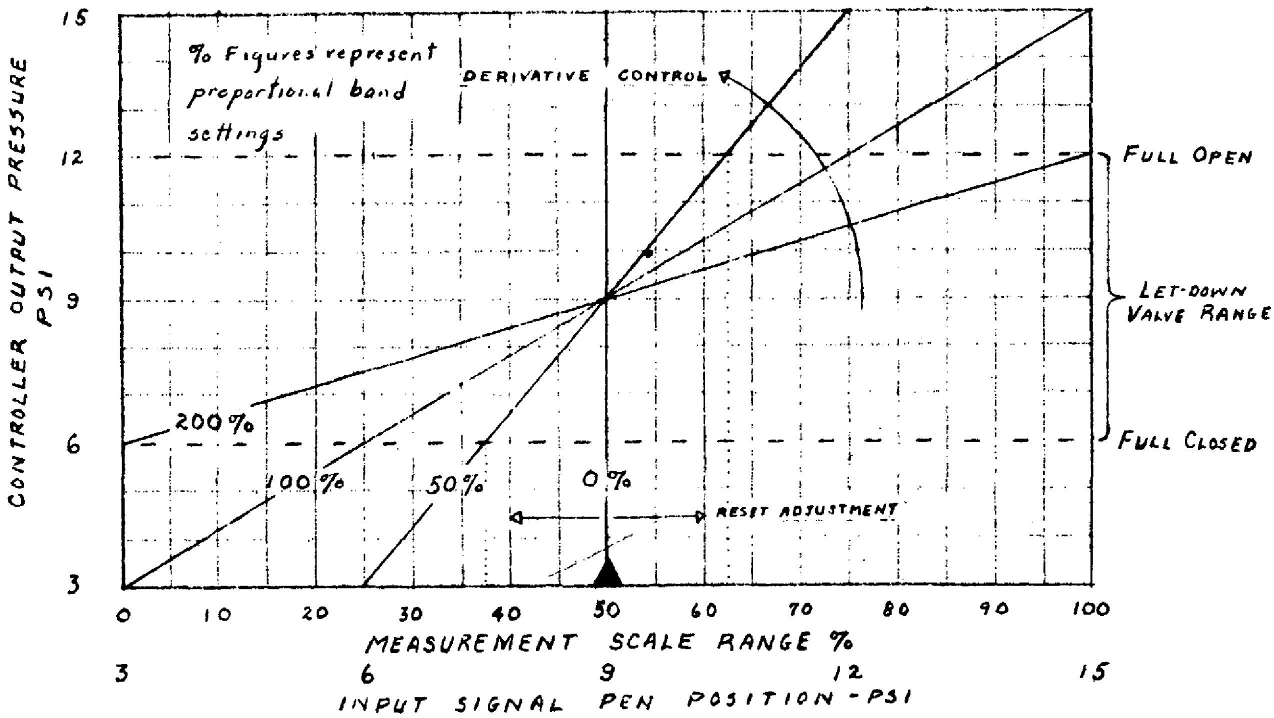


FIG. 3

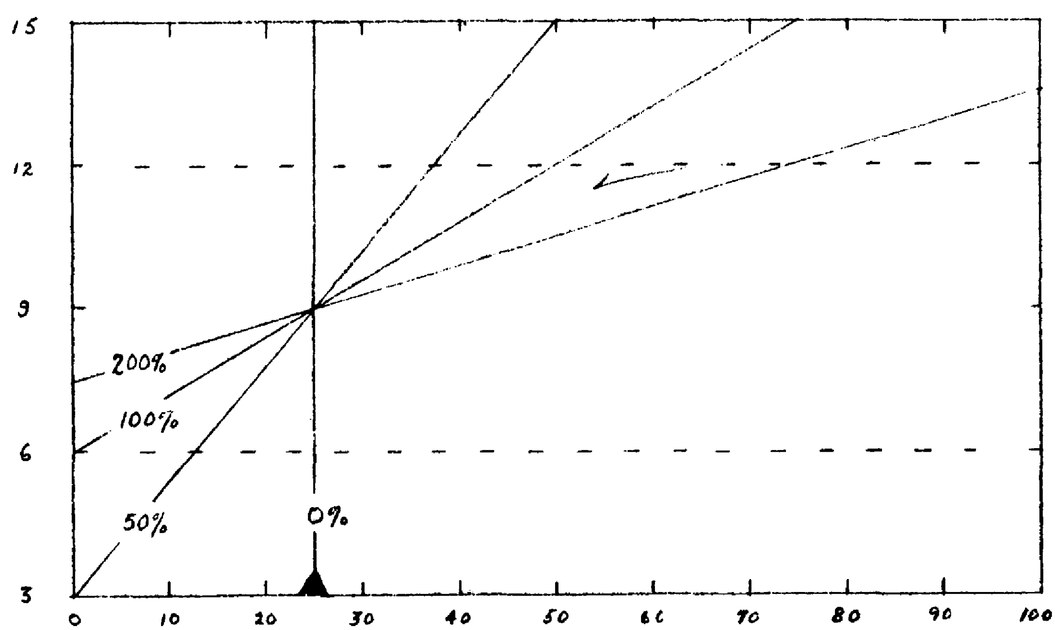


FIG. 4

Approved by [signature]

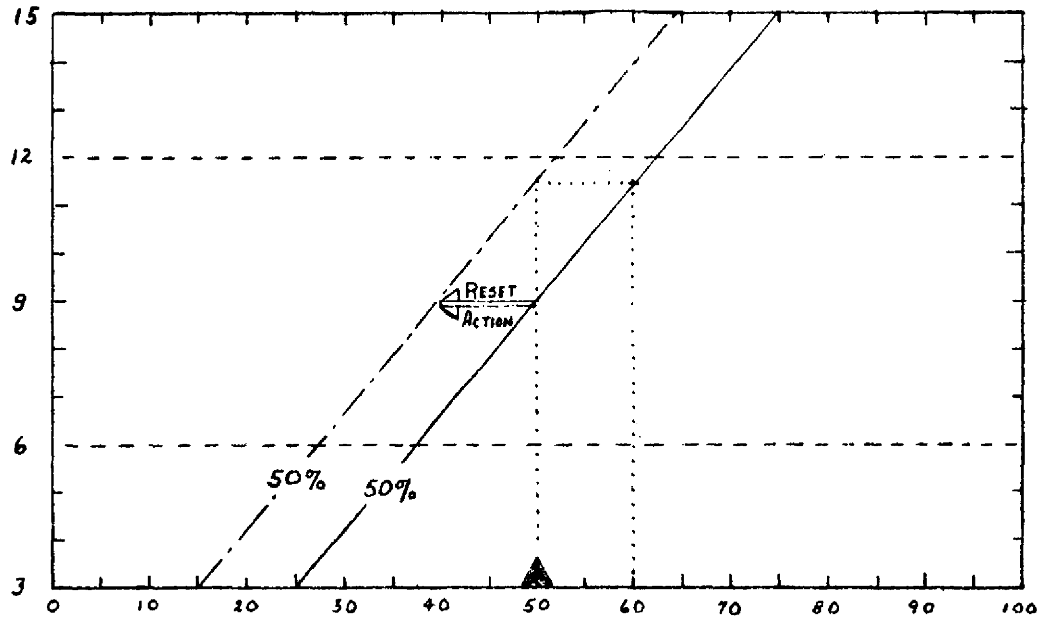


FIG. 5

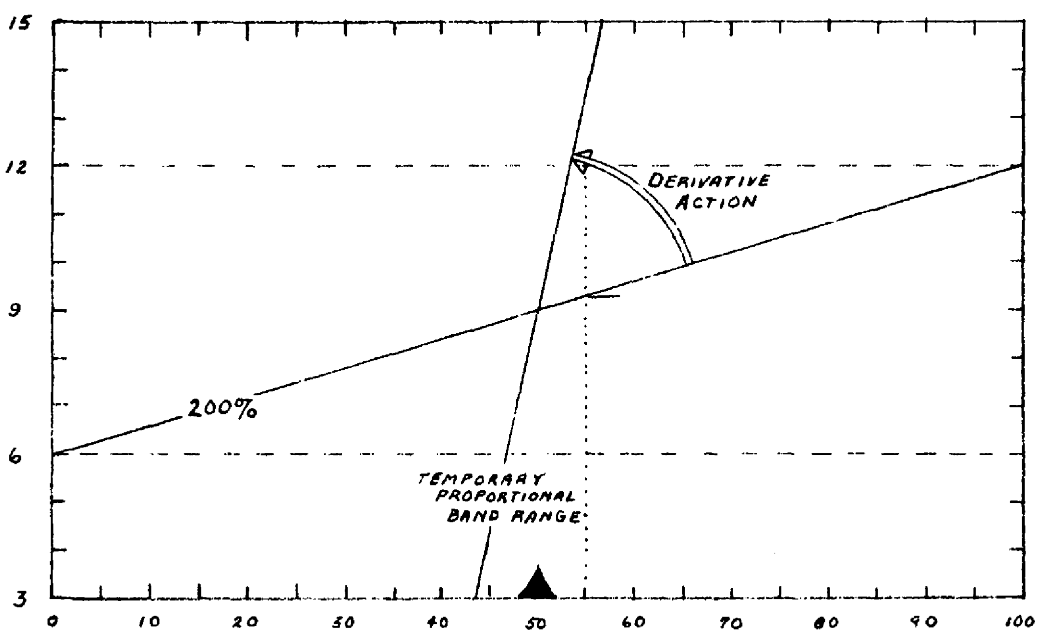


FIG. 6

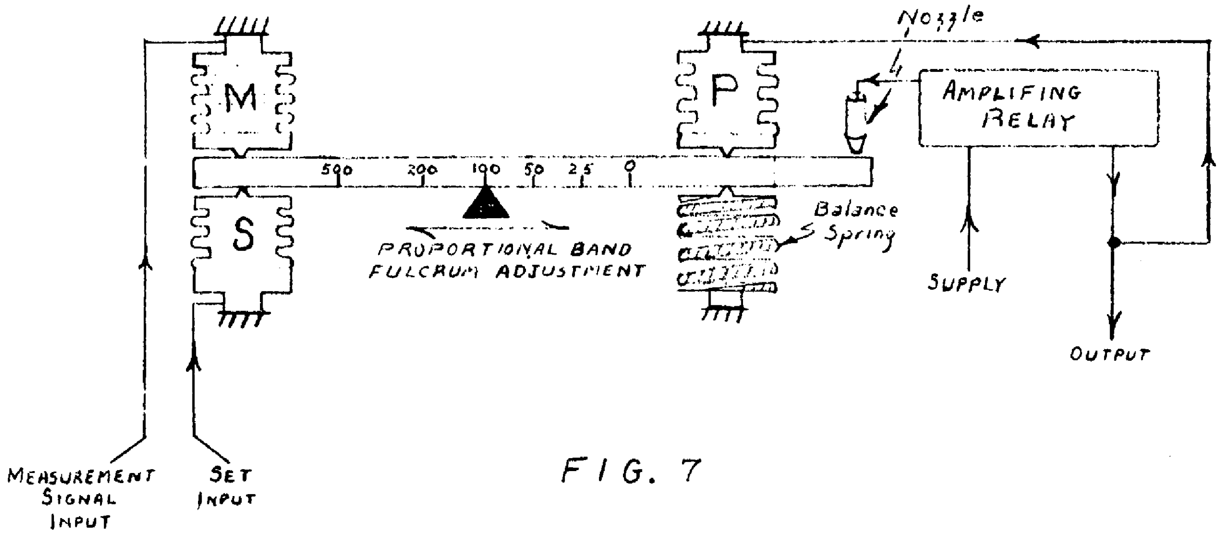


FIG. 7

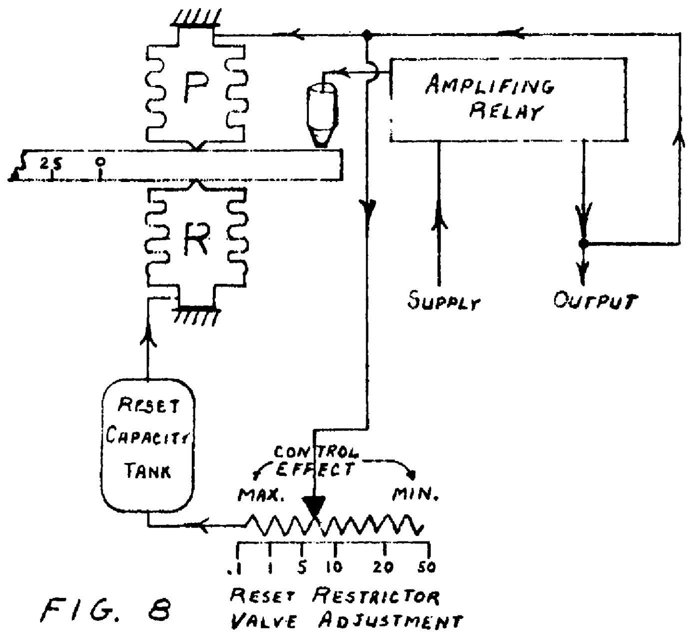


FIG. 8

DO NOT SCALE
POSITIONS OR
MOMENT ARMS

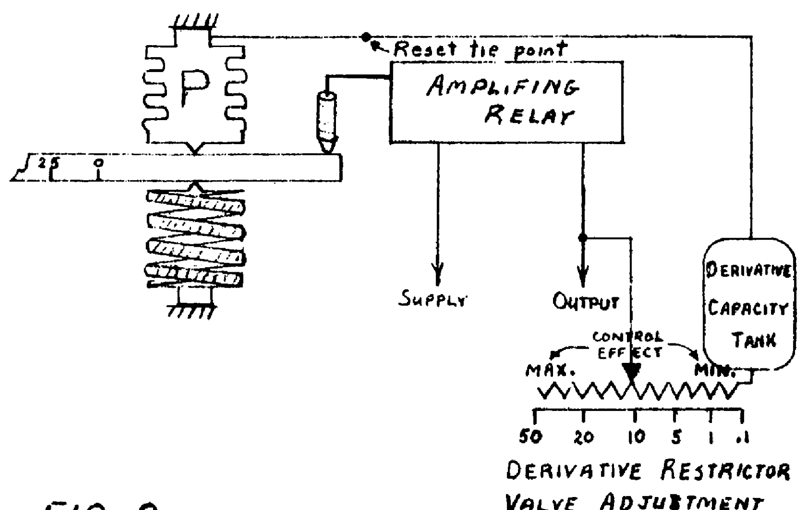
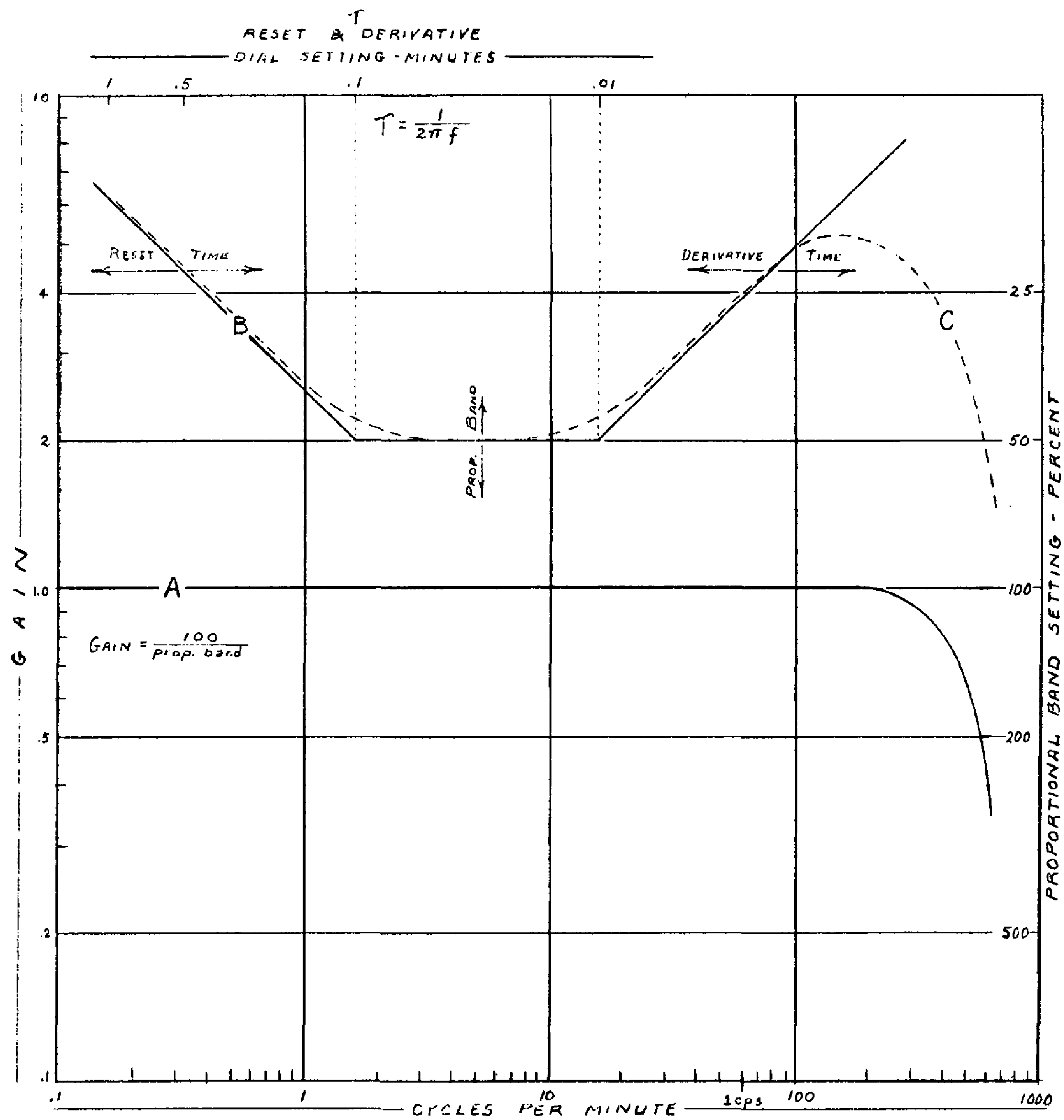


FIG. 9



CONTROLLER FREQUENCY RESPONSE

FIG. 10

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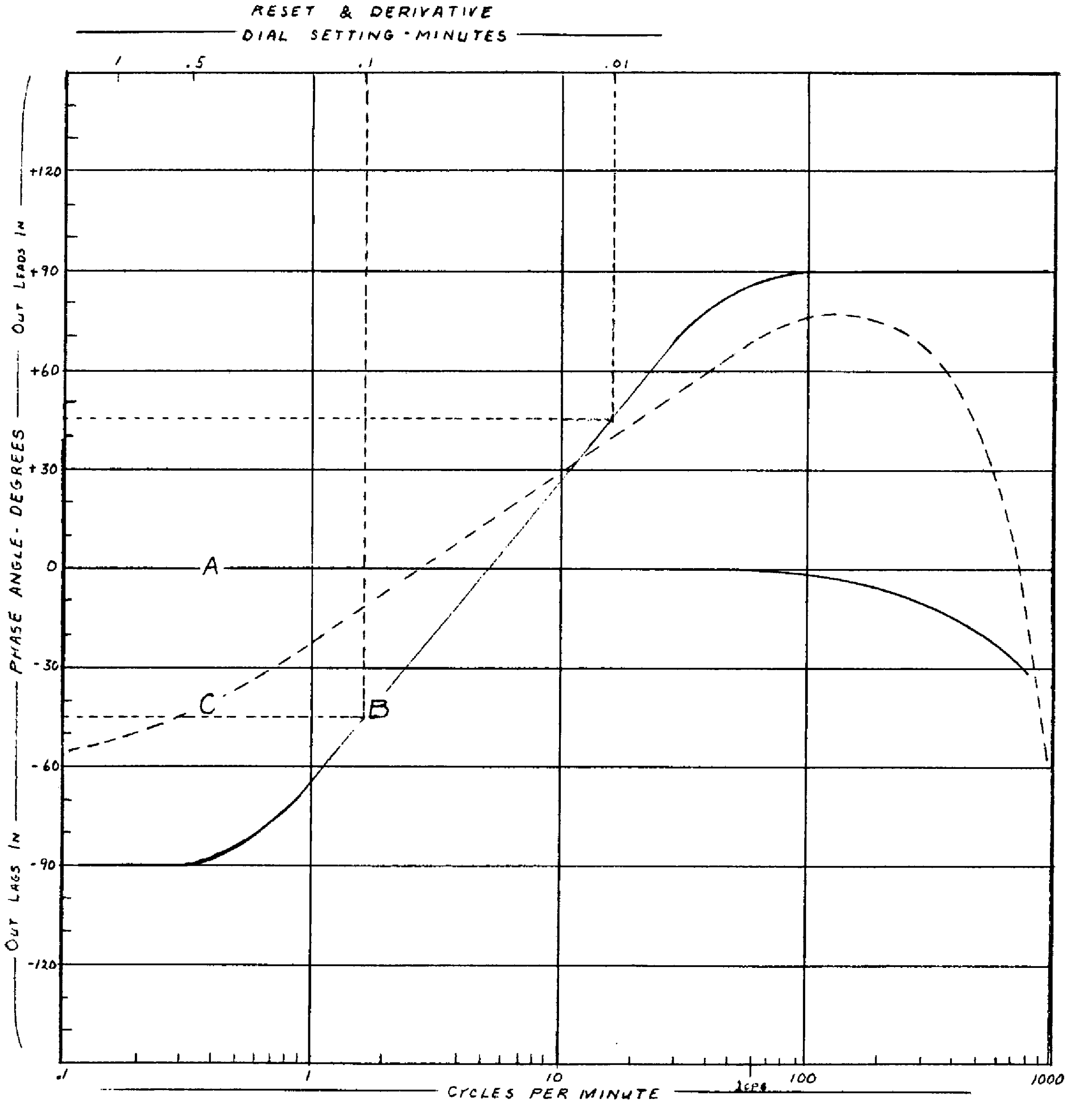

CONTROLLER PHASE SHIFT

FIG. 11

2 SCANNER

The scanner system, made up of five "scanners," provides alarm monitoring and readout for groups of thermocouples. The system consists of rotating mercury switches through which combinations of thermocouples are compared with a reference thermocouple and read out on an oscilloscope. The block diagram, figure 3H2-1 shows the various components of this system and their relationship to each other.

Since portions of the salt system must remain heated at all times, the scanners will be in continuous operation except for necessary shutdowns for repairs. Due to the many possible operating conditions of the salt system, considerable flexibility was built into the scanners which allow easy changing of inputs. Whenever a portion of the salt system is cooled, the associated thermocouple signals should be removed from the scanner so that the alarm feature will not be inactivated. It is necessary that all points on all operating scanners be connected to a thermocouple or millivolt signal. Noise from a disconnected point can completely saturate the amplifier and make the channel inoperable and can damage the amplifier. When changes of input are made, these should be logged in both sections of the thermocouple log showing swinglink connections, multipoint connections, etc. (See details below.)

The spare to the reference thermocouple for scanners A, B, and C should always be connected to a temperature recorder and point 100 on each scanner should be jumpered at the scanner panel to the reference thermocouple. The scanner gain should always be set as high as possible to increase the readability of temperatures and narrow the range in which an alarm will occur. After heatup the gain can usually be set at 100 which will give a reading of 50°F per inch and will alarm at ± 150°F from the reference.

The reference signal for scanner D and E will be from a potentiometer located at the scanner panel. During heatup this is varied by a vernastat knob, and the equivalent temperature in °F can be read out from the vernastat setting. During coolant salt circulation, the switch should be in the position to give a constant 1100°F input signal. The gain should be set at 100 (50°F per inch).

An alarm should occur at 950°F and 1250°F.

Periodic calibrations should be made of each scanner to assure that there has been no change in the gain or vertical size of the scope. This is accomplished by plugging a known EMF signal into a point of the scanner and comparing it with the reference as indicated by point 100. The vertical multiplier on the scope and the fine gain on the differential amplifier should be adjusted to alarm at ± 3 inches from the reference line on any gain setting and indicate on the scope as follows:

Gain	°F/inch
25	200
50	100
100	50
250	20

In order to increase the life of the mercury jet scanning switch, a continuous purge of nitrogen should be maintained as indicated on the building log.

There are only a few adjustments of the scanners necessary for routine operations. These are: dc amplifier, course gain, oscilloscope vertical and horizontal position, focus, brightness and point locator.

The thermocouple input to the scanner system is from 314 plug-ins on pyrometer panels #1 and #2, and 120 coolant cell thermocouples which are permanently tied into the scanner system. The 314 pyrometer panel plug-ins provide an input of 300 thermocouples, 9 duplicated thermocouples, and 5 reference thermocouples. The following is a detailed description of each component of the scanner (see figure 3H2-1 and drawings D-HH-B-41658, D-HH-B-41659, D-HH-B-41660, D-HH-B-41661, D-HH-B-41662, E-HH-B-41663, E-HH-B-41664, E-HH-B-41665, E-HH-B-41666).

2.1 909 thermocouples terminate with plug-in receptacles at "thermocouple jack panel #1" located in the auxiliary control room on the 852 level. Hand plug-in leads are used to continue all of these thermocouples to the scanner system.

2.2 "Pyrometer panels #1 and #2," also located on the 852 level just below the thermocouple jack panel, provide 300 scanner input receptacles, 100 each to scanners A, B, and C, to receive hand plug-in leads from the "thermocouple jack panel." A thermocouple log is necessary at the pyrometer panel.

2.3 "Thermocouple scanner panel #1" is located on the 840 level just southeast of column C-3. The thermocouple leads from the pyrometer panel route to the "thermocouple scanner panel #1." The following is the sequence circuit routing of the leads and a description of the components within the "thermocouple scanner panel #1."

2.3.1 The 300 thermocouple leads enter the "scanner panel #1" by connection to three terminal strips with "swing links." See table 3H2-1 for lead identification on the terminal strips.

A terminal strip is a strip of insulation through which two parallel rows of screw terminals have been mounted and which will accommodate 103 leads. Swing links are metal bars which permit circuit continuity between terminal strip terminals. Normally the thermocouple leads connect to one row of screw terminals and continue the circuit by the "swing links" across the terminal strip to the other row of screw terminals. There are 300 leads leaving the three terminal strips which provide circuitry to the remainder of the scanner system. The "swing links" can be rotated 90 degrees in order to couple the scanner terminals together, thus paralleling two or more of the scanner leads on a given terminal strip. A thermocouple log is necessary at the terminal strip.

The "swing link" terminal strips are constructed as shown on drawing E-HH-B-41663, "detail B." The swing link conductor bars are held in place by the terminal nuts, thus requiring a tool to rearrange them.

TABLE 3H2-1

Pyrometer Panel Receptacle	Scanner No.	Scanner Panel #1 Terminal Strip No. + Pole	Scanner Panel #1 Terminal Strip No. − Pole	Scanner Panel #1 Terminal Strip Terminal No.	Scanner Panel #1 25 Lead Polarized Connector Receptacle No.
421 through 445	A	TSPI-E	TSPI-F	1 through 25	J-A-1
446 through 470	A	TSPI-E	TSPI-F	26 through 50	J-A-2
471 through 495	A	TSPI-E	TSPI-F	51 through 75	J-A-3
496 through 520	A	TSPI-E	TSPI-F	76 through 100	J-A-4
521 through 545	B	TSPI-C	TSPI-D	1 through 25	J-B-1
546 through 570	B	TSPI-C	TSPI-D	26 through 50	J-B-2
571 through 595	B	TSPI-C	TSPI-D	51 through 75	J-B-3
596 through 620	B	TSPI-C	TSPI-D	76 through 100	J-B-4
621 through 645	C	TSPI-A	TSPI-B	1 through 25	J-C-1
656 through 670	C	TSPI-A	TSPI-B	26 through 50	J-C-2
671 through 695	C	TSPI-A	TSPI-B	51 through 75	J-C-3
696 through 720	C	TSPI-A	TSPI-B	76 through 100	J-C-4

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2.3.2 The 300 scanner leads from the terminal strips are then routed to twelve 50-point connector receptacles to form group connectors accommodating 25 leads each.

The connector receptacles are the polarized multipoint type, and are rectangular in shape. Two rows of 25 connector points make up the two major sides of the rectangle receptacle. The scanner leads are connected to the receptacle in sequential order with the plus pole on one side and the minus pole on the other side. See table 3H2-1 for lead identification to the 25 lead polarized receptacles.

2.3.3 The circuitry is then continued from the lead polarized receptacles by means of polarized connector plug-ins to another group of twelve 50-point connector receptacles as listed in table 3H2-2.

2.3.4 Any of the connector plug-ins as listed in table 3H2-2, "scanner panel #1 25 lead polarized connector plug-in" can be inserted into the connector receptacles listed in table 3H2-1. It is important to maintain a record of the effects of any changes made of these plug-ins in both sections of the thermocouple log.

This second group of receptacles are identical in construction to the ones described in 2.3.2 above, except all 50 points of each receptacle are connected to the same pole of 50 scanner leads. This segregates the 300 scanner leads into six 50-point receptacles of plus polarity and six 50-point receptacles of minus polarity. See table 3H2-2 for lead identification to the scanner lead segregated pole receptacles.

2.3.5 The scanner leads continue by means of the 50-point connector plug-ins to 3 rotating mercury switches of the scanner system. A rotating mercury switch is a device for cyclic switching of the signal from 100 thermocouples. A mercury stream rotating at 1200 rpm serves as a brush to perform the switching of each lead at a rate of 20 times

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TABLE 3H2-2

Scanner Panel #1 25 Lead Polarized Connector Plug-in	Scanner Panel #1 50 Pt. Segregated Pole Connector Receptacles + Pole	Scanner Panel #1 50 Pt. Segregated Pole Connector Receptacles − Pole
P-A-1	J-A-8	J-A-10
P-A-2	J-A-8	J-A-10
P-A-3	J-A-9	J-A-11
P-A-4	J-A-9	J-A-11
P-B-1	J-B-8	J-B-10
P-B-2	J-B-8	J-B-10
P-B-3	J-B-9	J-B-11
P-B-4	J-B-9	J-B-11
P-C-1	J-C-8	J-C-10
P-C-2	J-C-8	J-C-10
P-C-3	J-C-9	J-C-11
P-C-4	J-C-9	J-C-11

2.3.5 (continued)

per second. Each rotating mercury switch has two separate switch sections which are synchronized by the same motor shaft. This provides switching for both the plus and minus pole of the thermocouple lead. Both the plus and the minus switch bank are each lead adapted by two 50-point connector plug-ins of the rectangular type. See table 3H2-3 for lead identification to the mercury switch. The connector plug-ins from the lower section of each rotating mercury switch are for the negative pole and the plug-ins from the top section are for the positive pole. All the connector plug-ins of table 3H2-3 are identical so they can be plugged into any of the receptacles of table 3H2-3. It is imperative that the plug-ins of table 3H2-3 be oriented such that polarity and synchronization are not disrupted. This is done by pairing the even or the odd numbered plug-ins of a given mercury switch and then plugging into receptacles listed in table 3H2-2 that have been grouped similarily. It is further necessary to maintain pole continuity by noting polarity listed in tables 3H2-2 and 3H2-3. Any even or odd numbered pair of plug-ins may be plugged into any even or odd numbered pair of connector receptacles as long as the above mentioned pairing and polarity of each has been complied with.

The mercury switch motors are energized by plugging into the 120v AC outlets A15, B15, C15, D15, E15, located next to each mercury switch motor on "scanner panel #1." The mercury switches are purged by nitrogen continuously to prevent oxidation of the mercury.

2.4 The output leads of the mercury switches each route to a separate signal bucking network located on scanner panel # 2. The rotating mercury switch signal is bucked against a reference thermocouple signal to give a difference signal output. The difference signal output routes to individual "D.C. amplifiers."

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TABLE 3H2-3

Scanner Panel #1 50 Pt. Connector Plug-In − Pole	Scanner Panel #1 50 Pt. Connector Plug-in + Pole	Scanner Panel #1 Mercury Switch
P-A-10	P-A-8	A
P-A-11	P-A-9	A
P-B-10	P-B-8	B
P-B-11	P-B-9	B
P-C-10	P-C-8	C
P-C-11	P-C-9	C

The D.C. amplifier outputs each route to an "alarm discrimination" and also parallel to a selector switch called "selector scanner."

The "alarm discriminators" and the "selector scanner" switch are located on "scanner panel #2." "scanner panel #2" is located next to "scanner panel #1."

The selected signal from the selector switch is routed to an oscilloscope. The light beam across the face of the oscilloscope made up of 100 incremental steps displays the visual readout of a scanner within the scanner system. The amplitudes of the increments represent the temperatures based on a reference thermocouple. The following is a more detailed description of the "alarm discriminator," D.C. amplifier, and the oscilloscope.

2.4.1 The "alarm discriminators" of "scanners A, B, C, D, and E" are located on "scanner panel #2."

An "alarm discriminator" is an electronic device for triggering an alarm if the temperature difference between a reference thermocouple and a thermocouple exceeds a preset limit. This limit is preset by adjusting the "amplifier gain" knob of the "D.C. amplifier." It should be noted that false alarm will occur for a given scanner if there is not full circuit input to the mercury rotating switch.

The alarm discriminators have individual scanner annunciators located in "scanner panel #1" on the 840' level. The annunciation is by individual light indicators and a common alarm. An acknowledgement button is provided on "scanner panel #2" to silence the alarm, but the light indicator remains on until the out-of-limit temperature is corrected.

A Scanner System annunciator is provided in the main control panel on the 852' level. This provides a general alarm and general light indication at the main control panel on the 852' level for an out-of-limit thermocouple

2.4.1 (continued)

within the scanner system. This annunciator is also provided with an acknowledgement button to silence the alarm which is located on the main control console on the 852' level.

2.4.2 The "D.C. amplifiers," located on "scanner panel #2," amplify the difference signal from the "alarm discriminators." The oscilloscope readout is calibrated by adjusting the "amplier gain" knobs on the "differential D.C. amplifiers" and the vertical multiplier on the oscilloscope to give the beam amplitude corresponding to a Known thermocouple input to the scanner system. Adjustment should be as follows:

Gain	Oscilloscope Reading (^{o}F/in)	Scanner Alarm (^{o}F)
25	200	± 600
50	100	± 300
100	50	± 150
250	20	± 60

2.4.3 There are two oscilloscopes within the scanner system; one on the 840'level at scanner panel #2, and the other is on the 852'level in the main control panel. The oscilloscope on the 840 level is a console unit and plugs into the two receptacles on "scanner panel #2." The oscilloscope on the 852' level is mounted in the main control panel. Both oscilloscopes are provided with a "thermocouple identification marker." This is controlled from the 840' level and can be used on the 852' level oscilloscope only when both oscilloscopes are set on the same scanner position.

The six (6) control knobs located on the front of the oscilloscope to control the display of the light beam are as follows:

2.4.3.1 "Vertical adjustment"--used to move display up or down for centering reference line.

2.4.3.2 Horizontal adjustment--used to move display to either side for centering.

2.4.3.3 Focus adjustment--used to adjust the display to maximum sharpness.

2.4.3.4 Intensity--used to vary the light intensity of the display. This should be maintained at a good low intensity to minimize burning the cathod ray tube phosphorescent coating.

2.4.3.5 Thermocouple identification marker--the "thermocouple identification marker" serves to identify the incremental section of light beam on the oscilloscope corresponding to each of the programmed input thermocouples. The marker is a dot of light that appears just in the increment in question. The position of the marker dot is identified and controlled by a helipot selector switch called "thermocouple identification marker." The switch indicates the positions from 1 to 100, position 1 is the extreme left increment on the face of the oscilloscope and position 100 is the extreme right increment on the face of the oscilloscope.

2.4.3.6 Light beam amplitude control--normally this control is set to read a full scale amplitude with an input signal of ± 1 volt. This control is used when it is desired to change the calibration of the scope without changing the alarm calibration. (Refer to alarm discriminator for alarm calibration, section 2.4.1).

2.5 Reference thermocouples are thermocouples that have a known readout and are introduced into the scanner system to provide a datum temperature. Thermocouples are then readout by comparison with a reference thermocouple.

Each scanner has an input receptacle for a reference thermocouple at the "pyrometer panel." The circuitry of the reference thermocouple lead routes from the pyrometer panel to a terminal strip in "scanner panel #2." Then the reference thermocouple lead continues to the signal bucking network where the signal is bucked against the analytical thermocouples signal as previously described.

The reference thermocouple input can be simulated with an external electronic source and coupled into the scanner system at the pyrometer panel.

Table 3H2-4 details the routing of the reference thermocouple leads within the scanner system.

2.6 The scanner system has designed within circiutry that permits single input thermocouple signal to be read out on 25 consecutive increments of the oscilloscope display. This permits a more accurate examination of an individual thermocouple. Again it should be noted that false alarm will occur if the 100 points of a given scanner are not activated. Signal input can be either four (4) 25 duplicated thermocouple inputs or 100 single thermocouple inputs, or any combination thereof.

There are nine duplicated thermocouple input receptacles on the pyrometer panel as listed in table 3H2-5; 3 each to scanners A, B, and C.

The thermocouples to be read out on the duplicated scanner are introduced at the pyrometer panel by jumper leads from the "patch panel" as previously described. The leads from the pyrometer panel then proceed to the terminal strips with swing links in "scanner panel #1."

The swing links permit the paralleling of duplicated leads at the terminal strips.

The leads then continue from the terminal strips of "scanner panel #1" to the nine 25-point connector receptacle of "scanner panel #1." Each lead connects to all 25 points of a connector receptacle.

Table 3H2-4

REFERENCE THERMOCOUPLES

Pyrometer Panel Receptacle No.	Scanner Panel #2 Terminal Strip No.	Scanner Panel #2 Terminal Strip Terminal No. + Pole	Scanner Panel #2 Terminal Strip Terminal No. − Pole	Alarm Discriminator
56	TSP2-C	1	2	A
57	TSP2-C	3	4	B
58	TSP2-C	5	6	C
59	TSP2-C	7	8	D
60	TSP2-C	9	10	E

TABLE 3H2-5

DUPLICATED THERMOCOUPLES

Pyrometer Panel Duplicate Thermocouple Receptacle No.	Normal Scanner Designation No.	Scanner Panel #1 Terminal Strip No. + Pole	Scanner Panel #1 Terminal Strip No. − Pole	Scanner Panel #1 Terminal Strip With Swing Lengths Terminal No.	Scanner Panel #1 Duplicate Thermocouple 25 Point Polarized Connector Receptacle No.
172	A	TSPI-E	TSPI-F	101	J-A-5
173	A	TSPI-E	TSPI-F	102	J-A-6
174	A	TSPI-E	TSPI-F	103	J-A-7
175	B	TSPI-C	TSPI-D	101	J-B-5
176	B	TSPI-C	TSPI-D	102	J-B-6
177	B	TSPI-C	TSPI-D	103	J-B-7
178	C	TSPI-A	TSPI-B	101	J-C-5
179	C	TSPI-A	TSPI-B	102	J-C-6
180	C	TSPI-A	TSPI-B	103	J-C-7

Approved by [signature]

The connector receptacles are identical to the others previously described so any scanner connector plug-in can be coupled into them. Table 3H2-5 details the circuitry of the duplicated thermocouple facility.

2.7 The radiator temperature control is of crucial importance so scanners D and E are semi-permanently connected to 120 radiator thermocouples.

The thermocouple circuitry of scanners D and E is similar to that of scanners A, B, and C except that the 120 thermocouples couple directly into the terminal strips on "scanner panel #1" of scanner D and E.

Scanners D and E each readout 60 thermocouples, the first 40 of which are duplicated to activate all 100 points of the scanner.

The thermocouple leads route from their origin within the radiator section of the project to two terminal strips in "scanner panel #1." A parallel lead for each thermocouple also routes to the "patch panel" to provide duplicate readout. The terminal strips are equipped with swing link conductors so that one thermocouple lead can be paralleled into more than one scanner readout circuit within a given terminal strip. When swing lengths are used, sections of the thermocouple log should be corrected to indicate this.

The leads continue within the "scanner panel #1" from the terminal strip in sequence to eight 50-point pole segregated connector receptacles which are the same rectangular type that was explained in Section 2.3.2. The leads are pole segregated into four 50-point plus pole and four 50-point negative pole receptacles. Table 3H2-6 details routing of the radiator thermocouple leads within the scanner system.

Scanner mercury switches D and E "located on scanner panel #1" are plugged in at this point and are identical as described in Section 2.3.5. Again it is emphasized that the mercury switch connector plug-ins be paired by even or odd numbers and

TABLE 3H2-6

Thermocouple Nos.	Scanner No.	Scanner Panel #1 Terminal Strip No. + Pole	Scanner Panel #1 Terminal Strip No. − Pole	Scanner Panel #1 Terminal Strip Terminal No.	Scanner Panel #1 50 Pt. Connector + Pole	Scanner Panel #1 50 Pt. Connector −Pole
CR- 1	D	TSPI-G	TSPI-H	1 & 61	JD1 & JD2	JD4 & JD5
CR- 3	D	TSPI-G	TSPI-H	2 & 62	JD1 & JD2	JD4 & JD5
CR- 5	D	TSPI-G	TSPI-H	3 & 63	JD1 & JD2	JD4 & JD5
CR- 7	D	TSPI-G	TSPI-H	4 & 64	JD1 & JD2	JD4 & JD5
CR- 9	D	TSPI-G	TSPI-H	5 & 65	JD1 & JD2	JD4 & JD5
CR- 11	D	TSPI-G	TSPI-H	6 & 66	JD1 & JD2	JD4 & JD5
CR- 13	D	TSPI-G	TSPI-H	7 & 67	JD1 & JD2	JD4 & JD5
CR- 15	D	TSPI-G	TSPI-H	8 & 68	JD1 & JD2	JD4 & JD5
CR- 17	D	TSPI-G	TSPI-H	9 & 69	JD1 & JD2	JD4 & JD5
CR- 19	D	TSPI-G	TSPI-H	10 & 70	JD1 & JD2	JD4 & JD5
CR- 21	D	TSPI-G	TSPI-H	11 & 71	JD1 & JD2	JD4 & JD5
CR- 23	D	TSPI-G	TSPI-H	12 & 72	JD1 & JD2	JD 4 & JD5
CR- 25	D	TSPI-G	TSPI-H	13 & 73	JD1 & JD2	JD4 & JD5
CR- 27	D	TSPI-G	TSPI-H	14 & 74	JD1 & JD2	JD4 & JD5
CR- 29	D	TSPI-G	TSPI-H	15 & 75	JD1 & JD2	JD4 & JD5
CR- 31	D	TSPI-G	TSPI-H	16 & 76	JD1 & JD2	JD4 & JD5
CR- 33	D	TSPI-G	TSPI-H	17 & 77	JD1 & JD2	JD4 & JD5
CR- 35	D	TSPI-G	TSPI-H	18 & 78	JD1 & JD2	JD4 & JD5
CR- 37	D	TSPI-G	TSPI-H	19 & 79	JD1 & JD2	JD4 & JD5
CR-39	D	TSPI-G	TSPI-H	20 & 80	JD1 & JD2	JD4 & JD5
CR- 41	D	TSPI-G	TSPI-H	21 & 81	JD1 & JD2	JD4 & JD5
CR- 43	D	TSPI-G	TSPI-H	22 & 82	JD1 & JD2	JD4 & JD5
CR- 45	D	TSPI-G	TSPI-H	23 & 83	JD1 & JD2	JD3 & JD4
CR- 47	D	TSPI-G	TSPI-H	24 & 84	JD1 & JD2	JD3 & JD4
CR- 49	D	TSPI-G	TSPI-H	25 & 85	JD1 & JD2	JD3 & JD4
CR- 51	D	TSPI-G	TSPI-H	26 & 86	JD1 & JD2	JD3 & JD4
CR- 53	D	TSPI-G	TSPI-H	27 & 87	JD1 & JD2	JD3 & JD4
CR- 55	D	TSPI-G	TSPI-H	28 & 88	JD1 & JD2	JD3 & JD4
CR- 57	D	TSPI-G	TSPI-H	29 & 89	JD1 & JD2	JD3 & JD4

Approved by [signature]

TABLE 3H2-6 (Continued)

Thermocouple Nos.	Scanner No.	Scanner Panel #1 Terminal Strip No. + Pole	Scanner Panel #1 Terminal Strip No. − Pole	Scanner Panel #1 Terminal Strip Terminal No.	Scanner Panel #1 50 Pt. Connector + Pole	Scanner Panel #1 50 Pt. Connector −Pole
CR- 59	D	TSPI-G	TSPI-H	30 & 90	JD1 & JD2	JD3 & JD4
CR- 61	D	TSPI-G	TSPI-H	31 & 91	JD1 & JD2	JD3 & JD4
CR- 63	D	TSPI-G	TSPI-H	32 & 92	JD1 & JD2	JD3 & JD4
CR- 65	D	TSPI-G	TSPI-H	33 & 93	JD1 & JD2	JD3 & JD4
CR- 67	D	TSPI-G	TSPI-H	34 & 94	JD1 & JD2	JD3 & JD4
CR- 69	D	TSPI-G	TSPI-H	35 & 95	JD1 & JD2	JD3 & JD4
CR- 71	D	TSPI-G	TSPI-H	36 & 96	JD1 & JD2	JD3 & JD4
CR- 73	D	TSPI-G	TSPI-H	37 & 97	JD1 & JD2	JD3 & JD4
CR- 75	D	TSPI-G	TSPI-H	38 & 98	JD1 & JD2	JD3 & JD4
CR- 77	D	TSPI-G	TSPI-H	39 & 99	JD1 & JD2	JD3 & JD4
CR- 79	D	TSPI-G	TSPI-H	40 & 100	JD1 & JD2	JD3 & JD4
CR- 81	D	TSPI-G	TSPI-H	41	J-D-1	J-D-3
CR- 83	D	TSPI-G	TSPI-H	42	J-D-1	J-D-3
CR- 85	D	TSPI-G	TSPI-H	43	J-D-1	J-D-3
CR- 87	D	TSPI-G	TSPI-H	44	J-D-1	J-D-3
CR- 89	D	TSPI-G	TSPI-H	45	J-D-1	J-D-3
CR- 91	D	TSPI-G	TSPI-H	46	J-D-1	J-D-3
CR- 93	D	TSPI-G	TSPI-H	47	J-D-1	J-D-3
CR- 95	D	TSPI-G	TSPI-H	48	J-D-1	J-D-3
CR- 97	D	TSPI-G	TSPI-H	49	J-D-1	J-D-3
CR- 99	D	TSPI-G	TSPI-H	50	J-D-1	J-D-3
CR-101	D	TSPI-G	TSPI-H	51	J-D-2	J-D-4
CR-103	D	TSPI-G	TSPI-H	52	J-D-2	J-D-4
CR-105	D	TSPI-G	TSPI-H	53	J-D-2	J-D-4
CR-107	D	TSPI-G	TSPI-H	54	J-D-2	J-D-4
CR-109	D	TSPI-G	TSPI-H	55	J-D-2	J-D-4
CR-111	D	TSPI-G	TSPI-H	56	J-D-2	J-D-4
CR-113	D	TSPI-G	TSPI-H	57	J-D-2	J-D-4
CR-115	D	TSPI-G	TSPI-H	58	J-D-2	J-D-4
CR-117	D	TSPI-G	TSPI-H	59	J-D-2	J-D-4
CR-119	D	TSPI-G	TSPI-H	60	J-D-2	J-D-4

Approved by [illegible signature]

TABLE 3H2-6 (Continued)

Thermocouple Nos.	Scanner No.	Scanner Panel #1 Terminal Strip No. + Pole	Scanner Panel #1 Terminal Strip No. − Pole	Scanner Panel #1 Terminal Strip Terminal No.	Scanner Panel #1 50 Pt. Connector + Pole	Scanner Panel #1 50 Pt. Connector −Pole
CR- 2	E	TSPI-J	TSPI-K	1 & 61	JE1 & JE2	JE3 & JE4
CR- 4	E	TSPI-J	TSPI-K	2 & 62	JE1 & JE2	JE3 & JE4
CR- 6	E	TSPI-J	TSPI-K	3 & 63	JE1 & JE2	JE3 & JE4
CR- 8	E	TSPI-J	TSPI-K	4 & 64	JE1 & JE2	JE3 & JE4
CR- 10	E	TSPI-J	TSPI-K	5 & 65	JE1 & JE2	JE3 & JE4
CR- 12	E	TSPI-J	TSPI-K	6 & 66	JE1 & JE2	JE3 & JE4
CR- 14	E	TSPI-J	TSPI-K	7 & 67	JE1 & JE2	JE3 & JE4
CR- 16	E	TSPI-J	TSPI-K	8 & 68	JE1 & JE2	JE3 & JE4
CR- 18	E	TSPI-J	TSPI-K	9 & 69	JE1 & JE2	JE3 & JE4
CR- 20	E	TSPI-J	TSPI-K	10 & 70	JE1 & JE2	JE3 & JE4
CR- 22	E	TSPI-J	TSPI-K	11 & 71	JE1 & JE2	JE3 & JE4
CR- 24	E	TSPI-J	TSPI-K	12 & 72	JE1 & JE2	JE3 & JE4
CR- 26	E	TSPI-J	TSPI-K	13 & 73	JE1 & JE2	JE3 & JE4
CR- 28	E	TSPI-J	TSPI-K	14 & 74	JE1 & JE2	JE3 & JE4
CR- 30	E	TSPI-J	TSPI-K	15 & 75	JE1 & JE2	JE3 & JE4
CR- 32	E	TSPI-J	TSPI-K	16 & 76	JE1 & JE2	JE3 & JE4
CR- 34	E	TSPI-J	TSPI-K	17 & 77	JE1 & JE2	JE3 & JE4
CR- 36	E	TSPI-J	TSPI-K	18 & 78	JE1 & JE2	JE3 & JE4
CR- 38	E	TSPI-J	TSPI-K	19 & 79	JE1 & JE2	JE3 & JE4
CR- 40	E	TSPI-J	TSPI-K	20 & 80	JE1 & JE2	JE3 & JE4
CR- 42	E	TSPI-J	TSPI-K	21 & 81	JE1 & JE2	JE3 & JE4
CR- 44	E	TSPI-J	TSPI-K	22 & 82	JE1 & JE2	JE3 & JE4
CR- 46	E	TSPI-J	TSPI-K	23 & 83	JE1 & JE2	JE3 & JE4
CR- 48	E	TSPI-J	TSPI-K	24 & 84	JE1 & JE2	JE3 & JE4
CR- 50	E	TSPI-J	TSPI-K	25 & 85	JE1 & JE2	JE3 & JE4
CR- 52	E	TSPI-J	TSPI-K	26 & 86	JE1 & JE2	JE3 & JE4
CR- 54	E	TSPI-J	TSPI-K	27 & 87	JE1 & JE2	JE3 & JE4
CR- 56	E	TSPI-J	TSPI-K	28 & 88	JE1 & JE2	JE3 & JE4
CR- 58	E	TSPI-J	TSPI-K	29 & 89	JE1 & JE2	JE3 & JE4
CR- 60	E	TSPI-J	TSPI-K	30 & 90	JE1 & JE2	JE3 & JE4

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TABLE 3H2-6 (Continued)

Thermocouple Nos.	Scanner No.	Scanner Panel #1 Terminal Strip No. + Pole	Scanner Panel #1 Terminal Strip No. − Pole	Scanner Panel #1 Terminal Strip Terminal No.	Scanner Panel #1 50 Pt. Connector + Pole	Scanner Panel #1 50 Pt. Connector − Pole
CR-62	E	TSPI-J	TSPI-K	31 & 91	JE1 & JE2	JE3 & JE4
CR-64	E	TSPI-J	TSPI-K	32 & 92	JE1 & JE2	JE3 & JE4
CR-66	E	TSPI-J	TSPI-K	33 & 93	JE1 & JE2	JE3 & JE4
CR-68	E	TSPI-J	TSPI-K	34 & 94	JE1 & JE2	JE3 & JE4
CR-70	E	TSPI-J	TSPI-K	35 & 95	JE1 & JE2	JE3 & JE4
CR-72	E	TSPI-J	TSPI-K	36 & 96	JE1 & JE2	JE3 & JE4
CR-74	E	TSPI-J	TSPI-K	37 & 97	JE1 & JE2	JE3 & JE4
CR-76	E	TSPI-J	TSPI-K	38 & 98	JE1 & JE2	JE3 & JE4
CR-78	E	TSPI-J	TSPI-K	39 & 99	JE1 & JE2	JE3 & JE4
CR-80	E	TSPI-J	TSPI-K	40 & 100	JE1 & JE2	JE3 & JE4
CR-82	E	TSPI-J	TSPI-K	41	J-E-1	J-E-3
CR-84	E	TSPI-J	TSPI-K	42	J-E-1	J-E-3
CR-86	E	TSPI-J	TSPI-K	43	J-E-1	J-E-3
CR-88	E	TSPI-J	TSPI-K	44	J-E-1	J-E-3
CR-90	E	TSPI-J	TSPI-K	45	J-E-1	J-E-3
CR-92	E	TSPI-J	TSPI-K	46	J-E-1	J-E-3
CR-94	E	TSPI-J	TSPI-K	47	J-E-1	J-E-3
CR-96	E	TSPI-J	TSPI-K	48	J-E-1	J-E-3
CR-98	E	TSPI-J	TSPI-K	49	J-E-1	J-E-3
CR-100	E	TSPI-J	TSPI-K	50	J-E-1	J-E-3
CR-102	E	TSPI-J	TSPI-K	51	J-E-2	J-E-4
CR-104	E	TSPI-J	TSPI-K	52	J-E-2	J-E-4
CR-106	E	TSPI-J	TSPI-K	53	J-E-2	J-E-4
CR-108	E	TSPI-J	TSPI-K	54	J-E-2	J-E-4
CR-110	E	TSPI-J	TSPI-K	55	J-E-2	J-E-4
CR-112	E	TSPI-J	TSPI-K	56	J-E-2	J-E-4
CR-114	E	TSPI-J	TSPI-K	57	J-E-2	J-E-4
CR-116	E	TSPI-J	TSPI-K	58	J-E-2	J-E-4
CR-118	E	TSPI-J	TSPI-K	59	J-E-2	J-E-4
CR-120	E	TSPI-J	TSPI-K	60	J-E-2	J-E-4

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plugged into receptacles that are paired similarly. It is also imperative that polar continuity is maintained. Table 3H2-7 describes the connector plug-ins of mercury switches D and E.

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TABLE 3H2-7

Connector Plug-In No. Negative Pole	Connector Plug-In No. Plus Pole	Mercury Switch No.
P-D-3	P-D-1	D
P-D-4	P-D-2	D
P-E-3	P-E-1	E
P-E-4	P-E-2	E

3H INSTRUMENTATION

3. COMPUTER

The operation of the computer for collecting, recording, and processing reactor data is largely automatic and will require little attention. However, there are a few functions that must be performed by the reactor operators on a routine basis to keep the computer system operating properly under normal conditions. In addition, special operator actions are required when computer failures occur.

A large amount of published information is available which describes the computer and its operation at all technical levels. The principal documents and their general contents on these subjects are listed below for reference.

1) MSRE Design and Operations Report, Part II, Nuclear and Process Instrumentation, by J. R. Tallackson, ORNL-TM-729. This document contains a description of the hardware and the system capability, along with information concerning its use on the MSRE.

2) MSRE Reactor Operators' Computer Manual, by C. D. Martin, et al. This contains all the information normally required by reactor operations personnel to make full use of the computer. Because of its bulk and specific applicability, this document is separated from the rest of the reactor operating manual. Since the signal tabulations and other details within the computer are subject to change, an up-to-date copy of this report is kept at the computer console.

3) MSRE Computer System Report, by C. D. Martin, et al. This report is a complete description of the application of the computer to the MSRE. It includes engineering descriptions of the calculations as well as computer flow charts and program listings.

4) BR-340 System Manual, supplied by Bunker-Ramo Corporation. This is a highly detailed description of the entire 340 computer system. It is intended for use primarily by the computer programmers and maintenance personnel.

Since there is a separate operating manual for the computer (Computer Manual, item 2 above), the purpose of this part of the reactor operators' manual is to emphasize those functions that must be performed routinely.

3.1 Log Forms

The routine-logs typewriter, Typer No. 2, uses a pre-printed form which is completed each shift. The first information is typed on this form 15 minutes after the start of a shift and the last information appears about 15 minutes before the end of the shift. A new form must be inserted in this typer shortly after the start or shortly before the end of each shift. Detailed instructions for inserting and aligning the forms are given in the Computer Manual.

3.2 Calendar Date

Although the computer contains an internal device for generating clock time, there is no provision for calculating the calendar date. Since the computer makes frequent use of the date in storing data, this information must be manually entered each day shortly after midnight. Detailed instructions for entering "Date" are given in the Computer Manual.

The calendar date in the computer is typed automatically as part of the routine logs on Typer No. 2. It is NOT typed automatically by the other 3 typers. Therefore, the procedure for typing the date on each of Typers No. 1, 3, and 4 must be executed near the beginning of each shift. This procedure is detailed in the Computer Manual.

3.3 Magnetic Tape

During normal operation, the computer will store data on the magnetic tape on one of the two drive units; the second unit will be in standby with a full reel of blank tape. When the first reel is filled, the computer will automatically switch to the standby unit and announce the fact on Typer No. 1. When this occurs, a reactor operator will rewind the completed tape and replace it with another reel of blank tape.

Occasionally it will be desirable to remove a tape before it is completely filled. On these occasions, the operator will manually switch to the standby unit before rewinding and removing the "in-use" reel. Detailed procedures for switching tape units and for rewinding and changing tape reels are given in the Computer Manual. The handling and storage of new and completed magnetic tapes is described in 12D of this manual.

3.4 Computer Failure

There are two areas which will require special attention in the event of a failure of the computer. These are (1) the continued operation of the reactor system without data from the computer and (2) the restoration of computer operation.

When the computer is out of service, it will be necessary to collect a large amount of data manually in order to maintain adequate surveillance of the reactor systems. The changes in reactor operation for this condition are described in 9G of this manual.

Restoration of computer operation will usually require the attention of a programmer (ORNL) and/or a computer maintenance engineer (Bunker-Ramo). Once the computer is again operational, the way in which it is put in service depends on the condition of the reactor system and the duration of the outage. If no power change has occurred during the outage and the down time is less than 30 minutes, all the computer functions will be reactivated. If the reactor was in steady state with regard to xenon and samarium transients prior to the outage and no power changes occurred, all the computer functions will be reactivated even if the down time is greater than 30 minutes. If a xenon or samarium transient was in progress prior to an outage of more than 30 minutes or if a power change occurred, only part of the computer functions will be activated. The notable exception in this case is the

the reactivity balance which must be corrected for changes during the outage. The details of restarting the computer under various circumstances are described in the Computer Manual.

3.5 Procedure for Changes

One of the features which makes the computer so useful is its flexibility. Changes can be made in the form of calculations, the constants which are used, the form of output, and so on, to meet the changing needs of reactor operations and analysis or to improve the performance of the computer. Changes in such a complex system must be handled carefully, however. It is imperative that proposed changes be reviewed thoroughly before they are made and that changes be properly documented when they are made. To this end the following procedures will be adhered to.

Recommendations for changes will normally originate within the MSRE Operations Department, in either the operations group, the analysis group or the computer group. Any recommended change will be described by the person originating it on a Change Request Form. Changes originating in the operations group must be approved by the Operations Chief or Assistant Operations Chief. The head of the nuclear and mechanical analysis group, J. R. Engel, will evaluate and screen recommended changes and will coordinate computer changes and reactor operation. All changes must be approved by Engel and by the head of the MSRE Operations Department. The computer group will advise on the amount of effort involved in proposed changes and will make those changes which have been approved.

Requests originating in the operations group will go first to the Operations Chief (or Assistant Operations Chief). If he considers the change desirable, he will forward the request to Engel. Requests originating in the Analysis group will go directly to Engel. After he has evaluated the usefulness and desirability of any requested change from the standpoint of operations and analysis, Engel may return a request to the originator with an explanation of why it should not be made. Other requests he will pass on to the computer group for an estimate of the effort required to make the change. Recommendations for changes may be originated in the computer group. These will generally be of such a nature as to make more efficient use of the computer or to improve the accuracy of a particular calculation. They will submit their recommended changes with an estimate of the effort and improvement to Engel. After receiving an estimate from the computer group, Engel will evaluate the utility and cost of the change. If he decides the change is not worthwhile, he will file the Change Request, the estimate of effort, and pertinent notes and will notify the originator. If he approves the change, it will go to the department head for approval. If he approves the change, it will be sent to the computer group for action.

Upon receiving an approved Change Request, the computer group will proceed as follows:

1. Program the recommended change if applicable. If the change involves only altering a constant or similar word in the computer skip steps 2 and 3.
2. Assemble/compile the program on line and execute through On-Line Program Development.
3. Completely de-bug the program exercising all program options and check for correct answers.
4. Advise J. R. Engel when the change is ready for inclusion in the system and inform him of the amount of time the computer will have to be off line to incorporate the change.
5. Engel will give the go-ahead to take the computer off line to make the change or he will advise to wait until the next scheduled reactor shut-down or computer routine maintenance shut-down to make the change.
6. Make the change when advised by Engel.

7. Correct the master copy of the Reactor Operator's Computer Manual (on computer console) to reflect the change.
8. Enter time, date, and nature of the change in the computer log and the reactor log.
9. Enter the change in the master copy of the Computer System Report and list on the running list of changes to the computer system report for periodic publication.
10. Notify operations and the analysis group of the fact that the change has been made in the system.

There are certain constants (thermocouple bias corrections) which may vary from time to time requiring changes in the conversion-equation table code words to reflect the current bias. Certain other constants of similar nature may also need to be changed from time to time. Minor changes of this type will be verbally referred to J. R. Engel (if not originated by him) for approval to make the changes without following the above procedure. The only documentation required is that outlined in steps 7, 8, and 9 above.

If there is any doubt as to whether a change may be made following the abbreviated procedure, J. R. Engel will decide which procedure is to be used.

Approved by [signature]

3H4 ANNUNCIATORS

Visible and/or audible annunciators are provided to alert the operator when any of the important parameters are out of the prescribed limits.

In general, when a variable deviates from the normal value, an alarm first occurs on the computer and its value is typed on the alarm typewriter. If the variable deviates further from the normal, a conventional alarm will occur which will be indicated by a light above the main board and an audible signal. If the variable deviates still further, control action will occur.

There are fifteen different types or combinations of annunciators at the MSRE. These are outlined in Table 3 H4-1 and Fig. 3H4-1 and described in the following pages.

Table 3H4-2 is a list of each annunciator. The cause of the annunciation is described, the automatic control actions which are initiated by the condition causing the annunciation are enumerated and suggested remedial actions to be taken by the operator are given. Table 3H4-3 gives similar information for the Electro-system Temperature switches and alarms. It should be emphasized that the suggested operator action does not always apply. Consideration should be given to the condition of the system, what tests are in progress, and other pertinent information.

Table 3H4-4 describes the various audible alarms.

4.1 Type I - Annunciations coming Direct to the Control Room

These may contain one or more switches in series or parallel which will actuate the system. During normal operation the red and white lights above the main control board will be on dim indicating that the bulbs are good. There will be no audible alarm.

When a sustained abnormal condition occurs there will be an audible alarm in the main control room and the associated red and white lights above the main board will be on bright. Pushing the acknowledge button on the console will turn off the white light and audible signal. The red light will remain on. If the condition clears the red light will go off and the white light will come on. If the condition reoccurs the lights will come on bright and there will be an audible signal. If the reset button on the console is pushed before the condition reoccurs, the white light will go off.

4.2 Type II - Annunciators coming direct to the Auxiliary Control Boards with no Common Visual Alarm on the Main Control Board.

These may contain one or more switches in series or parallel which will actuate the system. During normal operation the white lights above the auxiliary control board will be off and there will be no audible alarm.

When an abnormal condition occurs there will be an audible alarm in the auxiliary control room. Both of the white lights above the auxiliary control board will be flashing. Pushing the acknowledge button on the auxiliary control board will turn off the flasher and audible signals. Both white lights will remain on if the abnormal condition is sustained. If the condition clears both of the white lights will go off. If the condition reoccurs the lights will flash and there will be an audible signal.

The lamp test button will turn all lights on to periodically test that they are operable.

4.3 Type III Annunciators Coming Direct to the Auxiliary Control Board with a Common Visual Alarm on the Main Control Board.

These may contain one or more switches in series or parallel which actuate the system on the sampler panel or on the auxiliary control board. Any one of several alarms will annunciate on a common annunciator in the main-control room. During normal operation the white lights above the auxiliary-control board will be off and the red and white lights above the main-control will be on dim indicating that the bulbs are good. There will be no audible alarm.

When an abnormal condition occurs there will be an audible alarm in the main control room and in the auxiliary control room. The associated red and white lights above the main board will be on bright and the associated white lights above the auxiliary control board will be flashing. Pushing the acknowledge button on the console will turn off the main-control board white light and audible signal. The red light on the main-control board and the audible alarm and flashing lights on the auxiliary control board will remain on. Pushing the acknowledge button at the auxiliary control board will turn off the flasher and the audible signal but will leave both white lights on at the auxiliary control room. The associated main-control board lights will change from red to white. Pushing the reset button on the console will clear the main board.

If, at any time after the auxiliary control board acknowledge button has been pushed, the condition clears and reoccurs or another abnormal condition occurs the lights will flash and there will be an audible signal in both the main control room and the auxiliary control board. When the condition has cleared, the white lights will be off above the auxiliary control board.

4.4 Type IV Annunciators Coming Direct to the Sampler, Scanner, Vapor Condensing System, or Chemical Processing Panel with a Common Visual Alarm on the Main Control Board.

These may contain one or more switches in series or parallel which actuate the system on the sampler, scanner, vapor condensing system, or chemical processing panel. Any one of several alarms will annunciate on a common annunciator in the main control room. During normal operation the red and white lights above the local panel, main control board will be on dim indicating that the bulbs are good. There will be no audible alarm.

When an abnormal condition occurs there will be an audible alarm in the main control room and at the local penel. The associated red and white lights above the main board will be on bright and the associated red and white lights above the local panel will be on bright. Pushing the acknowledge button on the console will turn off the main control board white light and audible signal. The red light on the main control board and the audible alarm and red and white lights on the local panel will remain on. Pushing the acknowledge button at the local panel will turn off the white light and the audible signal but will leave the red light on at the local panel. The associated main control board lights will change from red to white. Pushing the reset button on the console will clear the main board.

If, at any time after the sampler, scanner, vapor condensing system, or chemical processing board acknowledge button has been pushed, the condition clears and reoccurs or another abnormal condition occurs the red and white lights will come on and there will be an audible signal in both the main control room and at the local panel. After acknowledgment and when the condition has cleared, pushing the reset button on the local panel will clear the white light.

The vapor condensing panel differes from the others in that it has a test button which, when pushed, will cause an annunciation in the MCR.

4.5 Type V - VII Annunciators Coming Through The Auxiliary Control Room Temperature Modules

A number of temperature signals are connected to Electro System temperature switches. These are used to initiate annunciations or in some cases are in control circuits. The power supply switch should be on at all times as indicated by the amber light at the upper left hand corner. The manual-auto switch at the right hand side of the panel should be in the manual position. Some power supply panels have red lights, the red light will go on when an associated alarm module is actuated. All power supplies have reset buttons. Some not needed for present assignment of modules but would be needed if an alarm module

(Type ET-4200) were added. There are several variations in the way that this alarm system operates. These are described below:

With the exception of TS FD-1-19B and TS FD-2-19B which do not alarm, the operation of TX-3001 and TS-AD3-5B and AD3-7B is as follows:

Type V

During normal operation the power supply amber light is on and the red (alarm) light is off. The red lights on the modules are on dim. When an abnormal condition occurs there will be an audible alarm in the main control room and the associated red and white lights above the main board will be on bright. The red light on the power supply and the red light on the module will be on bright. Pushing the acknowledge button on the console will turn off the white light and audible signal in the main control room. The red light on the main control board will remain on and the lights in the auxiliary control room will not change. If another abnormal condition occurs, the associated module light will come on but there will be no audible or visual alarm in the main control room. When the abnormal condition clears, nothing will happen. Pushing the reset on the power supply will turn off the red lights on the module and switch from red to amber on the power supply. The red light on the main board will go off and the white light will be on. Pushing the reset on the console will clear the main board.

Type VI

With the exception of TS FD-1-20B and TS FD-2-20B which do not alarm, the operation of TX-3002 is as follows:

During normal operation the module red lights are on dim. When an abnormal condition occurs there will be an audible alarm in the main control room and auxiliary control room. The associated red and white lights above the main control board will be on bright and white lights above the auxiliary control board will be flashing. The red light on the module will be on. Pushing the acknowledge button on the console will turn off the white light and audible signal in the main control room. The red light on the main control board and the audible alarm and flashing lights and module red lights in the auxiliary control room will remain on. Pushing the acknowledge button in the auxiliary control room will turn off the flasher and audible signal but will leave the white light above the auxiliary board and red module light on. The associated main control board light will change from red to white. Pushing the reset button on the console will clear the main board. If another abnormal condition occurs on TX-3002 or if the condition clears and reoccurs, or if an abnormal condition occurs on TX-3002 and an obnormal condition already exists (for that particular FV) on TX-3003 through TX-3010, the associated module light will come on but there will be no audible or visual alarm in the main control room.

When the abnormal conditions clear nothing will happen. Pushing the reset on the power supply after the abnormal condition has cleared will turn off the red lights on the module and turn off the white light above the auxiliary control board.

Type VII

The remaining Electro System temperature switches are associated with freeze valves. Each temperature module has 2 lights. A bright amber light indicating that the temperature is in alarm and a green light indicating that the temperature is normal. Depending on the requested condition of the valve (frozen or thawed) either light could be on under normal conditions.

These temperature switch signals are included in an alarm (and control) circuit and will alarm if the temperature is outside the limits set for the selected condition of the freeze valve. Operation would be as follows:

During normal operation the main control board and auxiliary control board lights would be off and there would be no audible annunciation. When an abnormal condition occurs there will be an audible alarm in the main control room and auxiliary control room. The associated red and white lights above the main control board will be on bright and the white lights above the auxiliary control board will be flashing. To determine the switch module causing the alarm it will be necessary to consider all associated switches (i.e. all on FV-104) and the requested condition of this particular freeze valve. Pushing the acknowledge button on the console will turn off the white light and audible signal in the main control room. The red light on the main control board and the audible alarm and flashing lights in the auxiliary control room will remain on.

Pushing the acknowledge button in the auxiliary control room will turn off the flasher and audible signal but will leave both white lights above the auxiliary board on. The module lights will not change. Pushing the reset button on the console will clear the main board. If another abnormal condition occurs on the same freeze valve there will be no audible or visual alarm in the main control room. If the alarm clears the module lights will change and the white light above the auxiliary control board will go off. Another annunciation will then give an audible and visual alarm in the main control room.

An alarm on another freeze valve while the initial alarm condition exists will alarm in the normal manner.

4.6 Type VIII Annunciators Coming Through Rochester Alarm Substation Modules

A number of signals are connected to Rochester substations modules in the auxiliary control room and have common annunciators in the main control room. Operation of these are as follows:

During normal operation, the module selector switch should be in the operate position. The module light will be on. When an abnormal condition occurs there will be an audible alarm in the main control room and the associated red and white lights above the main board will be on bright. The light at the module will go off. Pushing the acknowledge button on the console will turn off the white light and audible signal in the main control room. The red light on the main control board will remain on. If another abnormal condition occurs there will be no visual or audible alarm in the main control room. Switching the module switch to "disable" will turn the module light on dim and will change the lights above the main control board from red to white. Pushing the reset button on the console will clear the main board. Other Rochester units on the same common annunciator can now cause an annunciation.

If the abnormal condition clears and the switch is on "disable" the module light will turn from dim to bright. Switching the module switch to operate prepares the module to cause an annunciation should another abnormal condition occur.

4.7 Type IX Annunciators Coming Through Personnel Radiation Monitors to the Main Control Board

During normal operation the annunciator lights will be on dim. There will be no audible alarms in the main control room or at the personnel radiation alarm center in the auxiliary control room. When an abnormal condition occurs there will be an audible alarm in the main control room and the associated red and white lights above the main control board will be on bright. There will be an audible alarm at the personnel monitor center in the auxiliary control room and one of the three lights on the personnel monitor module will be on bright. The three lights indicate high level activity, intermediate level activity and trouble with the instrument. Pushing the acknowledge button on the console stops the control room audible alarm and turns off the white light. Pushing the buzzer reset button will stop the instrument audible alarm and change the associated main control board lights from red to white. Pushing the reset button on the console will clear the main board. If the condition causing alarm clears and reoccurs nothing will happen. If another condition occurs (another monitor) there will be an audible signal in the main control room and the associated red and white lights above the main control board will be on bright. One of the three lights on the associated personnel monitor module will be on bright.

When the alarmed condition clears, nothing will happen. Pushing the reset button at the personnel radiation module will clear the bright lights on the module and reduce them to dim.

If 2 out of 6 monitrons or 2 out ot 4 CAM's alarm, the group light on the personnel monitor panel will go on and the plant evacuation siren will be actuated.

4.8 Type X Annunciation coming from Process Monitor to the Auxiliary Control Board and Subsequently to the Main Control Board. (GM Tubes on Q-1916 Indicators)

During normal operation the power light on the unit and the reset light on the reset panel will be on. When an abnormal condition occurs there will be an audible signal in the main control room and auxiliary control room. The red and white lights above the main control board will be on bright and the white lights above the nuclear panel will be flashing. The reset light will be off and the alarm light on the module will be on. Pushing the acknowledge button on the console will turn off the white light and audible signal in the main control room. The red light will remain on.

Pushing the acknowledge button on the auxiliary control board will turn off the flasher, and the audible signal at the auxiliary control board. The associated main control board lights will change from red to white. Pushing the reset button on the console will clear the main board. If the abnormal condition returns to normal and then reoccurs the only indication will be on the dial indicator on the process radiation panel.

If another Q-1916 unit monitoring the same process point exceeds the setpoint there will be no alarm. Other monitors will alarm in the main control room and the nuclear panel because they are connected to different nuclear panel alarm units.

When the condition clears, the only indication will be on the dial indicator on the process radiation panel. Pushing the reset button on this panel will turn on the reset light, turn off the alarm light on the instrument panel and turn off the white light above the nuclear panel.

4.9 Type XI Annunciation coming from the Process Monitors to the Auxiliary Control Board and Subsequently to the Main Control Board. (Ion Chambers and 202 Electrometer.)

During normal operation the power light will be on. When an abnormal condition occurs there will be an audible signal in the main control room and auxiliary control room. The red and white lights above the main control board will be on bright and the white lights above the nuclear panel will be flashing. Pushing the acknowledge button on the console will turn off the white light and audible signal in the main control room. The red light will remain on.

Pushing the acknowledge button in the auxiliary control room will turn off the flasher, and the audible signal at the auxiliary control board. The associated main control board lights will change from red to white. Pushing the reset button on the console will clear the main board. If the condition clears and reoccurs nothing will happen.

If another electrometer unit monitoring the same location exceeds the setpoint there will be no alarm. Other monitors will alarm in the main control room and the nuclear panel because they are connected to different nuclear panel alarm units.

When the condition clears, nothing will heppen. Pushing the reset button on the process radiation panel will turn off the white light above the nuclear panel and release the pointer.

4.10 Type XII Diesel Annunciators

There will be no annunciation indicating loss of TVA or that the diesels are in operation.

When an abnormal condition occurs while operating a diesel, there will be an audible alarm in the main control room and the associated red and white lights above the main board will be on bright. A light indicating which diesel has an abnormal condition will be actuated on the diesel panels in the auxiliary control room and an annunciator flag will be showing on the diesel panels in the switch house. There will be an audible alarm in the switch house. Pushing the acknowledge button on the console will turn off the main control board white light and audible signal. The red light on the main control board will remain on.

Actuating the signal reset on the diesel panels in the switch house will turn off the audible alarm in the switch house and the light in the auxiliary control room. The light above the main board will change from red to white. Pushing the reset button on the console after the alarm has been acknowledged at the diesel panel or after the abnormal condition has cleared will clear the main board. If the condition clears and reoccurs nothing will happen. If another abnormal condition occurs there will be an audible signal in the main control room and the lights above the main control board will be on bright. The light on the diesel panel in the auxiliary control room will be on. Another annunciator flag will be showing on the diesel panel in the switch house and there will be an audible alarm in the switch house.

When the condition has cleared, actuating the drop reset in the switch house will reset the flags. If the condition has not cleared, actuating the drop reset will initiate another annunciation at all locations.

4.11 <u>Type XIII Annunciation Coming from Computer to the Main Control Board</u>

During normal operation the main control board lights will be on dim, indicating that the bulbs are intact and there will be no audible annunciation. When an abnormal condition occurs there will be an audible signal in the main control room and the red and white lights above the main control board will be on bright. The data point or condition which is out of limits will be typed out in red on the "out of limits" typewriter. Pushing the acknowledge button on the console will turn off the white light and audible signal in the main control room; the red light will remain on. If the alarm condition clears and realarms or if another point goes out of limits, each will be annunciated on the main control board visually and audibly; each out of limits condition will also be typed out in red on Typewriter No. 1. If the alarm condition clears, the data point or condition will be typed out in black on Typewriter No.1. The red light above the main control board will go off and the white light will come on. Pushing the reset button on the console will clear the main board.

4.12 <u>Type XIV Annunciation Coming from Nuclear Power Panel to the Auxiliary Control Board and Subsequently to the Main Control Board (Wide-Range Counting Channel to Fast Trip Comparators)</u>.

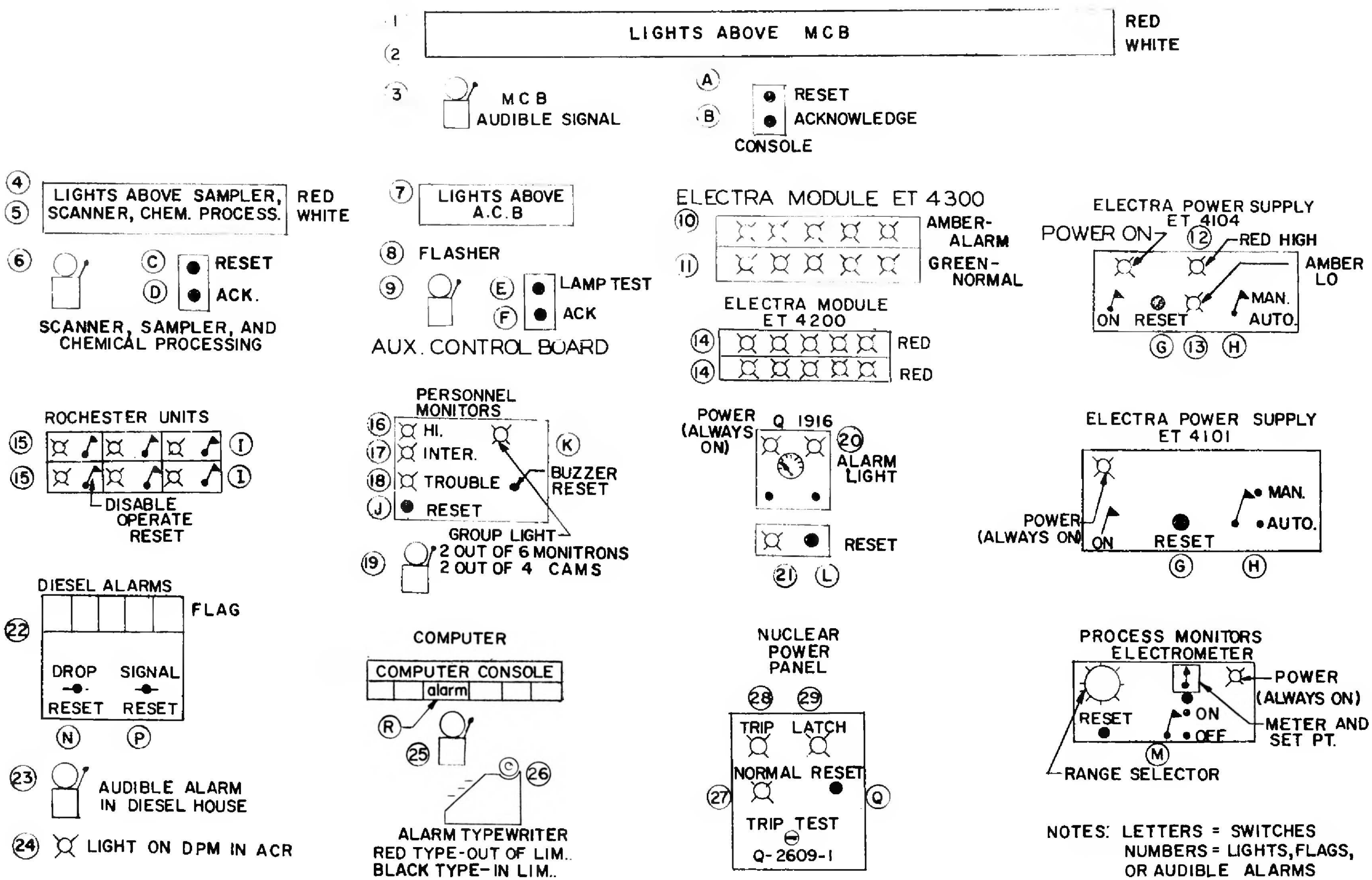
During normal operation, the normal light (white or green) will be on bright at the Fast Trip Comparators (Q 2609-1). When an abnormal condition occurs, there will be an audible alarm in the main control room and auxiliary control room. The associated red and white lights above the main control board will be on bright and the white lights above the auxiliary control board will be flashing. The normal light will go off and the Trip and Latch lights will come on at the fast trip comparator module. Pushing the acknowledge button on the console will turn off the white light and audible signal in the main control room. The red light on the main control board and the audible alarm and flashing lights in the auxiliary control room will remain on. Pushing the acknowledge button in the auxiliary control room will turn off the flasher and audible signal but will leave the white lights above the auxiliary board on. Pushing the console reset button will clear the main board.

When the alarm condition clears the Trip and Latch lights will go off and the normal light will come on at the modules;

this will also clear the white lights above the auxiliary control board. On the Scram Module only, the latch light will remain on while the trip light will clear and normal light will come on. The latch light will remain on until the reset button is pushed. If the alarm condition clears, and re-appears or if another alarm condition in the same group occurs, then another audible and visual annunciation will be generated at the auxiliary and main control boards.

4.13 Type XII Annunciation Coming from Computer to the Computer Console

During normal operation the computer will be on constantly and perform its programmed functions. It will annunciate on the main board and type out on Typewriter No. 1 any abnormal reactor condition (See Type XIII alarm). In addition, the computer also checks its own internal timer and circuitry every 1/4 second. An abnormal condition in the computer per se will be annunciated in the computer room by a flashing red alarm light - push button combination on the computer console and a repeating-gong audible alarm. Pushing the alarm light button combination will silence the audible alarm but leave a steady red alarm light on at the computer console. The computer will not perform any more of its programmed functions until restarted. When the computer malfunction is corrected and restarted the alarm light will clear.



MSRE ANNUNCIATORS

Fig. 3H4-1

Approved by [signature]

3H4-14
9/27/65

TABLE 3H 4.1 SEQUENCE OF ANNUNCIATORS

		NO ABNORM COND.		ABNORMAL CONDITION OTHER ACKNOWLEDGEMENT							ABNORMAL COND. CLEARED	
TYPE No.	DESCRIPTION	SWITCH SETTING	LTS.	AN ON ALM COND	MCB ACK B CLEARS	PUSH BUTTON	COND AFT ACTION	(A) CLEARS MCB	ACT IF ALRM CLEARS & REALARMS	ACT ON ANOTHER ALRM IN SAME GROUP*	ACTION ON CLEARING	TO CLEAR ALL INDICATORS
I	Direct to MCB	None		1,2,3	2,3	None	1	No	1→2→1,2,3		1→2	Push A
II	Direct to ACB	None		7,8,9	None	F	7	Clear	7→clear→7,8,9		7→clear	None
III	To ACB → MCB	None		1,2,3,7,8,9	2,3	F	2,7	Yes	7 → clear →1,2, 3,7,8,9	1,2,3,7',8',9',7	7→ clear	None
IV	To Sampler To Scanner To Chem Processing To Vapor Condensing System } → MCB	None		1,2,3,4,5,6	2,3	D	2,4	Yes	4→ 5→ 1, 2,3, 4,5,6	1,2,3,4',5',6',5	4→5 , 4'→5'	Push C
V	Electra Mod. ET4200 → ET4104→ MCB	Pwr. On H-Man		1,2,3,12,14	2,3	None	1,12,14	No	None	14'	None	Pugh G & A
VI	Electra Mod. ET4200 → ET4101 → MCB	Pwr. On H-Man		1,2,3,7,8,9,14	2,3	F	2,7,14	Yes	None	1,2,3,7',8',9,14', 14,7	None	Push G
VII	Electra Mod. ET4300 → (ET4101 or ET4104) → MCB	Pwr. On H-Man	10 or 11	1,2,3,7,8,9,10	2,3	F	2,7,10	Yes	7,10 → clear→ 1,2,3,7,8,9,10	10'	10 → 11	None
VIII	Rochester Mod to MCB	I in Operate	15 on	1,2,3, 15 off	2,3	None	1, 15 off	No	None	15' off	None	I → Reset → Oper & Push A
IX	Personnel Mon. to MCB	None		1,2,3 19(16,17, or 18)	2,3	K	2, (16,17, or 18)	Yes	None	1,2,3(16', 17', or 18') 19' (16,17,or 18)	None	Push J
X	Process Rad, GM or Q1916 - → MCB	None	21	1,2,3,7,8,9,20, 21 off	2,3	F	2,7,20,21 off	Yes	Dial Change	1,2,3,7',8',9,20',20	Dial Change	Push L
XI	Process Rad, Ion Ch, 202 Elect-NP-MCB	None		1,2,3,7,8,9	2,3	F	2,7	Yes	None	None	None	Push M
XII	Diesel Alarm-DPM(ACR)-MCB	Pwr. On		1,2,3,22,23,24	2,3	P	2,22	Yes	None	1,2,3,22,23,24	None	Switch N
XIII	Computer → MCB	None		1,2,3,26 red	2,3	None	1,26 red	No	1, 26 red → 2, 26 black→ 1,2, 3, 26 red	1,2,3,26' red	1,26 red→ 2,26 black	Push A
XIV	Nuclear Power Panel → ACB-MCB		27	1,2,3,7,8,9, 28,29	2,3	F	2,7,28,29	Yes	7,28,29,→ clear →1,2,3,7,8,9, 28,29	1,2,3,7',8',9',28', 29'	28,29→ 27	Push Q (On Scram Module Only)
XV	Computer (Computer Room)			25,R	None	R	R_1	Clear				Restart Computer

TABLE 3H4.2 ANNUNCIATORS

Location and Annunciator Number	Actuated by	Annunciates on (for setpoints see Switch Tab)	Control Action*	Operator Action
MCB-1				
XA 4000-1	XA 4029	Sump levels (Common)	Note 1	Note 1 Check XA 4029-1 to 8 in ACB 3
XA 4000-2	XA 4030-31	Instrument Air (Common)	Note 1	Note 1 Check XA 4030-1 to 11 & XA 4031-1 to 12 on ACB 4
XA 4000-3	XA 4026-27	Cooling water (Common)	Note 1	Note 1 Check XA 4026-1 to 12 & XA 4027-1-9 on ACB 3
XA 4000-4	PS 400 or 514	Hi Lo Leak Detector Pressure	None	Repressurize or vent & hunt for leaks
XA 4000-5	XA-4019, TVA Feeder, Diesel Pnl.	Electrical power (Common)	None	Note 1 Check XA-4019. Check and restart electrical equipment
XA 4000-6	K 1073A on XA 4017	Containment Air (Common)	Note 1	Note 1 Check XA 4017-1 to 5 on ACB 2
MCB-2				
XA 4001-1	K-1072A on XA 4016, 4018	Misc. Aux. Bd. Alarm	Note 1	Note 1 Check XA 4016, XA 4018
XA 4001-2	PA 9006-1	Lo N_2 Pressure Initial (Instrument Air)	None	Change banks and replace used cylinders
XA 4001-3	PA 9006-2	Lo N_2 Pressure Final (Instrument Air)	None	Change banks, replace cylinders & prepare to drain
XA 4001-4		Selected Drain tank not ready	None	Check that (1)FV 105 & 106 are thawed & FV 104 frozen (if FFT selected, FV 104 thawed & 105, 106frozen) (2) selected DT equalizers are open
XA 4001-5	K-1028A	Chem process common	Note 1	Note 1 Check XA 4051 and XA 4052 on Chem processing panel

Note 1: See individual Annunciators (Aux. C. R., Sampler, Chem. Plant, Etc.)

*Annunciation and control action do not necessarily occur at the same time.

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TABLE 3H4.2 (continued)

Location and Annunciator Number	Actuated by	Annunciates on (for set points see Switch Tab)	Control Action	Operator Action
<u>MCB-2</u>				
XA 4001-6	A-Be S1010-A1	Hi Be in radiator stack when in operation. Hi local Be during shutdown	None	Evacuate vicinity of monitor - Consult industrial hygienist
<u>MCB-3</u>				
XA 4002-1	PdA 960A1	Lo differential pressure. CCP 1 or 2	None	Stop running CCP, start alternate CCP & check PdIC 960A
XA 4002-2	PS 906B	Lo discharge pressure CCP 3	None	Check PC 906B in blower house or valve in auxiliary air compressor
XA 4002-3	PS 791B and 795B	Lo oil pressure CCP 1 or 2	Stops CCP	Start alternate CCP
XA 4002-4	SS CP G-1 or 2	Lo coolant pump speed	Stops FP - It & Low Coolant flow scrams radiator doors	Restart CP, stop radiator blowers & start up per procedures
XA 4002-5	PS 9013-2	Lo pressure to block valves	Blocks lines to cells causing start of drain, etc.	Check cell pressure
XA 4002-6	PSRCA-1 or 2 K-98C KC 84G K-30, K-31 K-32, KB84G KA84G	Li-Lo R. C. pressure	At 12.2 psia closes HCV 565. At 16.7 psia 2 out of 3 PSS closes Liq. waste Block valves and inst. air to Penetration block valves	Check cell pressure & temperature. If Hi pressure, open V-565C; check RCC-1,2

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TABLE 3H4.2 (continued)

Location and Annunciator Number	Actuated by	Annunciates on (for set points see Switch Tab)	Control Action	Operator Action
MCB-4				
XA 4003-1	RS-SI A1 RS-SI B1 RS-SI C1	Hi containment air Stack activity	None	If lo cell pressure - close 565C & V-569A, determine source & shut down system involved
XA 4003-2	TX 3003	Hi radiator annulus temperature	None	Note 1 Check TX 3003-19 & 20 on ACB-5
XA 4003-3	TS 202-A, B, or C	Lo radiator outlet temperature	2 out of 3 scrams radiator doors & starts coolant drain	Increase heat to radiator & coolant system. Close radiator doors & stop radiator blowers. A coolant drain may be necessary. If FV-204 or 206 do not thaw, turn off CCP 3.
XA 4003-4	PS 510 A-1 or 2	Hi Lo coolant oil tank pressure	None	Check PIC-510A & ECC-45 & 74
XA 4003-5	LSOT 2-A3	Lo coolant oil tank level	Close FSV 753A-1 (Coolant lube oil)	Check Oil tank (OT-2) & oil catch tank (OCT-2) levels. Pump seal leakage may necessitate a drain. Alarm setpoint may need changing.
XA 4003-6	PS 751B1 & 752B1	Lo coolant oil pump pressure	Starts alternate pump	Start alternate pump - check & stop defective pump. Be prepared to tie in fuel lube oil system (Section 6D)
MCB-5				
XA 4004-1	TSCOP-1 or 2	Hi motor temperature COP 1 or 2	None	Investigate and consider switching to alternate pump.
XA 4004-2	K-350A	Coolant sampler common	None	Check buffer header & glove box pressures. Adjust as necessary.
XA 4004-3	FS-512A	Lo cover gas flow to CP	None	Check supply pressure. FIC 512 & ECC-128

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TABLE 3H4.2 (continued)

Location and Annunciator Number	Actuated by	Annunciates on (for setpoints see Switch Tab)	Control Action	Operator Action
MCB-5				
XA 4004-4	FS 526C	Lo upper gas flow from CP	None	Check CP pressure. Plugged line may be opened by increasing CP pressure. Shutdown may be necessary.
XA 4004-5	WSCDT-C1	Lo CDT wt. (adjustable)	None	Check WR-CDT-C. Adjust alarm set point.
XA 4004-6	PS-511-D1 or D2	Hi-Lo CDT pressure	Hi closes He supply (HCV-511A) & opens vent (HCV-547A).	Check PIC-511C. For Hi pressure, vent CDT. For Lo pressure, add helium.
MCB-6				
XA 4005-1	FS-753A or 754A	Lo lube or coolant oil flow to CP	Prevents starting CP	Check lube-oil pumps & adjust flows. See Section 6D.
XA 4005-2	PS 528 A-1 or A-2	Hi-Lo CP pressure	Hi closes supply valve FCV-512 A-1	Check PRC-528, FIC-512A, and FI-526C
XA 4005-3	LS-595 C-2 or C-3	Hi-Lo CP level (Bubblers or float)	Hi opens CDT vent & closes He supply valve. Lo stop CP	Check all level instruments. Lo level may indicate salt leak & necessitate drain
XA 4005-4	PS-594-A1,A2 595-A1, A2 598-A1, A2	Hi-Lo gas flow to CP bubbler	None	Adjust flows & check ECC-75, 76, & 77, check that lines are not plugged.
XA 4005-5	FS-201-A or B	Lo coolant salt flow	Stops FP. 2 out of 2 Lo flows or one Lo flow & one Lo speed scrams radiator doors	Restart CP - Stop radiator blowers & start up per procedures
XA 4005-6	XpS 201-A	Hi reactor power at radiator	None	Check nuclear power. Close radiator doors if in doubt.
MCB-8				
XA 4006-1	RS-8100-1A-1B	Hi-Lo Linear Power Level	None	Change ranges on selector switch

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TABLE 3H4.2 (continued)

Location and Annunciator Number	Actuated by	Annunciates on (for set points see Switch Tab)	Control Action	Operator Action
MCB-8				
XA 4006-2	SSFPE-1 or -2	Lo FP speed	Switches from run, lowers heat & nuclear power to <1.5 Mw	Insert rods, lower heat load and start up per procedures
XA 4006-3 TS-100-1 TS-100-A1 TS-100-A2 TS-100-A3		Hi reactor outlet temperature	Rod reverse on 2 out of 3 channels	Insert rods
XA 4006-4	LS 593-C2 or C-3	Hi-Lo FP level (bubblers)	Hi opens FD-1, FD-2, & FFT vents and closes supply valves Control Rod reverse Lo stops FP	Check Lo-Hi level instruments. Lo level may indicate salt leak & necessitate a drain, or indicate a fuel system temperature decrease
XA 4006-5	PS 522 A1 or A2, 589A or 592B	Hi Lo FP pressure	Opens FP vent, FDT vents, equal. valves Starts drain	Check FP pressure. Determine cause of pressure
XA 4006-6	PS 592-600	Hi, Lo gas flow to FP & overflow tank bubblers	None	Adjust flows & check ECC-63-68 Check that lines are not plugged
MCB-9				
XA 4007-1	FS 703A or 704A	Lo Lube or coolant oil flow to FP	Prevents starting FP	Check lube-oil pumps & adjust flows. See Section 6D
XA 4007-2	LS-599B or 600B	Hi level in FP overflow tank	Emergency drain	Check FP and OFT levels. See Section 6D.
XA 4007-3	W9 FD1 C4 or FD2 C4	Hi fill rate from FD-1 or FD-2	Stops He addition & opens vent from FD-1 or FD-2	Stop He addition, vent DT or open equalizing valve if necessary

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TABLE 3H4.2 (continued)

Location and Annunciator Number	Actuated by	Annunciates on (for set points see Switch Tab)	Control Action	Operator Action
MCB-9				
XA 4007-4	WS FD-1, C5 FD-2 C5 or FFT C1	Lo FD-1, FD-2, or FFT wt. (adjustable)	None	Check WRFD-1, FD-2 & FFT - Adjust alarm setpoint
XA 4007-5	FS-516B	Lo cover gas flow to FP	None	Check supply pressure, FIC 516 & ECC-129
XA 4007-6	FS-524B	Lo upper gas flow from FP	None	Check FP pressure. Plugged line may be opened by increasing FP pressure. Shutdown may be necessary
MCB-10				
XA 4008-1	K-149C	Safety Circuit jumpered	Prohibits Operate Mode	[illegible]
XA 4008-2	KC-881A	Fuel Sampler (common)	Note 1	Note 1 Check XA-4035 to 37 - 1 to 4 at SE panels 1 to 3
XA 4008-3	TS FOP 1 or 2	Hi motor temperature. FOP 1 or 2	None	Investigate and consider switching to alternate pump
XA 4008-4	PS 513A-1 or A-2	Hi-Lo fuel oil tank pressure	None	Check PIC 513A & ECC 44 & 73
XA 4008-5	LS OT1 A-3	Lo fuel oil tank level	Closes FSV-703 (fuel lube oil)	Check oil tank (OT-1) & oil catch tank (OCT-1) levels. Pump seal leakage may necessitate a drain. Alarm setpoint may need changing
XA 4008-6	PS 701B2 & PS 702 B1	Lo FOP discharge pressure	Starts alternate pump	Start alternate - check & stop defective pump. Be prepared to tie in coolant lube oil system (Section 6D)

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TABLE 3H4.2 (continued)

Location and Annunciator Number	Actuated by	Annunciates on (for set points see Switch Tab)	Control Action	Operator Action
MCB-11				
XA 4009-1	PS 574B1 or B2	Li Lo FD-2 pressure	Hi closes He supply (HCV-574) & opens vent (HCV-575)	Check PIC-517A. For Hi pressure vent FD-2. For Lo pressure add He
XA 4009-2	PS-572 B1 or B2	Hi Lo FD-1 pressure	Hi closes (HCV-572) & opens vent (HCV 573)	Check PIC-517A. For Hi pressure vent FD-1. For Lo pressure add He
XA 4009-3	PS-576 B1 or B2	Hi Lo FFT pressure	Hi closes (HCV-576) & opens vent (HCV 577)	Check PIC-517A. For Hi pressure vent FFT. For Lo pressure add He
XA 4009-4	PS 608 B2 or B3	Hi Lo FST pressure	Hi closes (HCV 530) & opens vent (HCV 692)	Check PIC-530. For Hi pressure vent FST. For Lo pres- add He
XA 4009-5	WS FST-C1	Lo FST Weight (adjustable)	None	Check WR FST - Adjust alarm set points
XA 4009-6	XA 4028	Cover gas system (common)	Note 1	Note 1 - Check XA 4028-1 to 10 on ACB 3
MCB-12				
XA 4010-1	RS-7023	Hi activity - personnel monitors	Note 1	Note 1 - Check CAM & Monitron modules on NP 5
XA 4010-2	K-1060A	Hi activity - process monitors	Note 1	Note 1 - Check XA 4043 on NP 4
XA 4010-3	K-1074A on XA 4020-22	Freeze valve temperature. (common)	Note 1	Note 1 - Check XA 4020 to 22-1 to 4 on ACT 5 to 7 also TX 3002 through TX 3010
XA 4010-4	TX 3001	Freeze Flange temperature (common)	Note 1	Note 1 - Check TX 3001 on ACB-5

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Location and Annunciator Number	Actuated by	Annunciates on (for set points see Switch Tab)	Control Action	Operator Action
MCB-12				
XA 4010-5	K 1036A	Scanner (common)	None	Check XA 4053-1 to 6 on Scanner Panel (840 level)
XA 4010-6	Computer	Computer (common)	None	Note 1
MCB-6				
XA 4011-1	KB 139H RXS-NCC1 A8B RXS-NCC2 A8B	ϕ >1.5 Mw in start mode	Control rod reverse	Check Nuclear Panel. Adjust flux
XA 4011-2	KA 1048A	ϕ > 12 Mw common	Two out of three channels give control rod reverse	Adjust flux
XA 4011-3	KB 1048B	Period < 10 sec	Control rod reverse if not in Run Mode	Adjust control rods
XA 4011-4	KB 161C	Load set back	Lowers radiator doors, decreases ΔP set-point and stops one main blower per programmed sequence.	Check radiator outlet temperature. Check NP(ϕ >12 Mw) Adjust load.
XA 4011-5	KB 11D KB 12D	Load scram	Scrams both radiator doors. Stops MB-1 & MB-3	Check radiator outlet temperature, CP speed & coolant salt flow
XA 4011-6	KA 140D KA 141D	Emergency coolant salt drain	Opens CDT vent and bypass valve. Closes CDT He supply valve. Scrams both radiator doors. Stops MB-1 & MB-2. Thaws FV-204 & 206	Check radiator outlet temperature

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TABLE 3H4.2 (continued)

Location and Annunciator Number	Actuated by	Annunciates on (for set points see Switch Tab)	Control Action	Operator Action
MCB-8				
XA-4012-1	KA 18G KA 19G	Emergency fuel salt drain	Opens all vent and by-pass valves & closes all He supply valves to FD-1, FD-2, FFT. Thaws FV-103, 105, 106.	Reduce power to zero, reduce heat load to zero. Check Tro, FP pressure, OFT level, RE-565, RE-528
XA-4012-2	K248E K249E K 250E	Control Rod Scram	Two out of three safety channels scrams all rods. Opens DT vent valves.	Lower radiator doors and re-start per procedure. Checks for circuit trouble in flux channels, $\tau < 1$ sec, Tro, $\phi > 15$ kw, $\phi > 15$ Mw, reset latch on rod scram module
XA-4012-3	K 207D	T_o demand rod set back	Group insert of control rods	Check TSS-100A1-2, TSS-100A2-2 TSS-100A3-2
XA-4012-4	K-186E	Control Rod reverse	Group insert of control rods	Check $\phi > 1.5$ Mw, $\tau < 10$ sec
XA-4012-5	K-204D K-205D K-206D	$T_o > 1275°F$	Two out of three ther-mocouples gives rod reverse and decrease reactor temp. demand	Lower reactor temperature demand setpoint if in temp. servo. If not, lower flux.
XA-4012-6	K-241B	Reg. Rod @ L.L.	Prevents transfer to Run Mode if servo is is on	Lower reg rod limit switch. If servo is on, lower rods 2 & 3
MCB-9				
XA-4013-1	K-1054A	High temperature control rod housing	None	Shut down and drain reactor
XA-4013-2	TS-OFT-6A	Low Temperature FP OFT	None	Check TE-OFT-6B, Scanner A, ad-just heaters, consider a reactor drain

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Location and Annunciator Number	Actuated by	Annunciates on (for set points see Switch Tab)	Control Action	Operator Action
MCB-9				
XA-4013-3		Spare		
XA-4013-4		Spare		
XA-4013-5		Spare		
XA-4013-6		Spare		
MCB-5				
XA-4014-1		Spare		
XA-4014-2		Spare		
XA-4014-3	XA-4032	Low air flow, Battery room exhaust Induction Regulator Cooling Air	None	Note 1. Check fans, switches and power supplies
XA-4014-4		24v DC power off HP Radiation Monitor	None	Check instrument power panel #5
XA-4014-5	K-1114A	Vapor Condensing Tank Common	None	Note 1. Check XA-4054 out JB #151 at Vapor Condensing Tank area
XA-4014-6	K-85A	Low Pressure Reactor cell. Safety Interlocks	Closes HCV-565. Stops CCP-1 & 2 thus initiating reactor drain	Check to see that HCV-565, V-571, V-569 are closed. Increase N_2 to RC (sump bubblers) and possibly add air via 342 & 332. Restart CCP-1 & 2 as soon as possible
ACB-1				
XA-4016-1	TS-3100	Hi miscellaneous temperature TRA-3100	None	Check TR-3100 on MCB-12 - Adjust heat

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TABLE 3H4.2 (continued)

Location and Annunciator Number	Actuated by	Annunciates on (for set points see Switch Tab)	Control Action	Operator Action
<u>ACB-1</u>				
XA-4016-2	TS-3400A1 or 2	Hi-Lo coolant salt flow meter temperature. TR-3400	None	Check TR-3400 on SP-2 (840 level) Adjust heat.
XA-4016-3	PS-S-X10	Lo steam supply pressure	None	Condensate make-up rate may be too high. Check gage on steam header north of 7503. Call Utilities Dept.
XA-4016-4	TS-3500A1 or 2	Hi-Lo drain line temperature TRA-3500	None	Check TR-3500 or ACB-2. Adjust heat. Prepare to drain system before salt freezes.
XA-4016-5	K 2A	Hi-Temp sample surveillance test	None	Check to see that computer is in operation. Adjust heat if necessary.
<u>ACB-2</u>				
XA-4017-1	PS-HB-A1 or A2	Hi-Lo High Bay pressure	None	Check doors and dampers
XA-4017-2	PdS-936A	Lo auxiliary cell ventilation duct Diff.	None	Check auxiliary cell pressures & adjust dampers
XA-4017-3	PdS-927B	Hi filter pit Diff. pressure	None	Check dampers - filter replacement may be necessary.
XA-4017-4	FS-S1-A	Lo ventilation stack flow	None	Check dampers, filters, ΔP etc.
XA-4017-5	PS-927-A1 or A2	Containment air Duct 927 Vacuum pressure <1.5" H_2O	Starts stand-by containment air fan (SF-2)	Switch to alternate stack fan blower. Check blowers, motors, and dampers

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TABLE 3H4.2 (continued)

Location and Annunciator Number	Actuated by	Annunciates on (for set points see Switch Tab)	Control Action	Operator Action
ACB-3				
XA-4018-1	TS-705 TS-707	Hi fuel pump oil temperature	None	Check temperature on logger, check flows, lower power if necessary. Check cooling water flow & temp. Possibly increase by-pass oil flow.
XA-4018-2	TS-755 TS-757	Hi coolant pump oil temperature	None	Check temperature on logger, check flows, lower power if necessary. Check cooling water flow & temp. Possibly increase by-pass oil flow.
XA-4018-3	PS-9012-1A 1B, 1C	Lo Press. sump bubbler and scanner N_2 supply	None	Check N_2 supply press. at 840 level. Switch to alternate bank. Change out empty bottles
XA-4018-4	PxS-579, 580,581, 582, 584, 586	Hi pressure in PT reference	None	Consider draining fuel system (violation of primary conment)
XA-4018-5	PS-918-A1	Graphite Sampler blower inlet Hi pressure	None	Check N_2 purge
ACB-4				
XA-4019-1	UVR(48v DC)	Lo voltage 48v DC bus	None	Check MG sets. Check for ground. Start alternate MG possibly initiate emergency drain

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TABLE 3H4.2 (continued)

Location and Annunciator Number	Actuated by	Annunciates on (for set points see Switch Tab)	Control Action	Operator Action
ACB-4				
XA-4019-2	MG #2 off MG #3 off	48v DC MG-2 or MG-3 off	None	Check MG sets. Start alternate MG
XA-4019-3	Position switch on reverse current breaker handle	Reverse current trip breaker open	None	Check MG-1 and try to restart. If running, check reverse current trip and reset. If unsuccessful, shut down MG-4 (which transfers load to TVA)
XA-4019-4	UVR MG-4 (time delay)	Lo voltage MG-4	None. However, if voltage continues to drop, automatic transfer to TVA will occur	Check MG-4 voltage, frequency, etc. Make adjustments if necessary.
XA-4019-5	UVR open on low breaker trip voltage UVR open on low 13.8 KV feeder control voltage 250v batteries low or breaker "W" open.	Lo voltage at any of the 4 locations in left column	Would prevent 480v equipment trip, or prevent transfer to AH feeder	Check operation of MG-1. Check fuses and breakers at 250v panel. Check condition of 250v batteries.
ACB-5				
XA-4020-1	TS-FV-103-1A2 KA-652C, TS-FV-103-3A2 (K-659A and K-660A)	FV-103 Hi & Lo temp. for thaw & freeze	Turns air on or off as required ECC-650-660	Check TX-3003-1-6, TX-3004, 1-6. Adjust air and see Table 3H.4.3-2, 3
XA-4020-2	KA-663C, KB-663C, KG-665D, (KA-670 & K-671)	FV-104, Hi, Lo temp. for thaw & freeze	Turns air on or off as required. Permissive to thaw ECC-661-671	Check TX-3002-1, TX-3005, 1-6, 19, TX-3006-1-6. Adjust air see Table 3H.4.3-2, 3, 4

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TABLE 3H4.2 (continued)

Location and Annunciator Number	Actuated by	Annunciates on (for set points see Switch Tab)	Control Action	Operator Action
<u>ACB-5</u>				
XA-4020-3	KA-674C, KB-674C, KA-675B, KB-675B, K-681A& K-682A	FV-105 Hi & Lo temperature	Turns air on or off as required. Permissive to thaw. ECC-672-682	Check TX-3002-2, TX-3005 7-12 TX-3006 7-12, TX-3005-20 See Table 3H.4.3-2, 3, 4
XA-4020-4	KA-685C, KB-685C, KA-686B, KB-686B, KA-692A & K-693A	FV-106 Hi & Lo temperature	Turns air on or off as required, permissive to thaw ECC-683-693	Check TX-3002-3, TX-3005 13-18 TX-3006 13-18. See Table 3H.4.3-2, 4
XA-4020-5	TS-3300	FV End Temperature Hi	None	Check TR-3300. Adjust heat
XA-4021-1	KA-762C, KB-762C, K-763B, K-769A & K-770A	FV-204 Hi & Lo temperature	Turns air on & off, permissive to thaw. ECC 760-770	Check TX-3002-10, TX-3003, 7-12 TX-3004, 7-12. See Table 3H.4.3-2, 3
XA-4021-2	KA-773C, KB-773C, K-774B K-780A and K-781A	FV-206. Hi & Lo temperature	Turns air on and off, permissive to thaw ECC 771-781	Check TX-3002-10, TX-3003, 13-18, TX-3004, 13-18 See Table 3H.4.3-3
XA-4021-3	KA-696B, KB-696B, KA-698D, K-703A & K-704A	FV-107. Hi & Lo temperature	Turns air on & off. Permissive to thaw ECC 694-704	Check TX 3002-4, TX 3007 1-6 TX 3008, 1-6. See Table 3H.4.3-2, 4, 5

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TABLE 3H4.2 (continued)

Location and Annunciator Number	Actuated by	Annunciates on (for set points see Switch Tab)	Control Action	Operator Action
ACB-5				
XA-4021-4	KA-707B, KB-707B, KB-709D, K-714A & K-715A	FV-108. Hi & Lo temperature	Turns air on & off. Permissive to thaw ECC 705-715	Check TX 3002.5, TX 3007 7-12 TX 3008, 7-12. See Table 3H.4.3-2, 4, 5
XA-4021-5	Spare			
XA-4022-1	KA-718B, KB-718B, KB-720D, K-725A & K-726A	FV-109. Hi & Lo temperature	Turns air on & off, permissive to thaw ECC 716-726	Check TX 3002-6, TX 3007 13-18 TX 3008, 13-18. See Table 3H.4.3-2, 4, 5
XA-4022-2	KA-729B, KB-729B, KB-731D, K-736A & K-737A	FV-110. Hi & Lo temperature	Turns air on & off, permissive to thaw ECC 727-737	Check TX 3002-7, TX 3009, 1-6 TX 3010, 1-6. See Table 3H.4.3-2, 5
XA-4022-3	KA-740B, KB-740B, KB-742D, K-747A & K-748A	FV-111. Hi & Lo temperature	Turns air on & off. Permissive to thaw ECC 738-748	Check TX 3002-8, TX 3009, 7-12 TX 3010, 7-12. See Table 3H.4.3-2, 5
XA-4022-4	KA-751B, KB-751B KB-753D, K-758A & K-759A	FV-112. Hi & Lo temperature	Turns air on & off. Permissive to thaw ECC 749-759	Check TX 3002-9, TX 3009, 13-18 TX 3010, 13-18. See Table 3H.4.3-2, 5
ACB-3				
XA-4026-1	FS-844A	Lo water flow to thermal shield	None	Adjust flow, check ECC 56, 58, & 475 & TE 845. May be necessary to drain & cool reactor

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TABLE 3H4.2 (continued)

Location and Annunciator Number	Actuated by	Annunciates on (for set points see Switch Tab)	Control Action	Operator Action
ACB-3				
XA-4026-2	FS-810A	Lo water flow to DT condenser #1	None	Adjust flow
XA-4026-3	FS-812A	Lo water flow to DT condenser #2	None	Adjust flow
XA-4026-4	TS-826	Hi treated water temperature	None	Check CTW flow, TIC-858, CT fans, etc.
XA-4026-5	K-113 from FS-830A	Lo water flow to FP motor	Time delay to stop FP	Adjust flow, check ECV-56, 58, & 475 & TE 831-1. May be necessary to stop FP
XA-4026-6	K-114 from FS-832A	Lo water flow to CP motor	Time delay to stop CP	Adjust flow, check TE 833-1, may be necessary to stop CP
XA-4026-7	FS-836A	Lo water flow to DT space cooler	None	Adjust flow, check cell temperature & pressure & ECC 53
XA-4026-8	FS-838A	Lo water flow to RC space cooler 1	None	Adjust flow, check cell temperature & pressure & ECC 53
XA-4026-9	FS-840A	Lo water flow to RC space cooler 2	None	Adjust flow, check cell temperature & pressure & ECC 53
XA-4026-10	PS-829B	Lo TW pump discharge pressure	None (Check Inst. Ap. ECC)	Start alternate pump. Check flows. Check ECC (TS pressure)
XA-4026-11	PS-851B2 K-143	Lo CTW pump discharge pressure	Switches DT steam dome condensors from CTW to PW	Start alternate pump & check flows
XA-4026-12	PS-882B	Lo process water pressure	None	Check back flow preventer, curtail unnecessary water usage so that cooling tower can be kept in operation
XA-4027-1	FS-851C	Lo CTW flow to treated water cooler	None	Adjust flow, start alternate CTW pump

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TABLE 3H4.2 (continued)

Location and Annunciator Number	Actuated by	Annunciates on (for set points see Switch Tab)	Control Action	Operator Action
ACB-3				
XA 4027-2	FS-873A	Lo TW flow to component gas cooler	None	Adjust flow, start alternate TW pump
XA-4027-3	FS-875A	Lo TW flow to CCP 1 & 2 oil coolers	None	Adjust flow, start alternate TW pump
XA-4027-4	FS-821A	Lo CTW flow to oil supply of fuel oil system	None	Adjust flow, start alternate CTW pump
XA-4027-5	FS-823A	Lo CTW flow to oil supply of coolant oil system	None	Adjust flow, start alternate CTW pump
XA-4027-6	LA FWT-1A or 2A	Lo feed water tank 1 or 2 level	None	This may indicate that drain tank steam domes are in service. Check temperatures. If not, add condensate to prescribed level
XA-4027-7	LA ST-A	Lo treated water surge tank level	Condensate will be added from condensate tanks.	Check condensate tanks levels and valving
XA-4027-8	PSS-844B2	Hi H_2O Pressure Reactor Thermal Shield	Closes TS cooling water inlet block valve	Check that FSV 847 is open also check rupture discs and reset FSV-844
XA-4027-9	LS NP	Lo nuclear instrument penetration water level	None	Physically check level & add water through line 848
XA-4028-1	PS-500E	Lo He storage tank pressure	None	Check He trailer-valve in emergency cylinders
XA-4028-2	PS-500B1 or B2	Hi-Lo He header pressure	None	Check PRV 500G
XA-4028-3	FS-500J	Hi He flow	None	Check FIC 500J - Curtail unnecessary usage
XA-4028-4	PS 500K	Lo treated helium surge tank pressure	None	Check FIC 500J - Curtail unnecessary usage

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Location and Annunciator Number	Actuated by	Annunciates on (for set points see Switch Tab)	Control Action	Operator Action
ACB-3				
XA-4028-5	PS 500 L-1 or L-2	Hi-Lo regulated He pressure	None	Check PCV-500C (or 605A). Change to alternate regulator. Curtail unnecessary usage
XA-4028-6	PS-508A	Hi rupture disc discharge pressure (Line 508)	None	Excess He leakage through relief valve may necessitate a shutdown
XA-4028-7	PS-506	Hi pressure at O_2 removal No. 2 (Line 506)	None	Relieve pressure. Replace rupture disc if necessary
XA-4028-8	PS-507	Hi pressure at O_2 removal No. 1 (Line 507)	None	Relieve pressure. Replace rupture disc if necessary
XA-4028-9	K-46F, K-47F, K-48F	Lo He supply pressure safety channels	Closes all He Supply block valves	Check He surge tank pressure, FIC-500J, He trailer supply pressure valve in Emergency He cylinders
XA-4028-10	K-400B K-404B K-408B K-412B K-416B, K-420B	Hi Heater temp. or open thermocouple at He treating station	Turns heater off and prevents restarting heater at He preheater, dryers, or O_2 removers	Adjust heaters or repair thermocouple. Consider changing helium treating station
XA-4029-1	LS-RC-C LS-RC-D	Hi level RC sump	None	Jet to liquid waste tank. Determine source and leak rate. Prepare for reactor shutdown
XA-4029-2	LS-DTC-A LS-DTC-B	Hi Level DTC sump	None	Jet to liquid waste tank. Determine source and leak rate. Prepare for reactor shutdown

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TABLE 3H4.2 (continued)

Location and Annunciator Number	Actuated by	Annunciates on (for set points see Switch Tab)	Control Action	Operator Action
ACB-3				
XA-4029-3	LS-PRT	Hi Level Pump Room Tank	None	If radioactive, pump to liquid waste storage tank. Otherwise pump to catch basin.
XA-4029-4	LS-FSC-A	Hi Level FSC Sump	None	Jet to Liquid waste storage tank
XA-4029-5	LS-PRS-C	Hi Level PR & CDC sump	Operates jet syphon in CDTC sump	Check sump pumps 1 & 2. Check 60# steam supply header in filter house
XA-4029-6	LS-SC-A	Hi Level Euipment storage cell sump	None	Jet to liquid waste storage tank
XA-4029-7	LS-TC-A	Hi Level spare cell	None	Jet to liquid waste storage tank
XA-4029-8	LS-WTC-A	Hi Level waste tank cell sump	None	Jet to Liquid waste storage tank
ACB-4				
XA-4030-1	PS 9001-1	Lo Instrument air pressure - MCB- 20 psig	None	Check pressure reducing valve and usage
XA-4030-2	PS 9002-1	Lo instrument air pressure transmitter room 30 psig	None	Switch to alternate PCV if possible
XA-4030-3	PS 9002-3	Lo instrument air pressure transmitter room 20 psig	None	Switch to alternate PCV if possible
XA-4030-4	PS 9002-4	Lo instrument air pressure transmitter room 20 psig	None	Switch to alternate PCV if possible

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TABLE 3H4.2 (continued)

Location and Annunciator Number	Actuated by	Annunciates on (for set points see Switch Tab)	Control Action	Operator Action
ACB-4				
XA-4030-5	PS 9003-1	Lo instrument air pressure maintenance control room 20 psig Hdr	None	Switch to alternate PCV if possible
XA-4030-6	PS 9004-1	Lo instrument air pressure service room 20 psig Hdr	None	Switch to alternate PCV if possible
XA-4030-7	PS 9005-2	Lo instrument air pressure water room 20 psig Hdr	None	Switch to alternate PCV if possible
XA-4030-8	PS 9005-1	Lo instrument air pressure water room 60 psig (Supplier WR, Filter Pit, & Chem. Processing)	None	Switch to alternate PCV if possible
XA-4030-9	PS 9000-1	Lo instrument air pressure Main Supply 80 psig Hdr	Starts alternate compressor	Check air compressors & air usage
XA-4030-10	PS 9013-1	Lo instrument air pressure block valve Hdr. 80 psig	None, however low pressure (<20 psig) causes block valves to fail in closed position	Check air compressors & emergency nitrogen
XA-4030-11	K-302 & K-307	AC-1, AC-2 permissive Hi temperature. Lo oil pressure	Hi Comp. temperatures, Lo oil pressure. Stops compressor	Check AC cooling water, oil level S-53 not manual

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TABLE 3H4.2 (continued)

Location and Annunciator Number	Actuated by	Annunciates on (for set points see Switch Tab)	Control Action	Operator Action
<u>ACB-4</u>				
XA-4031-1	PS 9007-3	Lo instrument air pressure MCB & transmitter room <18 psig	None	Check pressure, reducing valve & air usage. Switch to alternate PRV if possible
XA-4031-2	PS 9007-4	Lo instrument air pressure, transmitter room, 30 psig Hdr	None	Check pressure, reducing valve & air usage. Switch to alternate PRV if possible
XA-4031-3	PS 9007-1	Lo instrument air pressure, transmitter room & MCR 60 psig Hdr	None	Check pressure, reducing valve & air usage. Switch to alternate PRV if possible
XA-4031-4	PS 9008-1	Lo instrument air pressure, MCR & transmitter room, 20 psig Hdr	None	Check pressure, reducing valve & air usage. Switch to alternate PRV if possible
XA-4031-5	PS 9009-1	Lo instrument air pressure, Sampler Enricher 30 psig	None	Check pressure, reducing valve & air usage. Switch to alternate PRV if possible
XA-4031-6	PS 9010-1	Lo instrument air pressure service room 30 psig Hdr	None	Check pressure, reducing valve & air usage. Switch to alternate PRV if possible
XA-4031-7	PS 9010-2	Lo instrument air pressure service room 20 psig Hdr	None	Check pressure, reducing valve & air usage. Switch to alternate PRV if possible
XA-4031-8	PS 9011-1	Lo instrument air pressure water room, service room & filter pit - 60 psig	None	Check pressure, reducing valve & air usage. Switch to alternate PRV if possible

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TABLE 3H4.2 (continued)

Location and Annunciator Number	Actuated by	Annunciates on (for set points see Switch Tab)	Control Action	Operator Action
ACB-4				
XA-4031-9	PS-9011-2	Lo instrument air pressure water room. 30 psig	None	Check pressure, reducing valve & air usage. Switch to alternate PRV if possible
XA-4031-10	PS-9011-3	Lo instrument air pressure water room. 20 psig	None	Check pressure, reducing valve & air usage. Switch to alternate PRV if possible
XA-4031-11	PS-9011-4	Lo instrument air pressure water room. 30 psig	None	Check pressure, reducing valve & air usage. Switch to alternate PRV if possible
XA-4031-12	PS-9011-5	Lo instrument air pressure filter pit. 20 psig	None	Check pressure, reducing valve & air usage. Switch to alternate PRV if possible
XA-4032-1	PS-9011-6	Chem. process. Emergency instrument air header, lo pressure	None	Switch to alternate PCV
XA-4032-2	Spare			
XA-4032-3	Spare			
XA-4032-4	Spare			
XA-4032-5	Spare			
XA-4032-6	Spare			
XA-4032-7	Spare			
XA-4032-8	Spare			
XA-4032-9	Spare			
XA-4032-10	Spare			

Approved by [signature]

TABLE 3H4.2 (continued)

Location and Annunciator Number	Actuated by	Annunciates on (for set points see Switch Tab)	Control Action	Operator Action
ACB-4				
XA-4032-11	FS	Lo flow, Battery Room Exh	None	Check blower switch & power
XA-4032-12	FS	Lo flow, Induction Regulator	None	Check blower switch & power
SAMPLER-ENRICHER				
SE-1				
XA-4035-1	PS-590A	Lo pressure He supply	None	Check main He supply
XA-4035-2	PS-650C	Hi rupture pressure access port supply	None	Set PV-650A to 80 psig; Replace rupture disc
XA-4035-3	PS-509D	Lo Pressure Regulated He header	None	Check main He supply and PV-509B setting
XA-4035-4	PS-674A	Hi rupture pressure Regulated He header	None	Set PV-509B to 40 psig. Replace rupture disc
XA-4035-5	PS-664B	Lo pressure leak detector Header #1	None	Repressurize through HV-664 If pressure fails to rise, find leak

Approved by [signature]

TABLE 3H4.2 (continued)

Location and Annunciator Number	Actuated by	Annunciates on (for setpoints see Switch Tab)	Control Action	Operator Action
SE-1				
XA-4035-6	PS-644B	Lo pressure leak detector header #2	None	Repressurize through HV-644. If pressure fails to rise, find leak
SE-2				
XA-4036-1	K-360D	Lo buffer pressure to removal valve	Prevents opening access port, operating valve or maintenance valve	If not caused by opening valve, find leak and correct
XA-4036-2	K-369D	Lo buffer pressure to access port	Prevents opening operating valve, maintenance valve, or removal valve	If not caused by opening port, find leak and correct
XA-4036-3	K-363D & K-366D	Lo buffer pressure to operating & maintenance valve	Prevents opening access port, removal valve, or offgas lines	If not caused by opening valves, find leak and correct
XA-4036-4	K-393B	Hi Boot Pressure	Closes HSV677-A	If pressurizing, throttle HV-663
XA-4036-5	PdS-1Ce	Area 1C pressure greater than Area 3A	Prevents opening access port	Acknowledge alarm. No action unless 1C pressure rising rapidly
XA-4036-6	PS-683A	Lo pressure buffer header	None	Open HV-683, check He supply, look for leak
SE-3				
XA-4037-1	PS-1CE	Hi pressure Area 1C	None	Vent pressure to offgas system Find leak causing pressure rise
XA-4037-2	PS-AR3A	Hi pressure Area 3A	None	Vent pressure to offgas system Find leak causing pressure rise

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TABLE 3H4.2 (continued)

Location and Annunciator Number	Actuated by	Annunciates on (for set points see Switch Tab)	Control Action	Operator Action
SE-3				
XA-4037-3	PS-659A	Hi Pressure Area 2B	None	Find leak causing pressure rise
XA-4037-4	PS-522A3	Hi pressure fuel pump bowl	Closes HSV-680E, HSV-668B, HSV-655B, HSV-657D. Prevent opening access port, operating valve, or maintenance valve	Acknowledge alarm. Do not sample
XA-4037-5	RS-675A or RS-675B	Hi activity containment areas	Close HSV-678A, 678B, HSV-677A, ESV-542A, HSV-675A, HSV-659B, HSV-657D, HSV-668B, and HSV-655B	Reset the radiation indicator. Locate source of activity.
XA-4037-6	RS-678C or RS-678D	Hi activity offgas	None	Acknowledge alarm. Determine reason for high activity
MB #11 & NB1				
XA-4040-1	K-200C	Φ >12 Mw Channel #1	None, however two out of 3 channels give load set back & rod reverse	Check RSS-NSC1-A2
XA-4040-2	K-201C	Φ >12 Mw Channel #2	None, however two out of 3 channels give load set back & rod reverse	Check RSS-NSC2-A2
XA-4040-3	K-202C	Φ >12 Mw Channel #3	None, however two out of 3 channels give load set back & rod reverse	Check RSS-NSC3-A2

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Location and Annunciator Number	Actuated by	Annunciates on (for set points see Switch Tab)	Control Action	Operator Action
MB #11 & NB-1				
XA-4040-4	RXS-NCC-1-A3B	Period <10 sec	Rod reverse if not in Run Mode	Insert control rods
XA-4040-5	RXS-NCC2-A3B	Period <10 sec	Rod reverse if not in Run Mode	Insert control rods
NB-2				
XA-4041-1	TS-NRR1-A1 TS-NRR1-A2	Hi-temperature Control Rod #1	None	Shut down and drain reactor
XA-4041-2	TS-NRR2-A1 TS-NRR2-A2	Hi-temperature Control Rod #2	None	Shut down and drain reactor
XA-4041-3	TS-NRR3-A1 TS-NRR3-A2	Hi-temperature Control Rod #3	None	Shut down and drain reactor
XA-4041-4		Spare		
XA-4041-5		Spare		

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TABLE 3H4.2 (continued

Location and Annunciator Number	Actuated by	Annunciates on (for set points see Switch Tab)	Control Action	Operator Action
<u>NB-3</u>				
XA-4042-1	RS-827-A2 RS-827-B2 RS-827-C2	Cooling H_2O Hi Activity	Closes in-cell cooling water block valves	Locate & isolate source, open block valves if necessary. Initiate a drain
XA-4042-2	RS-OT1-B RS-OT2-B	Fuel & coolant salt pump oil supply Hi Activity	None	Violation of primary containment. Reduce power to zero
<u>NB-4</u>				
XA-4043-1	RS-596-A2 RS-596-B2 RS-596-C2	FP bubbler He supply Hi Activity	Closes He supply line to in-cell bubblers	Reduce power to zero and and consider draining
XA-4043-2	RS-500D	Helium gas supply Hi Activity	None	Determine source. Consider reducing power to zero and draining reactor
XA-4043-3	RS-557-A2 RS-557-B2	Fuel salt system offgas Hi Activity	Closes block valve in main offgas line to stack	Determine source and reduce power if necessary
XA-4043-4	RS-528-B2 RS-528-C2	Coolant salt system offgas Hi Activity	Reactor Drain & Stop FP	Check RS-528 to drain
XA-4043-5	RS-565-B2 RS-565-C2	Reactor cell air Hi Activity	Reactor Drain. Closes cell evacuation block valve	Initiate a drain

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Location and Annunciator Number	Actuated by	Annunciates on (for set points see Switch Tab)	Control Action	Operator Action
CHEMICAL PROCESSING Panel #1				
XA-4051-1	Spare			
XA-4051-2	PS-604C	Helium supply to Line 111 Lo pressure	None	Check He supply valve and and He supply pressure
XA-4051-3	FS-608A1	Helium to top of FST Low Flow	Closes HCV-690	Check He supply pressure and valves
XA-4051-4	PS-608B1	FST Hi pressure	Opens FST vent valve Closes FST He supply valve	Determine cause of Hi pressure. Check HCV-692
XA-4051-5	PdS-694-A2	Lo pressure Line 690	Opens HCV-694	Check flow from GSS
XA-4051-6	FS 940	Offgas low flow	Close HCV-692	Turn off H_2 supply valve. Check fans, duct flow, and 940 damper
CP Panel #2				
XA-4052-1	PS-690B	F_2 supply Hi Pressure	None	Check FST and CS pressure. Check for restriction downstream of PS-690 and that HCV-694 is closed
XA-4052-2	(Remote) PS-696-A	HF Supply Hi pressure	None	Check temperature of water bath. Turn off steam supply at GSS
XA-4052-3	TS HFH TS SOP TS FLP	HF heater Lo SO_2 pre-heater Hi F_2 pre-heater Hi	None	Check power to HF heater. Check SO_2 and F_2 flow, check for excessive power to heaters

Approved by [signature] 12/14/65

TABLE 3H4.2 (continued)

Location and Annunciator Number	Actuated by	Annunciates on (for set points see Switch Tab)	Control Action	Operator Action
<u>CP Panel #2</u>				
XA-4052-4	PS SFA-C1 PS CP3-B1	Hi pressure instrument cubicle Hi pressure absorber cubicle	None	Check to see that V979 is open. Check to see that cubicle blower is on and V-978 is open
XA-4052-5	PS-CS-A1	Hi pressure caustic scrubber	None	Check for restriction in line 628. Check N_2 flow to bubbler
XA-4052-6	RS-940G RS-CP3-A RS SFA-A RS-994	Hi activity in fuel-processing system	None	Check for source of activity and prepare for possible shutdown
<u>SCANNER PANEL</u>				
XA-4053-1	TS-5001-A	Hi-Lo temperature Scanner A	None	Check Scanner A temperature trace
XA-4053-2	TS-5002-A	Hi-Lo temperature Scanner B	None	Check Scanner B temperature trace
XA-4053-3	TS-5003-A	Hi-Lo temperature Scanner C	None	Check Scanner C
XA-4053-4	TS-5004-A	Hi-Lo Temperature Scanner D	None	Check Scanner D Lower load
XA-4053-5	TS-5005-A	Hi Lo temperature Scanner E	None	Check Scanner E Lower load
XA-4053-6	PS-5000-A	N_2 supply pressure Lo to scanner	None	Switch supply banks and change out empty cylinders

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TABLE 3H4.2 (continued)

Location and Annunciator Number	Actuated by	Annunciates on (for setpoints see Switch Tab)	Control Action	Operator Action
JUNCTION BOX #151				
XA-4054-1	LS-VT1-B1	Lo-water level Vapor Condensing Tank. FINAL	None	Prepare to shut down reactor and add water
XA-4054-2	LS-VT1-B2	Lo-water level Vapor Condensing Tank. INITIAL	None	Punch list for water addition during next shutdown
XA-4054-3	LS-VT1-B3	Hi-water level Vapor Condensing Tank. INITIAL	None	Check thermal shield rupture disc
XA-4054-4	LS-VT1-B4	Hi-water level Vapor Condensing Tank. Final	None	Prepare to shut down and remove water
XA-4054-5		Spare		
XA-4054-6	PS-VT1-C	Hi pressure Vapor Condensing Tank	None	Release excess pressure through V-984. Do not leave valve open

Approved by [signature]

CODE FOR TEMPERATURE SWITCHES, TABLE 3H4.3

The code letters or numbers listed describe the automatic control action and Operator action to be taken when a module alarm condition exists.

CONTROL ACTION DESCRIPTION

A Air Off

B None unless 1A1 or 3A1 exceeds setpoint at which time interlocks (1) shuts off FP and (2) precludes start mode.

C High air and green flashing light on at Freeze Valve switch when valve is in the freeze position.

D None

E Red flashing light on at freeze valve switch when valve is in thaw position.

F Prevents closing of cooling-air control valve thus prevents thaw of freeze valve

G Center Heater and red flashing light on at freeze valve switch when valve is in thaw position.

H Opens ESV-806A -- Water to Steam Dome of FD-1

I Opens ESV-807A -- Water to Steam Dome of FD-2

OPERATOR ACTION DESCRIPTION

1 Increase hold air (decrease heat as last resort).

2 Check air off (raise shoulder heater as last resort).

3 Lower hold air (increase heat as last resort).

4 None

5 Turn on or raise line-heater power. Check adjacent line temperatures.

6 Check other thermocouples of freeze flange. Possibly adjust heat on adjacent heaters.

7 Check other thermocouples on reactor neck. Possibly adjust coolant air flow.

8 Check Drain Tank temperature, possibly turn off heaters or lower setting.

9 Check lube oil cooling water, lube oil flows. Lower reactor power if necessary.

10 Check that MB-2 and MB-4 are on.

11 Increase FP heaters or prepare to shut down reactor.

TABLE 3 H.4.3 TEMPERATURE SWITCHES

Number	TE-No.	Description	Module Light: Above Set Point	Module Light: Below Set Point	Approximate Set Point[a] (°F)	Control Action	Operator Action
TX 3001-1	FF 100-1	Freeze Flange Temperature	Red	---	Hi 975	B	6
-2	FF 100-3	Freeze Flange Temperature	---	Red	Lo 700	B	6
-3	FF 101-1	Freeze Flange Temperature	Red	---	Hi 975	B	6
-4	FF 101-3	Freeze Flange Temperature	---	Red	Lo 700	B	6
-5	FF 102-1	Freeze Flange Temperature	Red	---	Hi 1050	B	6
-6	FF 102-3	Freeze Flange Temperature	---	Red	Lo 700	B	6
-7	FF 200-1	Freeze Flange Temperature	Red	---	Hi 975	B	6
-8	FF 200-3	Freeze Flange Temperature	---	Red	Lo 700	B	6
-9	FF 201-1	Freeze Flange Temperature	Red	---	Hi 975	B	6
-10	FF 201-3	Freeze Flange Temperature	---	Red	Lo 700	B	6
-11	R 42 B	Reactor Neck Temp. (lower)	Red	---	Hi 800	B	7
-12	R 45 B	Reactor Neck Temp. (upper)	Red	---	Hi 400	B	7
-13	R-33	Reactor Neck Temp. (lower	Red	---	Hi 300	B	7
-14	R 46 B	Reactor Neck Temp. (upper)	Red	---	Hi 400	B	7
15 & 16	FD-1-19B	Bayonette Temperature	Red	---	Hi 1300	H	8
17 & 18	FD-2-19B	Bayonette Temperature	Red	---	Hi 1300	I	8
-19							
-20							

[a]See Switch Tabulation for current set point. Switches with two temperatures alarm at the high temperature and clear at the low temperature.

Approved by [signature]

TABLE 3 H.4.3 (con't)

Number	TE-No.	Description	Module Light[b]		Approximate Set Point[a] (°F)	Control Action	Operator Action
			Above Set Point	Below Set Point			
TX 3002-1	FV 104-5A	Freeze valve pot temperature	---	Red	Lo 900	F	5
-2	FV 105-5A	Freeze valve pot temperature	---	Red	Lo 785	F	5
-3	FV 106-5A	Freeze valve pot temperature	---	Red	Lo 900	F	5
-4	FV 107-5A	Freeze valve pot temperature	---	Red	Lo 900	F	5
-5	FV 108-5A	Freeze valve pot temperature	---	Red	Lo 900	F	5
-6	FV 109-5A	Freeze valve pot temperature	---	Red	Lo 900	F	5
-7	FV 110-5A	Freeze valve pot temperature	---	Red	Lo 900	F	5
-8	FV 111-5A	Freeze valve pot temperature	---	Red	Lo 900	F	5
-9	FV 112-5A	Freeze valve pot temperature	---	Red	Lo 900	F	5
-10	FV 204-5A	Freeze valve pot temperature	---	Red	Lo 900	F	5
11 & 12	FD-1-20B	FD-1 Bayonette temperature	Amber	Green	Hi 1300	H	8
13 & 14	FD-2-20B	FD-2 Bayonette temperature	Amber	Green	Hi 1300	I	8
-15	705-1B	FP lube oil return	Red	---	Hi 150	B	9
-16	707-1B	FP coolant oil return	Red	---	Hi 150	B	9
-17	755-1B	CP lube oil return	Red	---	Hi 150	B	9
-18	757-1B	CP coolant oil return	Red	---	Hi 150	B	9
19 & 20	OFT-6A	Temperature at Bottom of Overflow tank	Green	Amber		D	11
TX 3003-1 &-2	FV 103-1A1	Shoulder temperature, outside box, Reactor side	Yellow	Green	Hi 960-910	C	1
-3 &-4	FV 103-2A1	Center temperature in air box	Green	Yellow	Lo 900	E	2

[b] Yellow light is alarm condition for freeze valve modules. Take operator action if alarm persists at equilibrium.

Approved by [illegible]

TABLE 3 H.4.3 (con't)

Number	TE-No.	Description	Module Light[b] Above Set Point	Module Light[b] Below Set Point	Approximate Set Point[a] (°F)	Control Action	Operator Action
TX 3003-5&6	FV 103-3A2	Shoulder temperature, outside [illegible]box DT side	Green	Yellow	Lo 620	A	3
-7&8	FV 204-1A1	Shoulder temperature, coolant system side	Yellow	Green	Hi 800-750	C	1
-9&10	FV 204-2A1	Center temperature	Green	Yellow	Lo 1000	E	2
-11&12	FV 204-3A2	Shoulder temp., C.D.T. side	Green	Yellow	Lo 650	A	3
-13&14	FV 206-1A1	Shoulder temperature, coolant system side	Yellow	Green	Hi 800-750	C	1
-15&16	FV 206-2A1	Center temperature	Green	Yellow	Lo 1000	E	2
-17&18	FV 206-3A2	Shoulder temp., C.D.T. side	Green	Yellow	Lo 650	A	3
-19	AD3-5B	Radiator duct temperature	Red	---	Hi 1000	B	10
-20	AD3-7B	Radiator duct temperature	Red	---	Hi 800	B	10
TX 3004-1&2	FV 103-1A2	Shoulder temp. — Reactor side	Green	Yellow	Lo 675	A	3
-3&4	FV 103-2A2	Center Temp., in air box	Yellow	Green	Hi 550	B	1
-5&6	FV 103-3A1	Shoulder temp., DT side	Yellow	Green	Hi 765-715	C	1
-7&8	FV 204-1A2	Shoulder temp., Coolant system	Green	Yellow	Lo 650	A	3
-9&10	FV 204-2A2	Center temperature	Yellow	Green	Hi 550	D	1
-11&12	FV 204-3A1	Shoulder temp., C.D.T. side	Yellow	Green	Hi 800-750	C	1
-13&14	FV 206-1A2	Shoulder temp., Coolant system side	Green	Yellow	Lo 650	A	3
-15&16	FV 206-2A2	Center temperature	Yellow	Green	Hi 550	D	1
-17&18	FV 206-3A1	Shoulder temp. C.D.T. side	Yellow	Green	Hi 800-750	C	1
TX 3005-1&2	FV 104-1A1	Shoulder temp. F.F.T. side	Yellow	Green	Hi 645-595	C	1
-3&4	FV 104-2A1	Center temperature	Green	Yellow	Lo 925	E	2
-5&6	FV 104-3A2	Shoulder temp. — Reactor side	Green	Yellow	Lo 700	A	3
-7&8	FV 105-1A1	Shoulder temp., F.D.T. side	Yellow	Green	Hi 900-850	C	1
-9&10	FV 105-2A1	Center temperature	Green	Yellow	Lo 825	E	2
-11&12	FV 105-3A2	Shoulder temp. Reactor side	Green	Yellow	Lo 845	A	3

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TABLE 3 H.4.3 (con't)

Number	TE-No.	Description	Module Light[b] Above Set Point	Module Light[b] Below Set Point	Approximate Set Point[a] (°F)	Control Action	Operator Action
TX 3005-13 &14	FV 106-1A1	Shoulder temp., F.D.T. side	Yellow	Green	Hi 750-700	C	1
-15&16	FV 106-2A1	Center temperature	Green	Yellow	Lo 950	E	2
-17&18	FV 106-3A2	Shoulder temp. reactor side	Green	Yellow	Lo 765	A	3
-19	FV 104-6A	Vertical line temperature Reactor side		Red	Lo 900	F	5
-20	FV 105-6A	Vertical line temperature Reactor side		Red	Lo 900	F	5
TX 3006-1&2	FV 104-1A2	Shoulder temp., F.F.T. side	Green	Yellow	Lo 520	A	3
-3&4	FV 104-2A2	Center temperature	Yellow	Green	Hi 550	D	1
-5&6	FV 104-3A1	Shoulder temp. reactor side	Yellow	Green	Hi 795-745	C	1
-7&8	FV 105-1A2	Shoulder temp. FD2 side	Green	Yellow	Lo 820	A	3
-9&10	FV 105-2A2	Center temperature	Yellow	Green	Hi 550	D	1
-11&12	FV 105-3A1	Shoulder temp., Reactor side	Yellow	Green	Hi 930-880	C	1
-13&14	FV 106-1A2	Shoulder temp., FD 1 side	Green	Yellow	Lo 670	A	3
-15&16	FV 106-2A2	Center temperature	Yellow	Green	Hi 550	D	1
-17&18	FV 106-3A1	Shoulder temp., Reactor side	Yellow	Green	Hi 865-815	C	1
TX 3007-1&2	FV 107-1A1	Shoulder temp., F.F.T. side	Yellow	Green	Hi 800-750	C	1
-3&4	FV 107-2A1	Center temperature	Green	Yellow	Lo 1000	E	2
-5&6	FV 107-3A2	Shoulder temp. L 110 side	Green	Yellow	Lo 600	D	3
-7&8	FV 108-1A1	Shoulder temp. FD 2 side	Yellow	Green	Hi 800-750	C	1
-9&10	FV 108-2A1	Center temperature	Green	Yellow	Lo 1000	E	2
-11&12	FV 108-3A2	Shoulder temp. L 110 side	Green	Yellow	Lo 600	D	3
-13&14	FV 109-1A1	Shoulder temp. FD 1 side	Yellow	Green	Hi 800-750	C	1
-15&16	FV 109-2A1	Center temperature	Green	Yellow	Lo 1000	E	2
-17&18	FV 109-3A2	Shoulder temp. L 110 side	Green	Yellow	Lo 600	D	3
TX 3008-1&2	FV 107-1A2	Shoulder temp. FFT side	Green	Yellow	Lo 600	D	3
-3&4	FV 107-2A2	Center temperature	Yellow	Green	Not in Use	D	4

Approved for Use [signature]

TABLE 3 H.4.3 (con't)

Number	TE-No.	Description	Module Light[b] Above Set Point	Module Light[b] Below Set Point	Approximate Set Point[a] (°F)	Control Action	Operator Action
TX 3008-5&6	FV 107-3A1	Shoulder temp. L 110 side	Yellow	Green	Hi 800-750	C	1
-7&8	FV 108-1A2	Shoulder temp. FD 2 side	Green	Yellow	Lo 600	D	3
-9&10	FV 108-2A2	Center temperature	Yellow	Green	Hi Not Used	D	4
-11&12	FV 108-3A1	Shoulder temp., L 110 side	Yellow	Green	Hi 800-750	C	1
-13&14	FV 109-1A2	Shoulder temp., FD 1 side	Green	Yellow	Lo 600	D	3
-15&16	FV 109-2A2	Center temperature	Yellow	Green	Hi Not Used	D	4
-17&18	FV 109-3A1	Shoulder temp., L 110 side	Yellow	Green	Hi 800-750	C	1
TX 3009-1&2	FV 110-1A1	Shoulder temp., L 110 side	Yellow	Green	Hi 800-750	C	1
-3&4	FV 110-2A1	Center temperature	Green	Yellow	Lo 1000	E	2
5&6	FV 110-3A2	Shoulder temp., F.S.T. side	Green	Yellow	Lo 600	D	3
-7&8	FV 111-1A1	Shoulder temp., Add. side	Yellow	Green	Hi 800-750	C	1
-9&10	FV 111-2A1	Center temperature	Green	Yellow	Lo 1000	E	2
-11&12	FV 111-3A2	Shoulder temp., L 110 side	Green	Yellow	Lo 600	D	3
-13&14	FV 112-1A1	Shoulder temp., L 110 side	Yellow	Green	Hi 800-750	C	1
-15&16	FV 112-2A1	Center temperature	Green	Yellow	Lo 1000	E	2
-17&18	FV 112-3A2	Shoulder temp., Waste side	Green	Yellow	Lo 600	D	3
TX 3010-1&2	FV 110-1A2	Shoulder temp., L 110 side	Green	Yellow	Lo 600	D	3
-3&4	FV 110-2A2	Center temperature	Yellow	Green	Hi Not Used	D	4
-5&6	FV 110-3A1	Shoulder temp., F.S.T. side	Yellow	Green	Hi 800-750	C	1
-7&8	FV 111-1A2	Shoulder temp., Add. side	Green	Yellow	Lo 600	D	3
-9&10	FV 111-2A2	Center temperature	Yellow	Green	Hi Not Used	D	4
-11&12	FV 111-3A1	Shoulder temp., L 110 side	Yellow	Green	Hi 800-750	C	1
-13&14	FV 112-1A2	Shoulder temp., L 110 side	Green	Yellow	Lo 600	D	3
-15&16	FV 112-2A2	Center temperature	Yellow	Green	Hi Not Used	D	4
-17&18	FV 112-3A1	Shoulder temp., Waste side	Yellow	Green	Hi 800-750	C	1

Approved by [signature]

5 JUMPER BOARD

On the MSRE there are many interlocking features of control circuits and safety circuits to prevent undesirable and dangerous events from taking place. To provide for necessary flexibility under other-than-normal operating conditions, provisions are made to by-pass certain interlocks under strict administrative control. The jumper board provides this flexibility along with a visual indication of the condition of all circuits represented thereon. The location of the jumper board in the main control room provides both accessibility and ease of administrative control of any jumpers used.

5.1 Design Criteria, from operations standpoint, are as follows:

5.1.1 Safety circuit isolation is maintained by means of by-passing relays. Instead of insertion of a jumper pin directly into the circuit, as with non-safety circuits, the safety jumper pin operates a relay which indirectly by-passes the circuit function.

5.1.2 The jumper board displays the condition of circuits by means of indicating lamps. These lamps (white) are placed between the schematic contacts of the circuits and will indicate whether the circuit to this point is energized or de-energized. A brief notation of the condition required to energize the circuit is given at each schematic contact.

5.1.3 All jumper board safety circuits are designed so that failures of jumper board components will not jeopardize operation of the circuits. The indicator lamps described above are connected with diodes in series so that current cannot "back feed" through the lamps to maintain a circuit. For further information on the hookup of these diodes (or check valves) see the maintenance elementary drawings of jumper board safety circuits. Note that all circuits are not thus provided.

5.1.4 Jumper pin openings in safety circuits are distinguished by their red color. The presence of a safety system (red)

5.1.4 (continued)

jumper is annunciated (MB-10, XA 4008-1) and also will prevent entry into "operate" mode. If system is already in "operate" mode, the insertion of a safety jumper will cause system to go to "off." Other jumpers (block openings) will not give an annunciation when inserted.

5.2 Use of Jumper Board

5.2.1 Although the jumper board is provided for flexibility of operation it must be remembered that the use of jumpers violates the normal designed operational interlock functions. The use of jumpers is under strict administrative control. No jumper should be inserted without the permission of the Operations Chief or Operations Department Head.

5.2.2 To determine the condition of the circuits shown schematically on the jumper board observe the white lights located between contacts. The notations at all of the contacts down to a particular lamp give the conditions which must be met for the lamp to be on. If all white lamps in a circuit are on the end condition lamp (red, green, or amber) will be on to signify the action or condition notation at the bottom of the circuit. Some circuits give condition when de-energized – e.g. circuits 20 and 21 indicate fill restrict condition when de-energized. The color of indicating lamps is also of significance. During power operation in RUN mode all RED lights will be OFF, all GREEN lights will be ON, the AMBER lights may be ON or OFF as required.

5.3 Other information displayed on the jumper board involves freeze valves and instrument power circuits.

5.3.1 The freeze valve permissive lights on the lower jumper board (#4) give indication of system conditions which would allow thawing of the particular valve. Note that these lights do not indicate permission to thaw from the standpoint of the valve itself – i.e temperature of pot or

5.3.1 (continued)

shoulders. For example – a permissive light on jumper board for fill valves (FV-104, FV-105, FV-106) requires that all transfer freeze valves be frozen and the ΔP between tank and the FP be low. For a permissive light on transfer valves requires that all fill valves be frozen, the tank pressure low, and the reactor system be empty of salt. For details on FV permissive lights see block diagram D-HH-B-57331 or circuit diagrams for the individual freeze valves.

5.3.2 The IPP (instrument power) lights on the lower board (#4) indicate whether or not power is available to certain circuits in IPP-1, IPP-2, and IPP-4. See Table 3H5.1 for listing of these circuits and what is supplied by them. For details on these and other instrument power circuits see Drawing E-HH-Z-41695.

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Table 3H5-1

INSTRUMENT POWER CIRCUITS INDICATED ON JUMPER BOARD #4

Panel No.	Fed by	Circuit	Equipment On Circuit
IPP-1	48v DC	1	Safety Circuits
		2	Safety Circuits
		3	Safety Circuits
		4	Safety Circuits
		6	Safety Circuits
		7	Safety Circuits, Channel #3
		8	Control Circuits
		9	Control Circuits
IPP-2	MG-4 or TVA BUS 4	1	FV-103, FV-104, FV-105, FV-106
		2	FV-107, FV-108, FV-109 FV-110, FV-111, FV-112
		3	FV-204, FV-206
		4	AC#1, FOP#1, COP#1
		5	AC #2, FOP#2, COP#2
		7	Safety Circuits, Channel #1
		8	Radiator Load Control
		9	Control Rod Drives
IPP-4	TVA BUS 3	1	Safety Circuits, Channel #2

6 OTHER INSTRUMENTS

6.1 FqI-569-A, Reactor Cell Air Bleed Line Flow Totalizer (Wet Test Meter)

This instrument will be used to measure the amount of reactor cell and drain-tank cell in-leakage by bleeding it off to the containment stack. It is connected in parallel with line 565 which connects the component coolant pump discharge to the containment stack inlet. After the reactor and drain-tank cells have been brought to the desired operating pressure, HV-565-C will be closed and flow established through FqI-565-A to maintain the containment cell pressure within proper limits.

The instrument is an American Meter Controls, Inc. standard precision, positive displacement, wet test meter with a capacity of 5ℓ/min.

	Init.	Date/Time
6.1.1 Preparing the meter for use:		
6.1.1.1 Level the meter by adjusting the leveling screws at the base until the bubble in the spirit level is exactly in the center.	_____	_________
6.1.1.2 Fill the meter with distilled water until the water level is slightly above the tip of the pointer in the gage glass.	_____	_________
6.1.1.3 Make sure all connections are tight.	_____	_________
6.1.1.4 After the reactor cell leak rate has been determined, open HV-569-A ____ and HV-569-B ____ and close HV-565-C ____. Throttle HV-569-B until the flow rate through rotameter FI-569 is equal to the		

	Init.	Date/Time
6.1.1.4 (continued) cell leak rate plus the cell nitrogen-purge rate. Cell leak rate ____ + cell nitrogen-purge rate ____ = ____ ℓ/m through FI-569. Pass the gas to be measured through the wet test meter until the water is saturated. At normal rates of flow and room temperature, the approximate time required is one hour for a meter in which the water or gas has been changed.	____	____
6.1.1.5 Disconnect the tubing leading to the meter so that both inlet and outlet are under atmospheric pressure. Draw off water through the small pet cock at the base of the water line gage until the center of the concave meniscus in the gage glass coincides exactly with the tip of the pointer. Usually this may best be accomplished by viewing the pointer through a magnifying glass from below with the aid of a flashlight, if necessary. The image of the pointer will be visible on the underside of the meniscus and the tip of the image should just touch the tip of the pointer when sufficient water has been withdrawn.	____	____
6.1.1.6 Reconnect the tubing.	____	____
6.1.1.7 Place meter in service.	____	____

	Init.	Date/Time
6.1.1.8 For extended runs, the gas entering the meter should pass through a saturator to prevent a change of liquid level in the meter during the run. Fill saturator with distilled water.	_____	_______

6.1.2 Reading the instrument:

6.1.2.1 One revolution on the large dial is 1 liter. Subdivisions are 0.01 liter. The totalizing dials read 10,000 liters, maximum.

6.2 AO_2-566-A, Reactor Cell Oxygen Analyzer

The purpose of this instrument will be to monitor the oxygen concentration in the reactor and drain-tank cell atmosphere and to provide a means for calculating the containment cell in-leakage. A bypass flow will be circulated through the analyzer which is connected in parallel with line 566, the return line from the reactor cell air-bleed line to the component cooling pump suction.

The instrument is a Beckman Instruments, Inc., model F3, oxygen analyzer that continuously measures oxygen concentration in gaseous streams based on the magnetic susceptibility of the gas being analyzed. Two ranges, 0 to 10% and 0 to 25% are provided; and the accuracy is claimed to be ± 1% of full scale.

The general formula for calculating the leak rate is taken from Section 3E 1.2 B(3) of the Operating Procedures:

$$L_R = \frac{538 \frac{T_1}{P_1} (F_2 - F_1) + 12\ WF_1}{t\ (0.2 - F_2)}\ ft^3/day$$

F_1 and F_2 = oxygen analyzer readings at beginning and end of test (fraction of oxygen in containment atmosphere)

L_R = Leak rate, ft^3/day

P_1 = absolute pressure in containment at beginning of test, psia

t = time duration of test, hrs

T_1 = absolute temperature at beginning of test, ^oR

W = evacuated gas rate at FqI-569-A, ft^3/hr

6.2.1 Operating Controls

The instrument is provided with three operating controls: the Range Switch, the Zero Control, and the Span Control. The Range Switch sets the zero point of the scale and the Span Control sets the span point, a reference point at the opposite end of the scale from the zero point. The setting to which the operator must turn the Zero Control in order to establish a correct zero point (down scale standardization point) depends on several factors, two of the most important of which are the particular response

6.2.1 (continued)

characteristics of the individual instrument and the magnetic susceptibilities of the various background gases in the sample.

Similarly, the setting to which the operator must turn the Span Control in order to establish a correct span point (up scale standardization point) depends on several factors, of which the one most subject to change is the pressure in the analysis cell. This pressure can vary because of a change in either the pressure at which the incoming sample enters the instrument or the pressure against which the outgoing sample is discharged. If both Span and Zero Control adjustments are to be made, the zero adjustment must be made first.

6.2.2 Reference Gases

For calibration, the instrument requires two reference gases -- a zero gas and a span gas -- each of accurately known oxygen content.

6.2.2.1 Zero Gas

The terms "zero point" and "zero gas" as applied to the analyzer, are used in a specialized sense. The two terms, which relate to the electronic circuitry, refer to the potential on the suspension. The zero point is a reference point on that end of the readout scale which corresponds to a potential of zero on the suspension; the zero gas is a reference gas, the oxygen content of which is such that this gas can be used to establish the zero point. Note that the term "zero point" is not synonymous with "zero-percent oxygen point." Although in some instruments these two points coincide, in others they do not. In this instrument, zero voltage on the suspension corresponds to a reading at the low endpoint of the scale.

The zero gas (nitrogen) used with this instrument has an oxygen content of zero, or very nearly zero.

6.2.2.2 The Span Gas

The span point is set with a gas having a known oxygen content. Clean dry air, which contains 20.93% oxygen, is a convenient span gas; however, the span gas that will be used was specially made up and analyzed spectrographically. This gas, which contains 4.82% oxygen, will be used to set the span point of the analyzer.

6.2.3 Preliminary Procedure

Supply power to the instrument for 24 hours before standardizing it. This warm-up period is necessary because a reliable calibration can be obtained only after the analyzer has reached a stable operating temperature. Moreover, the resultant elevated temperature will help to prevent moisture from condensing in the analysis cell and damaging it. After the instrument has reached operating temperature, run gas through it until the reading ceases to drift. Ordinarily, approximately one hour will be required.

	Init.	Date/Time
6.2.3.1 Close or check closed the following valves: HV-566-A1 ______ HV-566-A2 ______ Zero gas valve _____ Span gas valve _____	_____	________
6.2.3.2 Instrument turned on at _____	_____	________
6.2.3.3 At least 24 hours after the instrument was turned on and with CCP No. 1 or No. 2 running, open or check open the following valves: HV-566-A1 ____ HCV-566-A2 ____ HV-566-A2 ____ HCV-566-A3 ____ HCV-566-A1 ____ HCV-566-A4 ____	_____	________

	Init.	Date/Time
6.2.3.4 Set back-pressure regulator to control at 1 atmosphere.	____	______
6.2.3.5 Close or check closed zero gas and span gas valves.	____	______
6.2.3.6 Open or check open sample valve ____, analyzer bypass valve ____, and turn the 3-way valve (ahead of analyzer FI) to sample gas position ____. Using sample valve and analyzer bypass valve, adjust flow of sample gas to analyzer to 250 cc/min. and 22 psia.	____	______
6.2.3.7 Pass gas through the analyzer until reading ceases to drift, but for at least one hour before taking readings.	____	______

6.2.4 Calibrating Instrument

Calibration of the instrument consists of two procedures, the zero-point adjustment and the span-point adjustment.

6.2.4.1 Zero Adjustment

6.2.4.1.1 Close HV-565-A1 ____, the sample gas valve ____, and the analyzer bypass flow valve ____.	____	______
6.2.4.1.2 Set the range switch to the lower range.	____	______
6.2.4.1.3 Open or check open HCV-566-A3 ____, and -A4 ____, and HV-566-A2 ____.	____	______
6.2.4.1.4 Set back-pressure regulator to control at 1 atmosphere.	____	______

6.2.4.1.5 Turn the 3-way valve to the zero gas position ____, open

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	Init.	Date/Time
6.2.4.1.5 (continued) the zero gas valve ____ and set the zero gas flow to 250 cc/min. at 22 psia ____.	____	____
6.2.4.1.6 Allow zero gas to purge the analyzer for a minimum of three minutes.	____	____
6.2.4.1.7 Set zero control so that reading shown by recorder or indicator is equal to oxygen content of zero gas.	____	____
6.2.4.1.8 Close the zero gas valve.	____	____
6.2.4.2 Span Adjustment		
6.2.4.2.1 Set the range switch to the upper range if air is used as the span gas, or to the lower range if the special span gas is used.	____	____
6.2.4.2.2 Turn the 3-way valve to the span gas position ____, open the span gas valve ____ and set the span gas flow to 250 cc/min. at 22 psia ____.	____	____
6.2.4.2.3 Allow span gas to purge the analyzer for a minimum of three minutes.	____	____
6.2.4.2.4 Set span control so that reading shown by recorder or indicator is equal to oxygen content of span gas: 20.93 if air is used, or 4.82 if special span gas is used.	____	____

	Init.	Date/Time
6.2.4.2.5 Close span gas valve.	____	____

6.2.5 Routine Operation

After standardizing the instrument, run the sample gas through it at the same flow rate at which the zero and span gases were admitted. The instrument will automatically and continuously record the oxygen content of the sample:

6.2.5.1 Open or check open the following valves:

HV-566-A1 ____ HCV-566-A2 ____
HV-566-A2 ____ HCV-566-A3 ____
HCV-566-A1 ____ HCV-566-A4 ____ ____ ____

6.2.5.2 Close or check closed the zero gas ____ and span gas valves ____. ____ ____

6.2.5.3 Turn the 3-way valve to the sample gas position ____, open the analyzer bypass flow valve ____, and open the sample gas valve ____. ____ ____

6.2.5.4 Set the back pressure regulator to control at 1 atmosphere. ____ ____

6.2.5.5 Using the analyzer bypass valve and the sample gas valve, adjust the flow of gas through the analyzer to 250 cc/min. at 22 psia. ____ ____

6.3 PdE-RC-E, Reactor Cell Differential Pressure Element (Hook Gage)

This instrument will be used to measure the differential pressure between the reactor and drain tank cell and the four reference volumes located in the cells for determining the containment cell in-leakage. It is identified as an F. W. Dwyer Mfg. Company No. 1420 transparent Hook Gage.

The general formula for calculating the leak rate is taken from Section 3E 1.2 B(2) of the Operating Procedures:

$$L_R = \frac{5.25 \times 10^5}{t} \frac{\Delta P}{T\ avg.} + \frac{24\ W}{t} - 24\ N\ ft^3/day$$

short test time, where

L_R = leak rate, ft^3/day
t = time duration of test, hrs
ΔP = change in pressure from beginning to end of test, psi
N = nitrogen purge rate, ft^3/hr
W = evacuated gas rate at FqI-569-A, ft^3/hr
T avg = average cell temperature, ^oR

	Init.	Date/Time
6.3.1 Close the valves to the reactor cell and to the reference volumes.	____	______
6.3.2 Open the equalizing valve between the two columns of the gage. Be certain no air is contained in the connecting tube between the wells. Bleed by slightly loosening the machine screw plug if necessary.	____	______
6.3.3 Check level before using. Set both micrometers at zero position.	____	______
6.3.4 Loosen both zero adjustment locking rings and turn hook handles until both hooks just dimple water surface. (observing from below, the bright		

Init. Date/Time

6.3.4 (continued)

mirror-like surface of the water will slightly distort at the moment of contact, or the image of the pointer will be visible on the underside of the meniscus and the tip of the image should just touch the tip of the hook). Lock zero adjustment rings, making sure both micrometers still read zero. ____ ____

6.3.5 Close equalizing valve and open the valves to the reactor cell and reference volumes. Turn both micrometers until each hook again dimples the water surface. Read each micrometer, and add the readings together:

left micrometer ____ in.
right micrometer ____ in.
total ____ in. ____ ____

6.4 A-Be-A-AD3, Beryllium Monitors

There will be two beryllium monitors in use, one in the vent house, and one in the high bay. Although these will be their normal locations, the monitors can be moved to other areas if desired. The instrument located in the vent house, designated the ORNL beryllium monitor model 1, will be used to monitor the air in the radiator stack when the reactor is operating, and the coolant-cell atmosphere during maintenance periods. This is a spectrographic monitor in which the air being sampled is drawn through a spark which excites any beryllium atoms which are present. The resulting ultraviolet radiation that is emitted is spectrographically analyzed for the characteristic beryllium wavelength. The beryllium concentration in the air is displayed on a strip chart on the instrument.

The other beryllium monitor, a model Sa-103 made by the National Spectrographic Laboratory, will normally be used in the southeast corner of the high bay. Air is drawn into the unit through a filter paper tape that moves under the arc of a spectrograph which analyzes the light emission for the characteristic beryllium wavelength. The beryllium concentration is integrated and recorded on a strip chart on the instrument.

6.4.1 ORNL Beryllium Monitor Model 1

6.4.1.1 General Precautions

6.4.1.1.1 Always assume that the air sampling system is beryllium contaminated. Use appropriate caution.

6.4.1.1.2 To avoid blowback of beryllium dust in the piping system, never operate the auxiliary air blast unless the sampling blower is on.

6.4.1.1.3 Never leave the spark supply voltage on unless spark discharges are occurring, as the spark transformer may be destroyed.

	Init.	Date/Time
6.4.1.2 Operation		
6.4.1.2.1 Check sample piping connections and exhaust piping connections for tightness.	____	________
6.4.1.2.2 Connect the power cord to a suitable source of 115 volt 60 cycle ac.	____	________
6.4.1.2.3 Check for adequate air pressure by adjusting the regulator to the rear of the right-hand side of the left-hand cabinet. An indication of 1 - 2 scale divisions on the air pressure gage above the regulator is satisfactory. Use a mirror to read the gage if necessary.	____	________

Approved by [signature]

	Init.	Date/Time
6.4.1.2.4 Turn "Power" switch on. "Power On" light comes on, sampling and cooling blowers start.	____	______

CAUTION: Do not leave air on unless blowers are running.

6.4.1.2.5 Turn "Spark Power" switch on. Spark starts, "Spark On" light comes on, "Spark Transformer Primary Current" meter indicates 3.0 to 3.5 amperes.	____	______
6.4.1.2.6 Recorder starts inking.	____	______
6.4.2 National Spectrographic Laboratory Model Sa-103 Beryllium Monitor		
6.4.2.1 Check tape mechanism to be sure paper is not fouled.	____	______
6.4.2.2 Check sample piping connections for proper installation, especially the slipjoint above the tape advancing mechanism.	____	______
6.4.2.3 Connect the power cord to a suitable source of 115 volt 60 cycle ac.	____	______
6.4.2.4 Turn both standby switches to "on" position, and turn master switch to "on" position.	____	______
6.4.2.5 After allowing the electronic circuits to warm up (~ 2 minutes), zero the instrument:		

NOTE: If spark light is on, wait until it goes out before proceeding to zero the instrument.

6.4.2.5.1 Turn black knob to "calibrate" position and zero the meter with the potentiometer marked "calibrate."	____	______

	Init.	Date/Time
6.4.2.5.2 Depress zero check and adjust meter to zero with potentiometer marked "zero."	_____	_____
6.4.2.5.3 Reset black knob to "integrate" position.	_____	_____
6.4.2.6 If filter-paper tape runs out, place both standby switches in "standby" position.	_____	_____
6.4.2.7 If reload light is on, check condition of filter-paper tape. Reset by momentarily turning off the master switch.	_____	_____

6.5 Cover Gas Oxygen Analyzer

A 100 cc/min. stream of helium cover gas is passed through a Lockwood and McLorie, Inc. model O-1000 oxygen analyzer to determine the oxygen concentration in the cover gas. The analyzer electrolytically determines the oxygen in the sample stream by first reducing it according to the equation

$$O_2 + 2H_2O + 4\ e \rightarrow 4OH^-,$$

and then measuring the electrolysis current. The amount of current is directly proportional to the oxygen concentration in the sample and is indicated on a meter on the instrument.

6.5.1 General Precautions

6.5.1.1 The potassium hydroxide used in the various cells of the analyzer should be handled carefully. After the analyzer is in operation, the reagent is in a pressurized system making the caustic even more hazardous. Do not disconnect sample lines, cells, or any fittings in the analyzer without first depressurizing the analyzer. Wear goggles or safety glasses when handling the caustic. Flush with copious amounts of water any areas of the skin, clothing, or working spaces accidently brought into contact

6.5.1.1 (continued)
with the reagent. Follow with a dilute acetic acid or vinegar rinse.

6.5.1.2 The lid on the reagent tank should be kept on at all times. The valve with the red handle at the base of the prescrubber should never be opened when the prescrubber is under pressure.

6.5.2 Operation

	Init.	Date/Time
6.5.2.1 Prescrubber Cell		
6.5.2.1.1 Fill the stainless steel reagent reservoir with about 1000 cc of 25% KOH solution.	_____	_________
6.5.2.1.2 Open toggle valve with white handle. Then open toggle valve with red handle. Observe drain at bottom of analyzer case or transparent plastic section in drain line. When reagent is observed flowing down the drain, close valve with red handle, then valve with white handle in that order.	_____	_________
6.5.2.1.3 To change reagent after analyzer has been in operation, shut down analyzer by closing off both the sample and reference gas lines. Depressurize the system by opening valve on the trap at the lower left-hand side of the analyzer. Open toggle valve with white handle slowly, then open valve with blue handle. When the cell has been completely		

	Init.	Date/Time
6.5.2.1.3 (continued) drained, close valve with blue handle. To refill, repeat procedure in above paragraph.	____	____
6.5.2.2 Set Up		
After the performance checks have been carried out as per the following instructions, the analyzer can be switched to the unknown sample gas.		
6.5.2.2.1 Make certain drain valve at the bottom of the 1/4" pipe nipple trap on the left side of the analyzer is closed.	____	____
6.5.2.2.2 Open valve in sample line or reference gas line, if used, on right-hand side of case. Open this valve <u>slowly</u>. If the valve is opened rapidly, the solution in the cell may be blown forward into the connecting lines and flow control system creating a maintenance problem.	____	____
6.5.2.2.3 Adjust the gas flow through the analyzer to 300 cc/minute.	____	____
6.5.2.2.4 The recorder will be reading off scale at this point due to the high concentration of oxygen in the analyzer. Reduce the "Span Adjust" setting until the recorder just comes on scale.	____	____
6.5.2.2.5 As the analyzer is gradually purged of air, the recorder reading will decrease. The "Span		

Init. Date/Time

6.5.2.2.5 (continued)
Adjust" setting may at the same time be increased if it is desired. ____ ____

6.5.2.2.6 After a period of time, the recorder indication will level out at some value representing the oxygen content of the sample. ____ ____

6.5.2.2.7 Reduce flow rate to 100 cc/minute and wait until recorder again levels out. ____ ____

6.5.2.3 Performance Check

Since under normal operating conditions, the analyzer performs in accordance with Faraday's law, the following sensitivities can be expected at 1 atmosphere at 25°C.

Flow Rate	Sensitivity per ppm O_2
50 cc/min	13.15 Microamps
100 cc/min	26.3 Microamps
150 cc/min	39.45 Microamps
200 cc/min*	52.6 Microamps
250 cc/min*	65.75 Microamps
300 cc/min*	78.9 Microamps

*For samples containing more than 100 ppm O_2, the analyzer should not be operated at flow rates greater than 150 cc/minute in order to avoid appreciable deviation from quantitative behavior. On occasion, certain silver electrodes may also deviate somewhat from quantitative behavior at lower concentrations with flow rates over 200 cc/min. while others will perform well up to 400 cc/min. In a properly functioning analyzer, all

6.5.2.3 (continued)

electrodes exhibit good quantitative behavior up to 200 cc/min. with gases below 100 ppm.

6.5.2.3.1 Span Adjustment

After the recorder has leveled out, the span may be adjusted in accordance with the above sensitivities.

To illustrate, if the flow rate is 100 cc/min., the sensitivity of the analyzer will be 26.3 microamps per ppm O_2.

With a 5 mv recorder and a desired full scale range of 20 ppm, the adjustment of the span adjustment potentiometer may be calculated as follows. Substitute in Ohm's Law.

Where E = Recorder full scale range in volts

R = Resistance in analysis cell circuit

I = Desired full scale range in amps,

Therefore $\frac{5\text{mv}}{1000} = R \times \frac{(20 \text{ ppm} \times 26.3 \text{ microamps})}{1,000,000}$

or R = 9.5 ohms.

Since the span adjustment potentiometer is 25 ohms with a dial of 1000 divisions, 380 divisions on the dial would be equivalent to 9.5 ohms (0.380 x 25 = 9.5) or the resistance required to give a full scale range of 20 ppm at a flow rate of 100 cc/min. Similar calculations can be made for other ranges and flow rates or see Appendix II for different ranges. Therefore,

$\mu a = \frac{\% \text{ scale}}{\text{span}} \times 2 \times 10^3$.

6.5.2.3.2 Zero Check

The above span adjustment does not take into account the zero or background current of the instrument. Normally, this zero or background

6.5.2.3.2 (continued)

amounts to about four to six microamps and may be disregarded except in the most critical applications.

The zero or background of the instrument may be checked as follows:

The method is based on the fact that when no gas is flowing through the instrument, there should be no output from the cell. When no gas is flowing, any reading on the recorder then is the zero or background of the instrument.

Step	Init.	Date/Time
6.5.2.3.2.1 Set the recorder span adjustment at 380 (20 ppm, or 760, 10 ppm).	_____	_________
6.5.2.3.2.2 Place a tubing cap over the vent of the analyzer or close shut-off valve in the vent line if provided.	_____	_________
6.5.2.3.2.3 Even through the flowmeter reads zero, there still may be appreciable flow through the electrode to give a false zero. Sufficient time should be allowed for the pressure to equalize on both sides of the silver electrode.	_____	_________
6.5.2.3.2.4 Leaks may also cause false or high zero readings in that they will permit a flow through the		

Init. Date/Time

6.5.2.3.2.4 (continued)
analysis cell even though the analyzer is apparently shut down.

6.5.2.3.2.5 The analyzer should not be left without gas flowing through the analysis cell for any appreciable length of time as the silver electrode may become plugged. The flow should only be closed off sufficiently long to accomplish a suitable no-flow zero and then returned to normal operating conditions. _____ _________

6.5.2.3.2.6 Occasionally, after the zero has been checked by the no-flow method, the analyzer will become noisy when returned to its normal operating conditions. This noise can usually be removed by setting the flow rate to a maximum for a short period and then returning it to its normal flow rate. If the noise does not disappear, after several hours, it means the electrode has become plugged and will require cleaning or replacing. _____ _________

Init. Date/Time

6.5.2.3.2.7 If a suitable zero is not obtained, consult the procedures to follow under trouble shooting, Section 6 of the manufacturer's instruction book. ______ ________

6.5.2.3.3 Sensitivity Check

The sensitivity of the analyzer may be checked by use of the coulometric generator which will add oxygen to the sample stream.

6.5.2.3.3.1 The span of the analyzer should be adjusted so that the full-scale range of the instrument is at least 10 ppm greater than the oxygen content of the sample or reference gas. It is preferable to use a reference gas of stable oxygen content rather than the sample. Set flow rate at 100 cc/min. ______ ________

6.5.2.3.3.2 Turn coulometric generator switch to the on position. ______ ________

6.5.2.3.3.3 Set the coulometric generator adjustment so that the meter on the control box reads 263 microamps, the equivalent of 10 ppm. ______ ________

	Init.	Date/Time
6.5.2.3.3.4 Within a minute the reading on the recorder will begin to rise.	____	______
6.5.2.3.3.5 Allow the recorder to level off.	____	______
6.5.2.3.3.6 The point at which the recorder levels off should represent about 80% of the calculated amount of oxygen that was added by the generator. In other words, the recorder will only increase about 8 ppm above the analysis of the sample or reference gas.	____	______
6.5.2.3.3.7 If the recorder shows only a corresponding rise of less than 5 ppm or 50%, see Section 6, on trouble shooting, and Section 6.2, Loss of Sensitivity, of the manufacturer's instruction book.	____	______
6.5.2.4 Analysis of Sample Gas		
6.5.2.4.1 After the above zero and sensitivity checks have been performed and familiarization is gained with the operation of the analyzer, the analyzer may be shifted over to the sample line.	____	______
6.5.2.4.2 The reference gas valve should be shut off and the valve in the sample line opened <u>slowly</u>.	____	______

Init. Date/Time

6.5.2.4.3 Even though the sample may contain a low amount of oxygen, chances are the analyzer will run off scale because of atmospheric oxygen in the sample line. This will eventually purge out of the system and the recorder will level out at a point representing the analysis of the sample stream. _____ _______

6.5.2.4.4 The span of the recorder should be set at the desired level following the procedure outlined in Step 6.5.2.4 or by refering to the table in Appendix II of the manufacturer's instruction book. In critical applications, the zero can also be compensated for either by deducting the zero from the final analysis or by compensating for the zero in making the span adjustment. _____ _______

6.6 Cover Gas Moisture Analyzer

A 100 cc/min. stream of helium covergas is passed through a Manufacturers Engineering and Equipment Corporation (Meeco) model W electrolytic moisture analyzer to determine the moisture concentration in the cover gas. The moisture is absorbed from the gas stream flowing through the electrolytic cell and an electrolytic current is established. This current depends on the rate of absorption of moisture and is directly connected with decomposition of this moisture. The decomposition products, hydrogen and oxygen, are carried off in the gas system. The metering circuitry is arranged so that the meter reads in parts per million by volume of moisture in the gas stream.

Init. Date/Time

6.6.1 Operation

6.6.1.1 Adjust the sample flow depending on which meter is in use as follows:

Meter Number	Sample Inlet Pressure, psig	Flowmeter Setting
1527	----	95
1764	0	102
1764	10	70
1764	20	53
1764	30	43

6.6.1.2 Turn the analyzer power switch on and set the range switch to the maximum range position. For standard range operation, this is 1000 ppm. An off-scale indication will occur during the initial dry-down period. This is normal. Leave the power switch on.

6.6.1.3 Depress the power check test button and note that the power supply is 70 ± 5 volts.

6.6.1.4 Depress the cell check test button and note that the cell voltage is >2 volts.

6.6.2 Reading the Instruments

Since the analyzers are presumed to operate in accordance with Faraday's law, the reading is directly proportional to the mass of water passing through the cell per unit time. If C = concentration of water, F = sample flow, and I = current

6.6.2 (continued)

or meter reading, the I = KCF, where K incorporates all necessary conversion factors. If F, sample flow, is maintained constant, the reading is directly proportional to the concentration. This is the normal mode of operation since concentration in ppm H_2O may be read directly <u>only</u> when a constant flow is maintained. The range of the meter may be varied by varying the sample flow rate: assume the moisture level is constant at 500 ppm with the range set on 0-1000 and a normal flow of 100 cc/min.; the reading would be 50% of full scale. Now assume that the flow is cut to 50 cc/min. The throughput of water would be 1/2 as much and the reading should drop to 25% of full scale. Since the moisture content of the gas did not change, the full scale range would then be four times 500, or 2000 ppm. Thus, the actual full scale range is inversely proportional to the flow rate:

$$\text{actual range} = \text{indicated range} \times \frac{100}{\text{actual flow rate}},$$

where indicated range means the range at 100 cc/min. For example, if the range is set at 1000 and the flow is set at 10 cc/min., the actual range would be

$$1000 \times \frac{100}{10} = 10,000.$$

Changes in ambient temperature usually affect the reading because of disturbance of the absorbed moisture equilibrium.

3I FREEZE VALVE OPERATION

Isolation of the salt in the MSRE drain, circulating, and processing systems is controlled by freezing a short plug of salt in a flattened section of 1 1/2" pipe called a "freeze valve." A combination of cooling air piped to a shroud attached to the flattened section of pipe and electrical heaters adjacent to the freeze valve is used to freeze or thaw the valve. Siphon break pots are provided on one or both sides of the freeze valves to prevent blowing all the salt out of the valve during transfers and drains.

The electrical heat is manually controlled for the desired condition. The coolant air is automatically switched between "off," "hold" and "blast" condition by temperature moduler or switches which obtain signals from thermocouples attached to the center or either shoulder of the freeze valve. In the "thaw" condition, all air is turned off. In the hold condition, sufficient air is supplied to the valve to keep it frozen. On FV's 104 and 107 through 112, the amount of air is manually adjusted using HIC's which throttle the cooling air valves. On FV's 103, 105, 106, 204 and 206, temperature indicator controllers are provided which regulate the "hold" cooling air to maintain a constant freeze valve shoulder temperature. The temperature setpoint is manually adjustable. When the temperature controller is in the manual position, it functions like the HIC's on the other freeze valve.

1 DEFINITIONS & CRITERIA

1.1 Deep Frozen

When a freeze valve is deep frozen, the cooling air will be turned off and the salt frozen by lowering or turning off the electrical heaters.

Fluorine evolution can occur if salt which is in a high radiation field is cooled below 400°F. Therefore FV 104 through 109 will be maintained above this temperature. The upper limit has been arbitrarily set at about 600°F.

Freeze valve 103 is emptied completely during a drain and therefore can be cooled to ambient temperature. Freeze valves

1.1 (continued)

110, 111, 112, 204 and 206 can also be cooled to ambient temperature since they are located in cells having less radiation.

1.2 Frozen

Freeze valves are considered frozen when the heaters, cooling air and temperature controllers have been adjusted so that a frozen plug exists and turning off the cooling air will thaw the valve. Freeze valves 103, 204 and 206 have an additional requirement that they must thaw within 15 minutes if electrical power fails.

1.3 Thawed

A freeze valve is considered thawed when all portions of it are above the freezing point of the salt. In general, the heaters will be on and the cooling air off.

2 BASIC OPERATION AND INTERLOCKS

2.1 Freeze

On each freeze valve, modules 1A1, 1A2, 3A1 and 3A2 are in circuits which control the cooling air flow to the valve.

If the freeze valve is in the normal thawed condition and the manually operated valve switch is set to freeze, the green light at the switch on the main control board will start flashing. The red light will also be on until the center valve temperature drops to Module 2A1 setpoint (~ 1000°F). When switched to freeze blast air flow will come on and stay on until the both shoulder temperatures drop to Module 1A1 and 3A1 setpoints (~ 750°F). At this point Module 1A1 and 3A1 open circuits which stops the high air flow but lets the hold air flow to continue. The green light will be on steady. As each shoulder temperature decreases below 850°F, its module green light comes on and the amber light goes off. Hold air flow will be automatically regulated to maintain the preset temperature on FV 103, 105, 106, 204 and 204. On other freeze valves, the hold air is adjusted manually.

2.1 (continued)

If the valve shoulder temperatures continue to decrease to ~ 650°F, either module 1A2 or 3A2 with either 1A1 or 3A1 will stop all air flow, and the amber module light will be on until the temperature increases to above this setpoint. Temperature above ~ 800°F will actuate the 1A1 or 3A1 module and turn on the high air to prevent valve melt-out. The green light will start flashing. Either module can actuate the high air mechanism and the air will continue on until both shoulder temperatures decrease to normal conditions.

Modules 1A1 and 3A1 have ~ 50F hysterisis; and therefore, if the air flow is adjusted to hold the shoulder temperatures between ~ 650 and 800°F, no alarm or control action should occur. For a control action to be initiated by a freeze valve requires that a combination of 2 modules be in alarm - either 3A1 and 1A1, 3A1 and 2A2, or 1A1 and 2A2.

2.2 Thaw Operation

When the manual operating switch is turned to thaw, all air to the valve is cut off, the red indicating light starts flashing, and the green light is on until both shoulder temperatures reach approximately 800°F (Modules 1A1 and 3A1).

When the 2A1 module thermocouple reaches the setpoint (~ 1000°F), the red light at the freeze valve switch will stop flashing and be a steady red.

2.3 Additional Interlock

In addition to the FV control modules, interlocks are provided to prevent thawing when the syphon break (pots) or vertical pipe on either side of the freeze valve are below 1000°F and when there is excessive ΔP between the drain tank and the circulating system.

3 OPERATION OF FREEZE VALVES

3.1 Adjustment and Startup

All freeze valves can be adjusted so that turning the freeze valve switch on the main board is all that is necessary

3.1 (continued)

to change from normal thawed to normal frozen position or from normal frozen to normal thawed position. To accomplish this, the heaters are first adjusted to obtain desired temperatures with the freeze valve in the thawed position. The freeze valve control is then switched to the freeze position and the air flow controllers set to control the desired temperatures. (For details see 4I.)

3.2 Normal Operation of Freeze Valves

During reactor shutdowns, salt transfers or additions may be made. The transfer freeze valves, FV 107 through 112, will be adjusted as described in 3.1. Thawing or freezing will be done using the freeze valve switch. After a transfer and prior to freezing a valve, it will be necessary to adjust differential pressures to assure that salt is in the flat portion of the freeze valve. Details of this are covered in other sections of this report. During shutdown periods, FV 103 through 106 and 204 and 206 will be deep frozen.

During a startup, FV 103, 104, 204 and 206 will be thawed to allow filling the reactor and coolant system. FV 105 through 112 will be deep frozen. During circulation of flush and coolant salt, FV 103, 204 and 206 will be in the normal frozen condition. After the flush salt is drained, FV 104 will be deep frozen. FV 105 or 106 will be thawed to fill the fuel system with fuel salt. After filling and during all power operations, FV 103, 204 and 206 will be normally frozen, FV 105 and 106 will be thawed, and FV 107 through 112 will be deep frozen.

3J LIQUID WASTE SYSTEM

The liquid waste system is designed to accumulate and dispose of radioactive aqueous waste material. Facilities are provided for sampling, diluting, neutralizing, and transferring these to the Melton Valley waste handling system. This system is also used for clarifying the shielding water used in the decontamination cell and tank.

Waste handling procedures are given in the following sections.

1 JETTING REACTOR CELL AND DRAIN TANK CELL SUMPS

Any water which accumulates in the sumps of the reactor or drain tank cells is removed by air jets which discharge to the liquid waste storage tank. These jets are permanently mounted in the drain tank cell. Pumping is started by simultaneously opening the air supply valve and air operated discharge valves. The operation must be well coordinated because opening either air supply or jet discharge valves prematurely allows air to be blown or sucked into the cells which are normally below atmospheric pressure.

The sumps would be jetted as part of the reactor startup procedure if there is any liquid in them and during operations whenever a high sump level is indicated. The procedure requires two technicians. Details are given below:

1.1 To Jet the Reactor Cell Sump to the Waste Tank

	Init.	Date/Time
(Transmitter Room)		
1.1.1 Record sump level, LIA-RC ______	______	______
1.1.2 Record waste tank level LI-WT ______	______	______
(Remote Maintenance Practice Cell)		
1.1.3 Check that waste blower is on.	______	______
(Water Room)		
1.1.4 Open block valve, V-332A.	______	______
1.1.5 Adjust PCV-332 to 30 psig.	______	______
1.1.6 Open V-332C and blow out any accumulated moisture. Close V-332C.	______	______

Approved by [signature]

	Init.	Date/Time
1.1.7 Jet sump by simultaneously opening V-332B (water room) and FCV-333A1 and A2 (HS-333A1 in Pos 4 TB 9). The two operators should be in contact by the intercom system and should notify the control room when jetting is started and stopped.	____	________
1.1.8 Stop jetting when LIA-RC reads zero or when PI-332 pressure drops or fluctuates, indicating loss of liquid suction. Close V-332B and then immediately close FCV-333A1 & A2 (HS-333A1 in Pos. 2 TB 9).	____	________
(Transmitter Room)		
1.1.9 Record levels LIA-RC _____, LI-WT_____	____	________
1.2 To Jet Drain Tank Cell Sump to the Waste Tank		
(Transmitter Room)		
1.2.1 Record level of LIA-DTC ______	____	________
1.2.2 Record level of LI-WT ________	____	________
(Remote Maintenance Practice Cell)		
1.2.3 Check to be sure waste blower is on.	____	________
(Water Room)		
1.2.4 Open valve V-332A.	____	________
1.2.5 Adjust PCV-332 to 30 psig.	____	________
1.2.6 Open V-332C and blow out any accumulated moisture. Close V-332C.	____	________
1.2.7 Jet sump by simultaneously opening FCV-343A1 & A2 (HS-343 A1 Pos 4 TR Panel 9) and V-342 (in water room). The two operators should be in contact with each other on the intercom system, and should notify the control room when jetting is started and stopped.	____	________

	Init.	Date/Time
1.2.8 When pump is empty, as indicated by zero level on LIA-DTC, or fluctuation in pressure of PI-332 (PCV), stop jetting by closing V-342 and immediately close FCV-343A1 and A2 (HS-343 A1 Pos. 2).	____	________
(Transmitter Room)		
1.2.9 Close air supply valve, V-332A ____.	____	________
1.2.10 Record time and level of LIA-DTC. ______	____	________
1.2.11 Record level of LI-WT ______.	____	________

2 SAMPLING REACTOR AND DRAIN TANK CELL SUMPS

The reactor and drain tank cell sumps are sampled during jetting by bypassing the flow from the jets through a sample bomb attached to lines 334 and 344. Details are given below:

NOTE: Protective clothing, rubber gloves, and a face shield shall be worn during the sampling. All sampling operations shall be monitored by Industrial Hygiene and Health Physics personnel.

(Remote Maintenance Practice Cell)

	Init.	Date/Time
2.1 Attach a liquid waste sampling bomb between lines 334 and 344.	____	________
2.2 Open V-334 and 344.	____	________
(Transmitter Room)		
2.3 Set valves to sample sumps as follows:		
2.3.1 To sample Reactor sump, open FCV-333A1 and close FCV-333A2 (HS-333A Pos. 1) and open FCV-343A2 (HS-343A1 Pos. 3) and keep it open while jetting reactor cell sump as given in 3J-1.1.	____	________

	Init.	Date/Time
2.3.2 To sample drain tank sump, open FCV-343A1 and close FCV-343A2 (HS-343 A-1) Pos 1 and open FCV-333A2 (HS-333 A-1 Pos 3) and keep it open while jetting Drain Tank cell sump as given in 3J-1.2.	____	________

(Remote Maintenance Practice Cell)

	Init.	Date/Time
2.4 When jetting is complete close V-334 and 344, and bomb valve.	____	________
2.5 Cautiously remove sample bomb. Catch drippings and put these into the liquid waste storage tank. Have Health Physics coverage.	____	________

3 JETTING AUXILIARY CELL SUMPS

The sumps in the fuel processing cell, equipment storage cell, liquid waste cell, and spare cell have steam jet pumps for the transfer of liquid to the waste tank. Each of these sumps will be emptied when a high level for that sump is annunciated. All process cell sumps have a common annunciator on the main control board (XA 4000-1) and individual indicator lights in the auxiliary control room (XA 4029) which can be deactivated to clear the common alarm. Details of jetting these sumps are given below.

(840 Level)

	Init.	Date/Time
3.1 Open V-311 at the 60-psi steam header.	____	________
3.2 Record name of cell ______ sump level _______ and liquid waste tank level ________ (see table below).	____	________
3.3 Open jet supply valve (see table below).	____	________
3.4 When jetting is complete, close jet supply valve.	____	________
3.5 Record sump level _______ and liquid waste tank level _________.	____	________

Cell	Level Indicator	Jet Supply Valve
Fuel Processing	LIA-FSC	V-321
Equipment Storage	LIA-SC	V-317
Liquid Waste	LIA-WTC	V-315
Spare	LIA-TC	V-319

4 BUILDING SUMP OPERATION

The main building sump, with a bottom at the 812-ft level, is accessible from the pump room located below the Special Equipment Room. The sump serves the building floor drains and French drains. There are two 1-1/2 hp sump pumps which are started and stopped automatically by integral float level switches. One starts pumping when the water level reaches 815' 8" and the other 816 ft. elevation. A start switch located at Col. C-9, 852-ft level, must be on to activate both sump pumps. Normally no operator action is required. A high sump level will be alarmed, LA-PRS-A, at 818 ft 6 in. elevation. This alarm can indicate pump trouble, pumps off or just insufficient pumping capacity. The sump alarm is connected to the common alarm, XA 4000-1, on the main control board with the cell sumps and individual indicator module on XA 4029 in the ACR. A switch activates a high coolant cell sump level alarm and energizes a solenoid valve, LCV 809 to a 1 in. steam jet located in the coolant drain cell at elevation 818' 6". This jet takes suction from coolant drain cell sump which has a bottom elevation of 817 ft., and is connected to the building sump at the 818 ft. elevation. The float level switch turns off jet when level drops to the 818 foot elevation.

The steam supply is through V-309 at the 100 psi steam reducing station, north of the filter house. The jet discharges to the sewer in the west tunnel. No level indicator is provided.

5 PIT PUMP OPERATION

The pit pump, located in the pump room, is used to transfer water from the 55-gal. tank in the pump room to the waste tank. The 55-gal. drum receives water from the ventilation stack and filter pit, and may be contaminated. A transfer should be made whenever an alarm occurs on LAPRT (XA 4029). To transfer, open valves V-SD and V-326 in the pump room and close V-325 and V-330. Start the pump from Col. C-9 on the 852-ft level. The pump should be stopped when the transfer is completed. If a large quantity of water accumulates in this tank and a radiation survey indicates no activity, the water can be pumped to the catch basin by closing V-326 and opening V-330. If activity is found in the main building sump, the pit pump can be used to pump from the sump to the waste tank by closing valve V-SD and opening V-325 and V-326. The pit pump can be used to empty the reactor cell annulus or the charcoal bed cell into the catch basin by V-330 and either V-329 (RC annulus) or V-328 (CB cell).

If the water is contaminated it can be pumped to the waste tank by opening V-326 and closing V-330.

6 TREATMENT AND DISPOSAL OF WASTE TANK CONTENTS

The general procedure for handling the contents of the waste tank will be to circulate and sample contents, dilute if activity is too high (>5 curies/gal.), adjust pH to >7 by caustic addition, mix thoroughly, resample, and transfer to Melton Valley Waste Station.

	Init.	Date/Time
6.1 Circulation and Sampling of Waste Tank Contents (Remote Maintenance Practice Cell)		
6.1.1 The following valves should be closed or checked closed. V-302 ______, V-305A ______, V-303B ______ V-305B ______, V-307 ______.	_____	__________
6.1.2 The following valves should be opened or checked open. V-300 ______, V-301 ______.	_____	__________
6.1.3 Check waste blower on ________.	_____	__________

Approved by R H Guymon

	Init.	Date/Time
6.1.4 Start waste pump ______. Check waste pump area for radiation.	____	________
6.1.5 Throttle V-301 until PI-305 reads 35 psi.	____	________

NOTE: Operator should wear protective clothing and face shield and have a health physics survey during sampling.

6.1.6 After circulating the waste tank contents for one hour or more, carefully flush 1 liter through the sample line, and take two 200-cc samples at V-305B. Take samples approximately 30 minutes apart.	____	________
6.1.7 Submit to the laboratory for total activity (millicuries/cc), pH, and vol of 0.1N NaOH to neutralize 100 cc of sample.	____	________
6.1.8 Put flush back into the waste storage tank via the caustic addition funnel.	____	________

6.2 Dilution of Waste Tank Solution

If the waste tank sample analysis for total activity is >1.3 millicuries/cc, dilute the contents by the following procedure.

(Transmitter Room)

6.2.1 Record LI-WT level, ____ft = V_1 _____gal.	____	________
6.2.2 Calculate final vol = V_2(ft) = $\frac{V_1 C_1 \text{ (analysis)}}{1.3 \text{ millicuries/cc}}$ V_2 = ________ft.	____	________

(Remote Maintenance Practice Cell)

6.2.3 Stop waste pump.	____	________

Approved by [signature]

	Init.	Date/Time
6.2.4 Close the following valves: V-300 ______, V-302 _____, V-303B ______, V-305A ______, V-305B ____, V-306 _______.	_____	__________
6.2.5 Open the following valves: V-306A _____, V-307 _____, V-301 _______.	_____	__________
(840 Level, North End)		
6.2.6 Open V-819 to start process water addition.	_____	__________
6.2.7 Close V-819 to stop water addition when LI-WT indicates the proper increase in level.	_____	__________
(Transmitter Room)		
6.2.8 Record LI-WT = _____ft. (V_2).	_____	__________
6.3 Neutralization of Waste Tank Solution		
If neutralization is necessary, proceed as follows:		
6.3.1 From sample analysis, calculate pounds of NaOH to neutralize contents of waste tank as follows: 3.5×10^{-4} XY = lb of NaOH to add. Y = vol of liquid in waste tank, gal. X = vol of 0.1 NaOH to neutralize 100-cc sample.	_____	__________
(High Bay)		
6.3.2 Dissolve NaOH calculated above in water and add to waste tank through funnel in the high bay (L-339). Wear face masks, rubber gloves, and rubber apron while handling caustic.	_____	__________
6.3.3 Rinse out line 339 with water following caustic addition.	_____	__________
6.4 Resampling		
If neutralization is not necessary circulate and sample waste tank per Section 6.1.	_____	__________

Approved by *[signature]*

	Init.	Date/Time
6.5 Transfer to Melton Valley Waste System		
6.5.1 Call Melton Valley Waste Station (Telephone _____________) and report activity, pH, and volume to be pumped.	_____	__________
6.5.2 When permission to transfer is obtained, set valves as follows:		
(Remote Maintenance Practice Cell)		
V-300 open ________		
V-301 closed _______		
V-302 closed _______		
V-303B closed ______		
V-305A closed ______		
V-305B closed ______		
V-307 closed _______	_____	__________
(Transmitter Room)		
6.5.3 Record WT level ________	_____	__________
(Remote Maintenance Practice Cell)		
6.5.4 Start the waste pump.	_____	__________
6.5.5 Throttle V-305A to give flow acceptable at Melton Valley Waste Station. PI-305 should not exceed _____psig. See curve in calibration book.	_____	__________
6.5.6 When desired amount has been transferred, stop pump.	_____	__________
6.5.7 Close V-300 and 305A.	_____	__________
(Transmitter Room)		
6.5.8 Record waste tank level ______.	_____	__________

7 CLARIFICATION OF DECONTAMINATION TANK OR DECONTAMINATION CELL LIQUID

A waste filter has been provided to clarify the water in the decontamination tank (or cell) to improve visibility for inspection or underwater repairs.

NOTE: This is a sand and gravel filter and should not be used to filter acid solution.

Approved by [signature]

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	Init.	Date/Time

To clarify water in the Decontamination Tank (Decontamination Cell valves in parentheses) proceed as follows:

(Remote Maintenance Practice Cell)

7.1 Check that the waste pump is off. ______ ______

7.2 Check valves as follows:

(High Bay)

306C (or 306D) closed ______

303A (or 304) closed ______

306D (or 306C) open ______

304 (or 303A) open ______ ______ ______

(Remote Maintenance Practice Cell)

300 closed ______

301 closed ______

305A closed ______

305B closed ______

302 closed ______

306A open ______

307 open ______

306B open ______

303B open ______ ______ ______

7.3 Start waste pump. Adjust flow to 30 gpm on FI-306 by opening V-302 and throttling V-307. (Check periodically and keep flow adjusted to 30 gpm.) ______ ______

7.4 Record pressures of PI-302 ______ PI-306 ______
Record ΔP (PI-302 minus PI-306) ______
(<5 psi). ______ ______

7.5 Upon completion of filtration or when filter $\Delta P \geqq 5$ psi, stop the waste pump. ______ ______

7.6 Close the following valves:
V-302 ______, V-303B ______, V-306B ______,
V-306A ______, V-307 ______. ______ ______

Init. Date/Time

(High Bay)

7.7 Close V-306D _____, (V-306C), _____
V-304 (V-303A) _________. _____ __________

8 BACKWASH OF THE WASTE FILTER

Use process water to backwash filter to waste tank. Proceed as follows:

(Remote Maintenance Practice Cell)

8.1 Close the following valves:
V-300 _____, V-305A _____, V-305B _____,
V-306A ____, V-307 ______, V-308 ______. _____ __________

8.2 Open V-302 ______, V-301 _______. _____ __________

(Transmitter Room)

8.3 Record LI-WT. _____ __________

(841 Level, North end)

8.4 Open V-819 very slowly (2 to 5 min) until PI-819 reaches 15 psi. Check ΔP of PI-306-PI-302 <6 psi = (~ 140 gpm). _____ __________

(Transmitter Room)

8.5 Check rate of level increase on LI-WT _____. _____ __________

(Remote Maintenance Practice Cell)

8.6 Catch a sample at V-305B every 5 minutes. (Flush sample line before sampling. Add flush to waste tank via the caustic addition funnel in high bay.) _____ __________

(840 Level, North End)

8.7 When sample is clear, or after 15 minutes of flushing, start closing V-819. Take 2 to 5 minutes to close V-819 to allow filter bed to settle slowly. _____ __________

(Remote Maintenance Practice Cell)

8.8 Close V-302 ______, V-301 _______. _____ __________

9 GENERAL DECONTAMINATION AND CLEAN UP

Periodically the building should be checked for contamination by health physicists and industrial hygienists. When radioactive contamination or beryllium is found, the area should be isolated and marked. A survey should be made to determine source of contamination or beryllium. A cleanup should be started as soon as practical. Where water will not damage equipment in the area, plenty of hot water, detergent, scouring powder or soap should be used to scrub the area. Then the area should be rinsed. This procedure should be repeated as necessary until the area is approved by health physics.

Caution should be used to prevent spread of the contamination. Contaminated or beryllium containing water should be put into the liquid waste storage tank through the caustic addition funnel in the high bay.

Electrical equipment, instruments, and panels containing equipment which cannot be wetted, should be wiped clean with damp sponges and detergent or scouring powder and followed by a damp sponge rinse. Many repetitions of washing and rinsing may be required. Used sponges, etc. should be put into the hot Dempster Dumpster or hot cans provided.

Equipment having porous coverings, such as insulation which would absorb moisture should be cleaned, using an approved vacuum cleaner. When possible the air from the vacuum cleaner should be discharged into a ventilation duct.

3K Be MONITORING SYSTEM

The Be Monitoring system consists of four units which take air samples from various areas of the MSRE facility and the Be concentration in the sample is determined. The operation and maintenance of this system is the responsibility of the IH (Industrial Hygiene) Department; however, the operations group will provide assistance as described in the following parts of this procedure.

1 GENERAL BUILDING AIR SAMPLING SYSTEM

1.1 One of the units consists of two air pumps, only one of which is in operation at any one time, with 15 sample points connected to it. The sample points are located as shown on dwg. D-ZZ-Z 56399. Each has a paper-type filter which removes the particulate matter from the air sample drawn through it. The filter is removed and analyzed for Be periodically by the IH Department. The MSRE Operations personnel will check the air pumps periodically to assure that one is operating and pulling a vacuum of $\sim$ 1.8" Hg. If the pump has stopped, the standby pump will be started and the IH Department informed of the failure. A low vacuum (<1.8" Hg.) would indicate an open line on the pump suction side or the pump is not operating properly. In this event the operating pump will be stopped, the standby pump started and the IH Department notified. If the trouble can be corrected by personnel available when it is discovered, it will be done. This pump becomes the standby pump when the trouble is corrected.

2 VENTILATION SYSTEM AIR SAMPLING

2.1 The second unit consists of a small air pump with the single sample point. It also uses a paper-type filter to collect the particulate matter and takes the air sample from the main building ventilation duct upstream of the filter pit. It is operated in essentially the same manner as the 15 sample point system. Since there is no standby pump, any trouble developing will be corrected as soon as it is practical. The IH Department

2.1 (continued)

will be notified of any difficulties developing.

3 NSL Be AIR MONITORING UNIT

3.1 The third unit consists of an NSL Be Air Monitor. This instrument collects an air sample from the duct upstream of the ventilation filter pit and makes an analysis for Be concentration once per hour automatically. A local alarm occurs if the Be concentration is ≥ 2 $\mu g/m^3$. Operations personnel will check the instrument periodically and inform the IH Department as soon as possible if an alarm has occurred due to a Be level. If the alarm is due to instrument trouble and the shift instrument mechanic cannot correct it, the IH Department will be informed as soon as possible if it occurs between the hours of 0800 and 1630. Otherwise, it will be put on standby and the IH Department informed at 0800. Operations personnel will check and service the instrument in accordance with the instructions of the IH Department.

4 COOLANT SYSTEM STACK Be MONITORING UNIT

4.1 The fourth unit is an Atomic Instrument Co. Be Air Monitor which normally monitors the air in the coolant system stack. The instrument is located in the vent house and takes its air sample through a tube connected to the stack. During shutdown operations it can be connected to tubes which take the air sample from the coolant cell. This will be done during maintenance operations which require that the salt containing pipe and equipment be opened. Air samples are taken and analyzed on a continuous basis. A high Be level (≥ 2 $\mu g/m^3$) or instrument trouble will give an alarm in the CR. If it is due to instrument trouble which the shift instrument mechanic cannot correct or a high Be level, the IH Department will be notified as soon as possible regardless of the time when the alarm occurs. The instrument will be checked and serviced by the operations personnel as instructed by the IH Department.

Approved by [signature] 8/3/65

SECTION 4

AUXILIARY SYSTEMS STARTUP CHECK LISTS

Successful operation of the reactor depends upon all essential equipment and instrumentation functioning properly. Prior to each startup all equipment is checked to assure that it is in the proper operating condition, all necessary motors are started, all valve and breaker positions are set and operational tests are made on all essential instrumentation.

The check lists covering these operations are given in this section. Items are listed by systems rather than chronologically and except where there is interdependence these can be completed in any order. Where possible items are grouped by areas to facilitate completion of the lists.

All operations listed must be completed before each reactor startup unless their deletion is approved by the operations chief.

Approved by [signature]

4A ELECTRICAL STARTUP CHECK LIST

The purpose of this section is to prepare the electrical system for startup, that is; motors are ready to be turned on, diesel ready for remote start and heaters ready to be turned on from heater control panel.

	Init.	Date/Time
1 ELECTRICAL CHECK LIST (EXCLUDING HEATERS)		
1.1 Main Control Board		
Note that breakers are energized as indicated by lights at push buttons.		
Stack Fan 1 and 2 (SF 1 and 2)	____	______
Component Coolant Pump 1 and 2 (CCP 1 and 2)	____	______
HCV 930A (BKR G3-13)* and HCV 930B (BKR G3-14)*	____	______
HCV 935* (T-2-S)	____	______
Coolant Oil Pumps 1 and 2 (COP 1 and 2)	____	______
Radiator Blowers MB1 and MB3	____	______
Duct Annulus Blowers MB2 and MB4	____	______
Radiator Bypass Damper	____	______
Coolant Pump	____	______
Fuel Pump	____	______
Fuel Oil Pumps 1 and 2 (FOP 1 and 2)	____	______
Treated Water Pumps 1 and 2 (TWP 1 and 2)	____	______
Cooling Tower Pumps 1 and 2 (CTP 1 and 2)	____	______
Tower Fans 1 and 2 (TF 1 and 2)	____	______
Coolant Cell Coolers 1 and 2 (CCC 1 and 2)	____	______
Reactor Cell Coolers 1 and 2 (RCC 1 and 2)	____	______
Drain Tank Cell Cooler (DCC 1)	____	______
Component Coolant Pump No. 3 (CCP 3)	____	______
Instrument Air Compressor No. 1 and No. 2 (AC 1 and 2)	____	______
1.2 Console Control Power Breakers		
Control Rod Drives 1, 2, and 3	____	______

*If breaker lights are not on, check closed breakers at switch house.

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	Init.	Date/Time
1.2 (continued)		
Radiator Door Drive Motor	____	______
Radiator Door Brake	____	______
Radiator Door Clutch	____	______
1.3 13.8 kv Panel (Auxiliary Control Room)		
Note that circuits are energized by lights.		
Pref. Line Potential	____	______
Switch 129 Closed and Energized	____	______
Emergency Line Potential	____	______
Switch 229 Open and Energized	____	______
Manual, Auto Switch set to automatic	____	______
Breaker 108 On and Tagged On	____	______
TD-1 - Switches A through J closed	____	______
TD-2 - Switches A, B, D through J closed	____	______
Lock out Light Off	____	______
North of Building		
Motor to Switch 129 connected	____	______
Motor to Switch 229 connected	____	______
1.4 Diesel Panel (Auxiliary Control Room)		
DPM3 S Closed ___ A-1 Closed ___ A-5 open ___	____	______
DPM4 T Closed ___ A-2 Closed ___ A-3 open ___	____	______
DPM5 Z Closed ___ AA Closed ___ BB closed ___	____	______
CC Closed _____ A-4 Open _____	____	______
1.5 48v System (840 ft. level, north)		
1.5.1 Check MG No. 2 energized.	____	______
1.5.2 Check MG No. 3 energized.	____	______
1.5.3 Number of MG set running _____	____	______
1.5.4 Check running MG set Generator Switch closed.	____	______
1.5.5 Check ground detector lights dim.	____	______
1.5.6 Check low dc voltage light dim.	____	______
In Battery Room:		
1.5.7 Check 48v battery switch closed and tagged.	____	______

Approved by [signature]

	Init.	Date/Time
1.5 (continued)		
1.5.8 Check all battery cells electrolyte level.	____	______
1.5.9 Check specific gravity of each cell to be 1.210. Give cells balancing charge if necessary.	____	______
<u>1.6 250v DC System</u>		
At 250v DC Panel (840 ft. level North) check the following switches closed.		
1.6.1 250v Panel Supply Switch	____	______
1.6.2 MG4 Supply (25 kw Gen.)	____	______
1.6.3 13.8 kv Control Power	____	______
1.6.4 Emergency Lights	____	______
1.6.5 Breaker DC Trip Power (480v Swgr. trip)	____	______
<u>In Battery Room</u>		
1.6.6 Check Battery Cells electrolyte level.	____	______
1.6.7 Check Cell Specific Gravity = 1.210. Give cells equalizing charge if necessary.	____	______
<u>In MG Room</u>		
1.6.8 MG-1 Running (Breaker "W" closed)	____	______
1.6.9 Generator switch (Reverse power trip) closed.	____	______
1.6.10 MG-4 running	____	______
1.6.11 MG-4 generator breaker closed.	____	______
1.6.12 Instrument Panel No. 2 and 3 Disc. Switch closed.	____	______
1.6.13 Process Power Panel No. 2 disconnect switch closed.	____	______
1.6.14 Diesel No. 5 control power disconnect closed.	____	______
<u>1.7 Switch House</u>		
Close the following breakers:		

	Init.	Date/Time
1.7 (continued)		
MCC-G-4		
1.7.1 Breaker 13, Panel DR-2	______	________
1.7.2 Breaker 16, Diesel Auxiliary Transfer Switch Supply ____ (G3 or G4)	______	________
1.7.3 Breaker 27 - Panel DR 1	______	________
1.7.4 Breaker 29 - Spect. Room Transformer	______	________
1.7.5 Breaker 31 Inst. Power Trans. No. 1	______	________
1.7.6 Breaker 33 - Air Compressor No. 3	______	________
MCC-G3		
1.7.7 Breaker 3 - Sump Pump and Pit Pump	______	________
1.7.8 Breaker 16 - Diesel Auxiliary Power	______	________
1.7.9 Breaker 18 - Inst. Panel No. 2	______	________
Switch Gear Bus 3		
1.7.10 Breaker M - Lighting Transformer	______	________
TVA Switch Gear		
1.7.11 Breaker MB-1 closing coil breaker	______	________
1.7.12 Breaker MB-3 closing coil breaker	______	________
1.7.13 Breaker FP closing coil breaker	______	________
1.7.14 Breaker CP closing coil breaker	______	________
1.7.15 Breaker CCP-1 closing coil breaker	______	________
1.7.16 Breaker CCP-2 closing coil breaker	______	________
1.7.17 Breaker MB-1 trip coil breaker	______	________
1.7.18 Breaker MB-3 trip coil breaker	______	________
1.7.19 Breaker FP trip coil breaker	______	________
1.7.20 Breaker CP trip coil breaker	______	________
1.7.21 Breaker CCP-1 trip coil breaker	______	________
1.7.22 Breaker CCP-2 trip coil breaker	______	________

NOTE: These control power breakers are inside the main breaker compartment.

1.8 Emergency ac Lighting

The following Lighting Panels should be supplied from Process Power Transformer (M).

Init. Date/Time

1.8 (continued)

Switch each to B Position.

1.8.1 Panel 2 (861 ft level in maintenance C. R.) ____ ____

1.8.2 Lighting Panel K (840 ft level, TR) ____ ____

1.8.3 Lighting Panel B (852' level, Hall) ____ ____

1.8.4 Lighting Panel A (852' level, Hall) ____ ____

1.8.5 Lighting Panel AB (840' level outside T. R.) ____ ____

1.8.6 Lighting Panel T (Switch House) ____ ____

1.9 Emergency DC Lighting

1.9.1 Tag switch adj, lighting panel H closed, North end, 840 ft level. ____ ____

1.9.2 Tag DC light switch, 250v DC Dist. Panel closed. (CKT No. 21) ____ ____

2 DIESEL STARTUP CHECK LIST (This prepares the diesels for quick startup.)

2.1 Fuel Supply (See Figure 4A.2-1)

2.1.1 Check all fuel oil valves open as listed below:

Supply Valve at Storage Tank VS ____ ____ ____

V 3-1 ____, V 3-2 ____, V 3-3 ____

Diesel No. 3 oil system. ____ ____

V 4-1 ____, V 4-2 ____, V 4-3 ____

Diesel No. 4 oil system. ____ ____

V 5-1 ____, V 5-2 ____, V 5-3 ____

Diesel No. 5 oil system. ____ ____

2.1.2 Check Oil Storage Tank Level ____gal. (>1000) ____ ____

2.1.3 Close and tag P-3 Switch ____

Close and tag P-4 Switch ____

Close and tag P-5 Switch ____ ____ ____

2.1.4 Check and Record Oil Level in Day Tanks

DT 3 ____, DT 4 ____, DT 5 ____ ____ ____

Approved by [signature]

	Init.	Date/Time
2.1.5 Drain sludge and water from Fuel Oil Supply Filters on DT 3 ____ and DT 4 ____, DT 5 ____.	____	____
2.2 Cooling Water		
2.2.1 Check Radiators level of D3 ____, D4 ____, D5 ____.	____	____
2.2.2 Check specific gravity for antifreeze. Note: If water is added, add antifreeze.	____	____
2.2.3 Close Heater Switch to all three Diesels: Diesel 3 ____, Diesel 4 ____, Diesel 5.	____	____
2.2.4 Check Diesel water temperature Gauge >90°F on Diesel 3 ____, Diesel 4 ____, Diesel 5 ____.	____	____
2.2.5 Check to see there are no obstructions north of diesel units outside building.	____	____
2.2.6 Check that air inlet louvers south side of building can be opened. (Open these louvers when diesels are running.)	____	____
2.3 Batteries on Diesels No. 3 and No. 4		
2.3.1 Turn on battery chargers D3 ____ and D4 ____.	____	____
2.3.2 Check and record electrolyte in Battery D3 ____ and D4 ____.	____	____
2.3.3 Check for dead cells in each battery.	____	____
2.4 Local Manual-automatic Switch on Diesel No. 3 and No. 4		
2.4.1 Turn switch to automatic position and tag. D3 ____ D4 ____	____	____
2.5 Air System on Diesel No. 5 (See Sketch 4A-2.1)		
2.5.1 Open or check open and tagged: V 5-4 ____ and V 5-5 ____.	____	____
2.5.2 Close or check closed starting switch to compressor C 5 ____.	____	____

Approved by [signature]

	Init.	Date/Time
2.5.3 Check PI discharge of air receiver >150 psi.	____	____
2.6 Diesel Units (See Diesel Operation Manual)		
2.6.1 Check crank case oil level D3 ____, D4 ____, D5 ____. Should be full (or above).	____	____
2.6.2 Check or fill Fuel Injection Pump. D3 ____, D4 ____, D5 ____.	____	____
2.6.3 Check oil level in air cleaners. D3 ____, D4 ____, D5 ____. Check governor oil level D3 ____, D4 ____, D5 ____.	____	____
2.6.4 Set the Diesel Governor settings as follows: Speed droop = 0 D3 ____, D4 ____, D5 ____.	____	____
Load Limit , Setpoint and Dial indicator approximately as follows. D3 = 5 ____, D4 = 5 ____, D5 = 10 ____.	____	____
Synchronizer Indicator at Scribed Mark. D3 ____, D4 ____, D5 ____.	____	____
2.7 Additional Checks for Diesel No. 5		
2.7.1 Check oil level in oiler of airstarting motor.	____	____
2.7.2 Oil pressure alarm switch should be in the "on" position.	____	____
2.7.3 Check that governor has reset. Reset marker should be at white mark. Use mirror mounted on manifold.	____	____
2.8 Diesel Auxiliary Panel (Diesel Room)		
Close or check closed the following breakers:		
2.8.1 Bkr. No. 1 Gen. No. 5 Fuel pump and heater.	____	____

	Init.	Date/Time
2.8.2 Bkr. No. 2 Gen. No. 4 Fuel pump and heater.	____	________
2.8.3 Bkr. No. 3 Gen. No. 3 Fuel pump and heater.	____	________
2.8.4 Bkr. No. 6 Gen. No. 5 air compressor.	____	________

2.9 Lighting Panel T

Close or check closed the following breakers:

2.9.1 Bkr. No. 7 and No. 9. Gen No. 4 battery charge.	____	________
2.9.2 Bkr. No. 11 and No. 13. Gen. No. 3 battery charge.	____	________

3 HEATER PRESTARTUP CHECK LIST

This section is to be completed to ensure the following objectives:

(1) that all heater controllers are at the lowest setting before breakers are closed;
(2) that all breakers are closed;
(3) that induction regulator blowers are on;
(4) heaters are ready when required.

3.1 Procedure for Completing Heater Check List

3.1.1 Check all heater controllers on Heater Control Panels. Circle in Red all heaters (in tables) which have amps indicated on the ammeters. These heaters should be left on during completion of the check list.	____	________
3.1.2 Have Shift Supervisor approve list before proceeding.	____	________

3.1.3 Set all manual powerstats to zero that are not circled in red. Circle each heater number as the controller is checked at or set to zero using black pencil. Note: Check with Shift Supervisor

Init. Date/Time

3.1.3 (continued)

before turning off any heaters (not checked in No. 1) which show current on ammeters. ____ ______

3.1.4 Check that heater control power and induction regulator motor power is on; that is, the following breakers are closed:

3.1.4.1 Switch gear Breaker No. Z ____ ______

3.1.4.2 Switch gear Breaker BB ____ ______

3.1.4.3 Safety Switch G 5-1-D (adj. transformer GS-1-D) ____ ______

3.1.4.4 Heater Panel Breakers G5-1-D3- 1, 2, 4, 5, 6, 8, 9, 10, 12. ____ ______

3.1.4.5 Heater Panel Breakers G5-1-D4- 1, 2, 5, 6, 9, 10. ____ ______

NOTE: Circle heater panel breaker numbers which are closed or as they are closed.

Check that all induction regulators and motor operated powerstats are at the lowest setting before closing the heater breakers. ____ ______

Approved by [signature]

4A-10
10/14/65

G5-1-A CIRCUITS

HEATER	CONTROL*	HEATER CONTROL PANEL	HEATER PANEL BREAKERS	INIT.	DATE/TIME
FV 103	P	8	G5-1-A4-2		
H 103	P	8	G5-1-A4-4		
H 104-1	P	8	G5-1-A1-1		
FV 104-1	P	9	G5-1-A1-9		
FV 104-1A	P		G5-1-A4-1		
FV 104-3	P	9	G5-1-A1-11		
H 104-5	P	9	G5-1-A1-3		
H 104-6	P	9	G5-1-A1-5		
FV 105-1	P	9	G5-1-A1-6		
FV 105-1A	P		G5-1-A1-10		
FV 105-3	P	9	G5-1-A1-8		
H 105-1	P	9	G5-1-A1-2		
H 105-4	P	9	G5-1-A1-4		
FV 106-1	P	9	G5-1-A2-5		
FV 106-1A	P		G5-1-A4-3		
FV 106-3	P	9	G5-1-A2-7		
H 106-1	P	9	G5-1-A2-1		
H 106-4	P	9	G5-1-A2-3		
H 107-1	P	10	G5-1-A2-2		
H 107-2	P	10	G5-1-A2-4		
H 107-3	P	10	G5-1-A2-6		
FV 107-1	P	10	G5-1-A2-8		
FV 107-3	P	10	G5-1-A2-12		
H 108-1	P	11	G5-1-A3-1		
H 108-2	P	11	G5-1-A3-3		
H 108-3	P	11	G5-1-A3-5		
FV 108-1	P	11	G5-1-A3-11		
FV 108-3	P	11	G5-1-A3-7		
H 109-1	P	11	G5-1-A3-2		
H 109-2	P	11	G5-1-A3-4		

Approved by B. N. Feynman

G5-1-A CIRCUITS (continued)

HEATER	CONTROL*	HEATER CONTROL PANEL	HEATER PANEL BREAKERS	INIT.	DATE/TIME
H 109-3	P	11	G5-1-A3-6	____	________
FV 109-1	P	11	G5-1-A3-12	____	________
FV 109-3	P	11	G5-1-A3-8	____	________
H 110-1	P	11	G5-1-A2-9	____	________
RAN-1	P	7A	G5-1-A5-1	____	________
RAN-2	P	7A	G5-1-A5-2	____	________

Breaker G5-1-A ____________

*P = Powerstat

Approved by [signature]

G5-1-C CIRCUITS

HEATER	CONTROL*	HEATER CONTROL PANEL	HEATER PANEL BREAKERS	INIT.	DATE/TIME
H 104-2	P(m)	10	G5-1-C1-1		
H 104-3	P(m)	10	G5-1-C1-3		
H 104-4	P(m)	10	G5-1-C1-5		
H 105-2	P(m)	10	G5-1-C1-4		
H 105-3	P(m)	10	G5-1-C1-6		
H 104-7	P(m)	10	G5-1-C1-7		
H 110-2	P(m)	10	G5-1-C1-2		
H 110-3	P(m)	10	G5-1-C1-8		
H 203-1	P(m)	4	G5-1-C2-8		
H 204-1	P(m)	4	G5-1-C2-6		
H 206-1	P(m)	4	G5-1-C2-5		
CDT-1	P(m)	4	G5-1-C2-4		
H 106-2	P(m)	10	G5-1-C2-2		
H 106-3	P(m)	10	G5-1-C2-7		
H 204-2	P	3	G5-1-C3-5		
FV 204-1	P	4	G5-1-C3-5		
FV 204-1A	P	3	G5-1-C3-9		
FV 204-2	P	4	G5-1-C3-4		
FV 204-3	P	3	G5-1-C3-6		
FV 206-1	P	4	G5-1-C3-1		
FV 206-1A	P	4	G5-1-C3-3		
Receptacles		HCP-1-7A	G5-1-C3-8		
Receptacles		HCP-8-12	G5-1-C3-7		

Breaker G5-1-C ________________

*P(m) Motor operated powerstat.

Approved by [signature]

G5-BB CIRCUITS

HEATER	CONT.*	HCP	HEATER PANEL BREAKERS	TRANSFORMER BREAKERS	DIST. PANEL BREAKERS	INIT.	DATE/TIME
CR1	I	1	CR1 - 1,2,3,4,5	CR1 ____	G5-BB-3		
CR2	I	1	CR2 - 1,2,3,4,5	CR2 ____	G5-BB-5		
CR3	I	1	CR3 - 1,2,3,4,5	CR3 ____	G5-BB-7		
CR4	I	1	CR4 - 1,2,3,4,5	CR4 ____	G5-BB-9		
FFT-1	I	8	FFT-1-1,2,3,4,5 6,11,12	FFT-1 ____	G5-BB-6		
FD1-1	I	8	FD1-1-1,2,3,4,5 6,7	FD1-1 ____	G5-BB-10		
FD2-1	I	8	FD2-1-1,2,3,4,5 6,11,12	FD2-1 ____	G5-BB-8		
Ind. Regulator Blower Started				____	G5-BB-1		
Ind. Regulator Blower Started				____	G5-BB-2		
Ind. Regulator Motors		1	G5-1-D3-1	____			
		6	G5-1-D3-5	____			
		8	G5-1-D3-9	____			
Ind. Regulator Cont. Circuits		1	G5-1-D3-2	____			
		6	G5-1-D3-4	____			
		7	G5-1-D3-6	____			
		8	G5-1-D3-8	____			
		4	G5-1-D3-10	____			
Powerstat Motor		10	G5-1-D3-12	____			
Ind. Regulator Motors		1	G5-1-D4-1	____			
		1	G5-1-D4-2	____			
		1	G5-1-D4-5	____			
		1	G5-1-D4-9	____			
		7	G5-1-D4-6	____			
		7	G5-1-D4-10	____			

*I - Induction Regulator

NOTE: Circle heater panel breaker numbers which are closed or as they are closed.

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G5-2-Y CIRCUITS

HEATER	CONT.	HCP	HEATER PANEL BREAKERS	TRANSFORMER BREAKERS	DIST. PANEL BREAKERS		INIT.	DATE/TIME
CR5	I	1	CR5-1,2,3,4,5	CR5 ______	G5-2-Y 3	__	____	__________
CR6	I	1	CR6-1,2,3,4,5	CR6 ______	G5-2-Y 4	__	____	__________
CR7	I	1	CR7-1,2,3,4,5		G5-2-Y 5	__	____	__________
CR8	I	1	CR8-1,2,3,4,5		G5-2-Y 6	__	____	__________
Induction Regulator Blower Started				______	G5-2-Y-1	__	____	__________
Breaker G5-2-X _______								
Breaker G5-2-Y _______								

NOTE: Circle heater Panel breaker numbers which are closed or as they are closed.

Approved by [signature]

T-1-A AND T-1-B CIRCUITS

HEATER	CONT.	PANEL	HEATER PANEL BREAKERS	TRANSFORMER BREAKERS	DIST. PANEL BREAKERS	INIT.	DATE/TIME
H200-13	I	1	H200-13-1,2,3 4,5,6	H200-13 ___	T-1-A-5 ___	____	________
H201-12	I	1	H201-12-1,2,3 4,5,6	H2-1-12 ___	T-1-A-7 ___	____	________
H202-2	I	1	H202-2-1,2,3 4,5,6	H202-2 ___	T-1-A-9 ___	____	________
RCH-3	I	6	RCH-3-1,2,3		T-1-A-6 ___	____	________
FP-1	I	7	FP-1-1,2,3 4,5	FP-1 ___	T-1-A-10___	____	________
FP-2	I	7	FP-2-1,3,4,5 6	FP-2 ___	T-1-A-8 ___	____	________
Induction Regulator Blower Started				_______	T-1-A-1 ___	____	________
Induction Regulator Blower Started				_______	T-1-A-2 ___	____	________
RCH-4	I	6	RCH-4-1,2,3 4		T-1-B-6 ___	____	________
HX1	I	7	HX1-1		T-1-B-9 ___	____	________
HX2	I	7	HX2-1		T-1-B-10___	____	________
HX3	I	7	HX3-1		T-1-B-8 ___	____	________
FFT-2	I	8	FFT2-1,2,3,4 5,6,7,8	FFT-2 ___	T-1-B-7 ___	____	________
FD1-2	I	8	FD1-2-1,2,3,4 5,6,9	FD1-2 ___	T-1-B-3 ___	____	________
FD2-2	I	8	FD2-2-1,2,3,4 5,6,7,8	FD2-2 ___	T-1-B-5 ___	____	________
Induction Regulator Blower Started				_______	T-1-B-1 ___	____	________
Induction Regulator Blower Started				_______	T-1-B-2 ___	____	________
Breaker T-1-A ________							
Breaker T-1-B ________							

NOTE: Circle heater panel breaker numbers which are closed or as they are closed.

Approved by [signature]

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T-1-C CIRCUITS

HEATER	CONT.	PANEL	HEATER PANEL BREAKERS	TRANSFORMER BREAKERS	DIST. PANEL BREAKERS		INIT.	DATE/TIME
RCH-1	I	6	RCH-1-1,2,3		T-1-C-7	___	____	__________
RCH-2	I	6	RCH-2-1,2		T-1-C-9	___	____	__________
RCH-5	I	7	RCH-5-1,2		T-1-C-10	___	____	__________
RCH-6	I	7	RCH-6-1,2,3		T-1-C-8	___	____	__________
RCH-7	I	7	RCH-7-1,2		T-1-C-5	___	____	__________
H102-2	I	7	H102-2-1,2		T-1-C-6	___	____	__________
Induction Regulator Blower Started				______	T-1-C-1	___	____	__________
Induction Regulator Blower Started				______	T-1-C-2	___	____	__________
Breaker T-1-C ________								

NOTE: Circle heater panel breaker numbers which are closed or as they are closed.

Approved by

T-2-V AND T-2-Y CIRCUITS

HEATER	CONT.	HCP	HEATER PANEL BREAKERS	TRANSFORMER BREAKERS	DIST. PANEL BREAKERS	INIT.	DATE/TIME
H200-15	P	2	T-2-V1-22 ___			___	___
H200-16	P	7A	T-2-V1-17 ___			___	___
H201-10	P	2	T-2-V1-18 ___			___	___
H201-14	P	7A	T-2-V1-19 ___			___	___
CDT-2	P	4	T-2-V1-2 ___			___	___
CDT-3	P	4	T-2-V1-6 ___			___	___
CP1	P	4	T-2-V1-10 ___			___	___
CP2	P	4	T-2-V1-14 ___			___	___
H100-1	P	5	T-2-V1-1 ___			___	___
H100-2	P	6	T-2-V1-5 ___			___	___
H101-2	P	6	T-2-V1-9 ___			___	___
H101-3	P	6	T-2-V1-13 ___			___	___
R1	I	7	R1-1,2,3 ___	R1 ___	T-2-Y-3 ___	___	___
R2	I	7	R2-1,2,3 ___	R2 ___	T-2-Y-5 ___	___	___
R3	I	7	R3-1,2,3 ___	R3 ___	T-2-Y-6 ___	___	___
Induction Regulator Blower Started				___	T-2-Y-1 ___	___	___
Breaker T-2-V ___							
Breaker T-2-Y ___							

T-2-W CIRCUITS

HEATER	CONTROL	HEATER CONTROL PANEL	HEATER PANEL BREAKERS	INIT.	DATE/TIME
H200-14	P	2	T2-W1-2		
H201-11	P	2	T2-W1-5		
H201-13	P	2	T2-W1-9		
H201-14	P				
H202-1	P	3	T2-W1-20		
H205-1	P	3	T2-W1-18		
FT201A-1	P	3	T2-W1-2		
FT201A-2	P	3	T2-W1-4		
FT201A-3	P	3	T2-W1-6		
FT201A-4	P	3	T2-W1-8		
FT201B-1	P	3	T2-W1-10		
FT201B-2	P	3	T2-W1-12		
FT201B-3	P	3	T2-W1-14		
FT201B-4	P	3	T2-W1-16		
H 203-2*	P	3	T2-W1-17		
H200-1	P	5	T2-W2-2		
H200-11	P	5	T2-W2-6		
H200-12	P	5	T2-W2-10		
H201-1	P	5	T2-W2-14		
H201-2	P	5	T2-W2-18		
H201-9	P	5	T2-W2-17		
H102-5	P	7A	T2-W2-13		
H102-1	P	7A	T2-W2-5		
H102-4	P	7A	T2-W2-9		
Breaker T-2-W ______					
LE-CP-1P	P	3	T2-W1-15		
LE-CP-2P	P	3	T2-W-19		

*Fill line disconnected, leave heater off

All items on the Electrical Startup Check List are complete.
Shift Supervisor ________________ Date ____________

Approved by [signature]

4 INSTRUMENT POWER PANEL CHECK LIST

This section is to be completed to ensure all instrument power breakers are turned on.

	Init.	Date/Time
4.1 Instrument Power Panel #1 (48v DC)		
4.1.1 Close breakers 1, 2, 3, 4, 5, 6, 7, 8, 9, 10.	____	______
4.2 Instrument Power Panel #A1 (48v DC converted to 120v AC)		
4.2.1 Close breakers 1, 2, 3.	____	______
4.3 Instrument Power Panel #2 (115v AC)		
4.3.1 Close breakers 1, 2, 3, 4, 5, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 20.	____	______
4.4 Instrument Power Panel #3 (115v AC)		
4.4.1 Close breakers 1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 13, 15.	____	______
4.5 Instrument Power Panel #A3 (Regulated 115v AC)		
4.5.1 Close breakers 1, 2, 3, 4.	____	______
4.6 Instrument Power Panel #4 (115v AC-TVA Bus)		
4.6.1 Close breakers 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 16.	____	______
4.7 Instrument Power Panel #A4 (Regulated 115v AC)		
4.7.1 Close breakers 1, 2, 3.	____	______
4.8 Instrument Power Panel #5 (120/208v AC 3ϕ-TVA)		
4.8.1 Close breakers 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 25, 27, 29.	____	______
4.9 Instrument Power Panel #6 (120/208v AC 3ϕ - TVA)		
4.9.1 Close breakers 1, 2, 3, 4, 5, 6, 9, 11, 12, 17, 18, 23, 24, 25, 26, 28.	____	______

All items on the Instrument Power Check List are complete.

Shift Supervisor ________________ Date ____________

Approved by [signature]

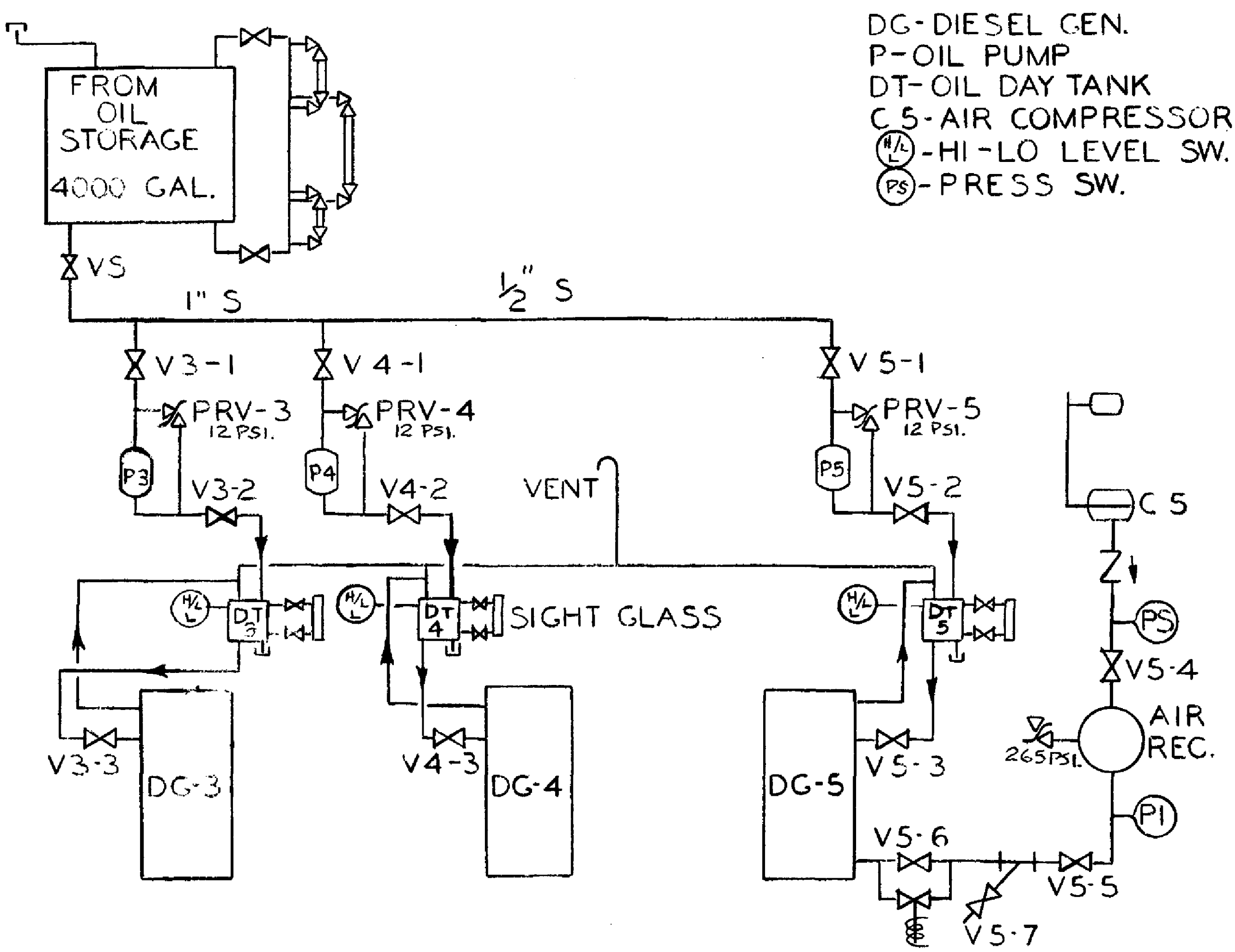

FIG. 4A2-1 DIESEL GENERATOR OIL AND AIR PIPING

Approved by [signature]

4B INSTRUMENT AIR SYSTEM STARTUP CHECK LIST

The instrument air system will normally be operated with one instrument air compressor, one air dryer and both air receivers in service, with the second instrument air compressor and air dryer in standby.

This check list covers the startup of the instrument air system for normal operation, and assumes that related portions of the electric system check list have been completed. Some portions of the system may already be in service; however, each item listed should be checked.

1 INSTRUMENT AIR COMPRESSORS AND DRYERS

(Diesel House)

	Init.	Date/Time
1.1 Close, or check closed the cooling water drain valve, V-881-B.	____	______
1.2 Close, or check closed, the following valves in the instrument air compressor and after cooler cooling water circuits: V-880-1C ____ V-880-2C ____ V-881-1C ____ V-881-2C ____	____	______
1.3 Open, or check open, the following valves in the instrument air compressor and after cooler cooling water circuits: V-881-A ____ V-881-1A ____ V-881-1B ____ V-881-2A ____ V-881-2B ____ V-880-1B* ____ V-880-2B* ___ V-880-1A ____ V-880-1D** ___ V-880-2A ____ V-880-2D** ___	____	______
1.4 If the cooling tower water system is in operation, close, or check closed, V-872 ____. If this system is not in operation, open, or check open, V-872 ____.	____	______

NOTE: If the instrument air compressor is already in operation, the valves marked * should be left throttled, and the valves marked ** should be left closed.

Approved by [signature]

	Init.	Date/Time
1.5 Check that the oil level is visable in the bulls eye of both instrument air compressors. No. 1 ____ No. 2 ____	____	____
1.6 Close or check closed, the following valves in the air system:		

V-9110-C ____	V-9113-C ____	V-9113-E ____
V-9113-F ____	V-9114-C ____	V-9114-E ____
V-9114-F ____	V-9115-E ____	V-9116 ____
V-9119* ____	V-9120-C ____	V-9123-C ____
V-9123-E ____	V-9123-F ____	V-9124-C ____
V-9124-E ____	V-9124-F ____	V-9125-E ____
V-9126 ____	V-9129* ____	V-9130 ____
V-9132 ____	V-9000-3 ____	V-9000-4 ____
V-9000-5 ____		

Init. ____ Date/Time ____

*NOTE: If an instrument air compressor and air dryer are already in operation, either V-9119 or V-9129 will be open, and should be left open.

1.7 Open, or check open, the following valves in the air system:

V-AC1-A ____	V-AC1-B ____	V-AC1-C ____
V-9110-A ____	V-9110-B ____	V-9111 ____
V-D1 ____	V-9113-A ____	V-9113-B ____
V-9113-F ____	V-9114 ____	V-9114-A ____
V-9114-B ____	V-9114-D ____	V-R1 ____
V-9115-A ____	V-AC2-A ____	V-AC2-B ____
V-AC2-C ____	V-9120-A ____	V-9120-B ____
V-9121 ____	V-D2 ____	V-9123-A ____
V-9123-B ____	V-9123-D ____	V-9124 ____
V-9124-A ____	V-9124-B ____	V-9124-D ____
V-R2 ____	V-9125-A ____	V-9000 ____
V-9000-1 ____	V-9000-2 ____	V-9001 ____

Init. ____ Date/Time ____

(Control Room)

1.8 Check that instrument air compressor

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Init. Date/Time

1.8 (continued)
selector switch (S-53) is set to the compressor which is in operation, or to the compressor to be operated and start the compressor selected. ____ ____

(Diesel House)

1.9 After the instrument air compressor has been started, check that the cooling water flow to the compressor has been established. Close the temperature control valve by-pass valves V-880-1D ____ and V-880-2D ____ ____ ____

1.10 Turn the electric power on to both air dryers and note that both air dryers are cycling. Lighting panel T, Bkrs. 15 and 17. ____ ____

1.11 Adjust the purge flow through both air dryers to 19 C F M (4.5 on rotameter). ____ ____

1.12 Adjust the bleed, from the moisture indicator petcocks, on both air dryers to a small bleed. ____ ____

1.13 When the moisture indicators on both air dryers are blue, open or check open valve V-9119 to place air dryer No. 1 in service, <u>or</u> V-9129 to place air dryer No. 2 in service. ____ ____

1.14 Momentarily open valves V-9116 and V-9126 to blow down the filters downstream of the air dryers. ____ ____

1.15 Close V-9129, V-9125-A if dryer unit No. 1 is to remain in service, or close V-9119, V-2115-A, if dryer unit No. 2 is to remain in service.

Dryer unit No. ____ is in service ____ ____

Close bleed petcock on standby dryer ____ ____

De-energize standby dryer

Lighting Panel T Bkr. 15 for Dryer No. 1. ____ ____

Lighting Panel T Bkr. 17 for Dryer No. 2. ____ ____

Init. Date/Time

1.16 Check that moisture indicator XmI-9000 in line 9000 is less than 20%. ____ ____

1.17 Check that the instrument air pressure as indicated on PI-AC1-K and PI-AC2-K is between 70 and 85 psig. ____ ____

2 TEST AUTOMATIC START OF STANDBY INSTRUMENT AIR COMPRESSOR

(Diesel House)

2.1 With the instrument air pressure as indicated on PI-AC1-K and PI-AC2-K above 70 psig, open the blow down valve at the separator outlet of the operating instrument air compressor (V-9110-C if instrument air compressor No. 1 is operating or V-9120-C if instrument air compressor No. 2 is operating.) ____ ____

2.2 Observe PI-AC1-K if instrument air compressor No. 1 is operating, or PI-AC2-K if instrument air compressor No. 2 is operating. The standby instrument air compressor should start and XA-4030-9 should annunciate when the instrument air pressure drops to 70 psig. Record the instrument air pressure when the standby instrument air compressor starts: ____ psig and when XA-4030-9 annunciates ____ psig. ____ ____

NOTE: If the time required to decrease the instrument air pressure to 70 psig is excessive, the operating instrument air compressor may be momentarily stopped from the control room and restarted after the standby instrument air compressor starts. ____ ____

2.3 Close valve V-9110-C or V-9120-C, whichever was opened in Step 2.1 above. ____ ____

(Main Control Room)

2.4 After annunciator XA-4030-9 clears, stop

Init. Date/Time

2.4 (continued)
the air compressor which had been selected in Step 1.8, and change the instrument air compressor selector switch (S-53) to the other instrument air compressor. ____ ____

2.5 Start the selected instrument air compressor. ____ ____

(Diesel House)

2.6 With the instrument air pressure as indicated on PI-AC1-K and PI-AC2-K above 70 psig, open the blow down valve at the separator outlet of the operating instrument air compressor (V-9110-C if instrument air compressor No. 1 is operating or V-9120-C if instrument air compressor No. 2 is operating.) ____ ____

2.7 Observe PI-AC1-K if instrument air compressor No. 1 is operating, or PI-AC2-K if instrument air compressor No. 2 is operating. The standby instrument air compressor should start and XA-4030-9 should annunciate when the instrument air pressure drops to 70 psig. Record the instrument air pressure when the standby instrument air compressor starts: ____ psig and when XA-4030-9 annunciates ____ psig. ____ ____

NOTE: If the time required to decrease the instrument air pressure to 70 psig is excessive, the operating instrument air compressor may be momentarily stopped from the control room and restarted after the standby instrument air compressor starts. ____ ____

2.8 Close valve V-9110-C or V-9120-C, whichever was opened in Step 2.6 above. ____ ____

(Control Room)

2.9 Note that annunciator XA-4030-9 clears and stop the standby instrument air compressor. ____ ____

Init. Date/Time

2.10 Note the position of the instrument air compressor selector switch (S-53) and which instrument air compressor is in operation:

S-53 position:

IAC-1 _____ MANUAL _____ IAC-2 _____

Operating instrument air compressor:

IAC-1 _____ IAC-2 _____ _____ _____

3 INSTRUMENT AIR PRESSURE REDUCTION AND DISTRIBUTION

(Auxiliary Control Room)

3.1 Control Room Instrument Air Reducing Station

3.1.1 Close or check closed the following valves:

Line 9001-1 vent valve _____

Line 9007-1 vent valve _____

PCV-9001-1 filter blow down valve ____

PCV-9001-2 filter blow down valve ____

PCV-9007-1 filter blow down valve ____

PCV-9007-2 filter blow down valve ____

PCV-9001-2 inlet valve ____ and outlet valve ____

PCV-9007-2 inlet valve ____ and outlet valve ____ _____ _____

3.1.2 Open, or check open, the following valves:

Valve to PI-9001-1 ____ Valve to PI-9001-2 ____

Valve to PI-9007-1 ____ Valve to PI-9007-2 ____

Valve to PI-9007-4 ____ Valve to PI-9007-5 ____

PCV-9001-1 inlet valve ____ and outlet valve ____

PCV-9007-1 inlet valve ____ and outlet valve ____

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	Init.	Date/Time
3.1.2 (continued) PCV-9007-3 inlet valve ____ and outlet valve ____ PCV-9007-5 inlet valve ____ and outlet valve ____ Line 9001-1 shut off valve ____ Line 9007-1 shut off valve ____	____	____
3.1.3 While observing PI-9001-2, slowly increase PCV-9001-1 setting until HSV-9001-1 opens. (30 psig). Record PI-9001-2 ____ psig.	____	____
3.1.4 Reset PSV-9001-1 at 20 psig as indicated by PI-9001-2.	____	____
3.1.5 Set PCV-9007-1 at 60 psig as indicated by PI-9007-2.	____	____
3.1.6 While observing PI-9007-4, slowly increase PCV-9007-3 setting until HSV-9007-1 opens (30 psig). Record PI-9007-4 ____ psig.	____	____
3.1.7 Reset PCV-9007-3 at 20 psig as indicated by PI-9007-4.	____	____
3.1.8 While observing PI-9007-5, slowly increase PCV-9007-5 setting until HSV-9007-2 opens (40 psig). Record PI-9007-5 ____ psig.	____	____
3.1.9 Reset PCV-9007-5 at 30 psig as indicated by PI-9007-5.	____	____
3.1.10 Check that the following annunciators are clear: XA-4030-1 ____ XA-4031-1 ____ XA-4031-2 ____ XA-4031-3 ____	____	____

<u>3.2 Control Room Instrument Air Distribution</u>

	Init.	Date/Time
3.2.1 Behind Main Panel 12, open, or check open, all valves on the following headers that are permanently connected to instrument lines. Header 9001-1 ____ Header 9007-1 ____ Header 9008-1 ____.	____	____
3.2.2 Behind Main Panel 11, open, or check open, all valves on the following headers that are permanently connected to instrument lines. Header 9001-1 ____ Header 9007-1 ____ Header 9008-1 ____.	____	____
3.2.3 Behind Main Panel 10, open, or check open, all valves on the following headers that are permanently connected to instrument lines. Header 9001-1 ____ Header 9007-1 ____ Header 9008-1 ____.	____	____
3.2.4 Behind Main Panel 9, open, or check open, all valves on the following headers that are permanently connected to instrument lines. Header 9001-1 ____ Header 9007-1 ____ Header 9008-1 ____.	____	____
3.2.5 Behind Main Panel 8, open, or check open, all valves on the following headers that are permanently connected to instrument lines. Header 9001-1 ____ Header 9007-1 ____ Header 9008-1 ____.	____	____
3.2.6 Behind Main Panel 7, open, or check open, all valves on the following headers that are permanently connected to instrument lines. Header 9001-1 ____ Header 9007-1 ____ Header 9008-1 ____.	____	____
3.2.7 Behind Main Panel 6, open, or check open, all valves on the following headers that are permanently connected to instrument		

Init. Date/Time

3.2.7 (continued)

lines. Header 9001-1 ____ Header 9007-1 ____ Header 9008-1 ____. ____ ______

3.2.8 Behind Main Panel 5, open, or check open, all valves on the following headers that are permanently connected to instrument lines. Header 9001-1 ____ Header 9007-1 ____ Header 9008-1 ____. ____ ______

3.2.9 Behind Main Panel 4, open, or check open, all valves on the following headers that are permanently connected to instrument lines. Header 9001-1 ____ Header 9007-1 ____ Header 9008-1 ____. ____ ______

3.2.10 Behind Main Panel 3, open, or check open, all valves on the following headers that are permanently connected to instrument lines. Header 9001-1 ____ Header 9007-1 ____ Header 9008-1 ____. ____ ______

(High Bay)

3.3 Sampler Enricher Instrument Air Reducing Station

3.3.1 Close, or check closed, the following valves:

Line 9009-1 vent valve ____
PCV-9009-1 filter blow down valve ____
PCV-9009-2 filter blow down valve ____
PCV-9009-2 inlet valve ____
PCV-9009-2 outlet valve ____ ____ ______

3.3.2 Open or check open, the following valves:

Valve to PI-9009-1 ____
Valve to PI-9009-2 ____
PCV-9009-1 inlet valve ____ and outlet valve ____
Line 9009-1 shut off valve ____. ____ ______

Approved by [signature]

	Init.	Date/Time
3.3.3 While observing PI-9009-2, slowly increase PCV-9009-1 setting until HSV-9009-1 opens (40 psig). Record PI-9009-2 ____ psig.	____	____
3.3.4 Reset PCV-9009-1 at 30 psig as indicated by PI-9009-2.	____	____
3.3.5 Check with the control room that annunciator XA-4031-5 is clear.	____	____

3.4 High Bay Area Instrument Air Distribution

3.4.1 Behind Sampler Enricher Panel 1, open, or check open, the yellow-handled valves that supply air to HSV-675 ____ and HSV-678 ____, and the black-handled valve that supplies air to the removal valve ____.	____	____

NOTE: The startup of the instrument air system for the Chemical Processing Plant is covered in the Chemical Processing Plant Startup Procedure.

(Filter Pit)

3.5 Containment Air Panel 1 Instrument Air Distribution

3.5.1 Behind Containment Air Panel 1, open, or check open, the valve on header 9005-3 that supply air to the following: FCV-925-A ____ FCV-926-A ____	____	____
3.5.2 Behind Containment Air Panel 1, open, or check open, the valves on header 9011-5 that supply air to the following: Line S1-A1 ____ FCV-934-A ____	____	____

(Blower House)

3.6 Blower House Instrument Air Reducing Station

3.6.1 Close, or check closed, the following valves:

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from

Original Document

	Init.	Date & Time
(Main Control Room)		
14. Stop the component coolant pumps after the FV's in the DTC have cooled to the point where they will not thaw on loss of air.	____	________
(High Bay)		
15. Place the necessary masonite sheets in place for alternate top shield blocks on both cells.	____	________
16. Place alternate top shield blocks in place on the masonite, and bolt in place.	____	________
(Water Room)		
17. Set the pressure control valve PCV 332 for 2 psig.	____	________
18. Open V 332 A & B and V 342.	____	________
(High Bay)		
19. When the cell pressure reaches 2 psig as indicated by PI-RC-B, check all accessible membrane welds with leak detector solution.	____	________
(Water Room)		
20. Close V 332 A	____	________
(Service Tunnel)		
21. Open V 955 A & B	____	________
22. When the cell reaches atmospheric pressure as indicated by PI-RC-B close V 955 A & B	____	________
(High Bay)		
23. Remove the top shield blocks and masonite sheets put in place in steps 4E 14.	____	________
24. Place in their proper place the masonite sheets not placed in step 4E 14.	____	________
25. Place the corresponding top shield blocks on these sheets of masonite and bolt in place.	____	________
(Water Room)		
26. Open V 332 A	____	________

(High Bay)	Init.	Date & Time
27. When the cell pressure reaches 2 psig check the remaining membrance welds with leak detector solution.	_____	_____
28. When all leaks in the membrane have been repaired place all masonite and top shield blocks in place.	_____	_____
29. Bolt down the upper shield blocks.	_____	_____
30. A leak rate test of the RC and DTC will be performed at 20 psig prior to start-up after either of the cells has been opened. A number of the valves will also be tested while the cells are at 20 psig pressure. These are HCV's 930 A & B, V 930 C, V's 955 A, B, & C, CV 332, CV 342, FCV's 333 A & B, FCV's 343 A & B, CV 965, and CV 966.	_____	_____
Open V 980 A & B before pressurizing.	_____	_____

There are numerous other valves, penetrations and lines which require periodic leak testing at a cell pressure of 20 psig. When these are to be tested it will be done while the cells are at 20 psig for the leak rate test. Others requiring the periodic leak test which can be performed with the cells at 0 psig will be tested when the cells are depressurized after the 20 psig leak rate test. The penetrations and their locations are given in tables 4.1 and 4.2 in the MSRE Design and Operations Report, Part VIII.

The detailed steps for the leak tests follow. The first group is tested each time a leak rate test at 20 psig is performed. The second group is tested periodically during one of the 20 psig leak rate tests. The third group is tested periodically with the second group following the 20 psig leak rate test.

Check		Init.	Date & Time
/	31. HCV 930 A & B and V 930 C in the following manner.		
	HP coverage and gas masks are required.		
	(Control Room)		
	31.1 Check to see that the following freeze valves are frozen.		
	FV 104	____	________
	FV 105	____	________
	FV 106	____	________
	FV 107	____	________
	FV 108	____	________
	FV 109	____	________
	31.2 Check to see that the space coolers are in operation.	____	________
	31.3 Check to see that the component coolant pumps are stopped.	____	________
	(Transmitter Room)		
	31.4 Check the drain tank weight indicators to see that all the salt is in the tanks.	____	________
	(Water Room)		
	31.5 Set PCV 332 for 20 psig.	____	________
	31.6 Open V 332 A.	____	________
	(Special Equipment Room)		
	31.7 Close V 980 A & B after the cell pressure reaches 20 psig.	____	________
	31.8 Close V 332 A.	____	________
	(Service Tunnel)		
	31.9 Connect an instrument air line with a pressure regulator having a gauge of 0 to 50 psi minimum range and a rotameter having a range of 0-100 cc/min to valve 930 C.	____	________
	31.10 Connect a 0-10 cc/min range rotameter to the lantern ring plug on HCV 930 A.	____	________
	31.11 Connect a 0-10 cc/min range rotameter to the lantern ring plug on HCV 930 B.	____	________

		Init.	Date & Time
31.12	Open V 930 C.	______	______
31.13	Pressurize the region between HCV 930 A and HCV 930 B to 20 psig.	______	______
31.14	Check the external parts of V 930 C, HCV 930 A and HCV 930 B with leak detector solution. No leakage acceptable.	______	______
31.15	Flow through V 930 C ____________.	______	______
31.16	Leakage from lantern ring on HCV 930 A ____. Acceptable leakage 5 scc/min	______	______
31.17	Leakage from lantern ring on HCV 930 B ____. Acceptable leakage 5 scc/min		
31.18	Subtract the sum of the leakage through the lantern rings from the leakage through V 930 C. This is the leakage through HCV 930 B. Leakage __________. The acceptable leakage is 50 scc/min.	______	______
31.19	If the leakages exceed the acceptable values make repairs and recheck as above.	______	______
31.20	Close V 930 C.	______	______
31.21	Disconnect the instrument air line and reverse the rotameter connection to V 930 C. Do not reconnect the air line.	______	______
31.22	Connect a bleed line from V 930 C to exhaust into line 931. Open V 930 C slowly to relieve the pressure between HCV 930 A and HCV 930 B.		
31.23	With V 930 C open and pressure relieved read the rotameter. This is the leakage through HCV 930 A. Leakage ______. The acceptable leakage is 50 scc/min.	______	______
31.24	Close V 930 C and cap.	______	______
31.25	If repairs on HCV 930 A are required which necessitates opening the 30 in. duct (line 930) complete all other containment checks		

Init. Date & Time

31.25 (Continued)

required at a cell pressure of 20 psig before lowering this pressure to make required repairs. _____ _____

31.26 If the leakage rates on HCV 930 A & B and V 930 C are now acceptable tag the valves closed. _____ _____

32. Check V 955 A, B, & C in the following manner after testing HCV 930 A & B and V 930 C. HP coverage and gas masks are required.

(Control Room)

32.1 Check PI-RC-B to see that the cell pressure is 20 psig. _____ _____

32.2 Connect the instrument air line with a pressure regulator having a gauge of 0-50 psi minimum range and a rotameter having a range of 0-10 cc/min to valve V 955 C. _____ _____

32.3 Open V 955 C. _____ _____

32.4 Pressurize the line between V 955 A, V 955 B to 20 psig with the air. _____ _____

32.5 Leak test the exterior of V 955 A, B, & C with leak detector solution. No leakage acceptable. _____ _____

32.6 If repairs are required on V 955 A the cell will have to be vented to atmospheric pressure. All other containment tests to be performed at a cell pressure of 20 psig should be completed prior to venting the cell. _____ _____

32.7 When the no leak requirement of step 32.5 is satisfied read the rotameter. This is the leakage through V 955 B. _____ _____

32.8 Close V 955 C. _____ _____

32.9 Disconnect the air line and reverse the rotameter connection. Do not reconnect the air line. _____ _____

		Init.	Date & Time
32.10	Open V 955 B to relieve the pressure between V 955 B and V 955 A then close V 955 B.	____	________
32.11	Slowly open V 955 C and read the rotameter. This is the leakage through V 955 A. Leakage ______. Acceptable leakage 2 cc/min.	____	________
32.13	Close V 955 C, cap and tag closed.	____	________

(Water Room)

33. Check CV 332 in the following manner. HP coverage and gas masks are required. The RC should be at 20 psig.

		Init.	Date & Time
33.1	Close V 332B.	____	________
33.2	Connect a 0-10 cc/min rotameter to the tap upstream of CV 332.	____	________
33.3	Read the leakage through CV 332. Acceptable leakage 2 scc/min. Leakage ________.	____	________
33.4	Disconnect the rotameter and cap the tap.	____	________

34. Check CV 342 in the following manner. HP coverage and gas masks are required. The RC should be at 20 psig.

		Init.	Date & Time
34.1	Close V 342.	____	________
34.2	Connect a 0-10 cc/min rotameter to the tap upstream of CV 342.	____	________
34.3	Read the leakage through CV 342. Acceptable leakage 2 scc/min. Leakage _______.	____	________
34.4	Disconnect the rotameter and cap the tap.	____	________

35. Check FCV 333 A1 & A2 and V 334 in the following manner. HP coverage and gas masks are required. The RC should be at 20 psig.

(Liquid Waste Cell)

		Init.	Date & Time
35.1	Connect a 0-10 cc/min rotameter to V 334 (rotameters outlet to the valve and the valve closed).	____	________

	Init.	Date & Time
(Transmitter Room)		
35.2 Open FCV 333 A2	_____	__________
(Liquid Waste Cell)		
35.3 Pressurize V 334 with air to 20 psig. Leakage _______. Acceptable leakage 2 scc/min.	_____	__________
(Transmitter Room)		
35.4 Close FCV 333 A2	_____	__________
(Liquid Waste Cell)		
35.5 Open V 334. This pressurizes FCV 333 A2. Leakage _______. Acceptable leakage 2 scc/min.	_____	__________
35.6 Close V 334 disconnect the air line and reverse the rotameter connection.	_____	__________
35.7 Connect a 1/4" Copper tube to the rotameter and extend it into the ventilation duct pullout.	_____	__________
35.8 Slowly open V 334 to relieve the pressure then read the rotameter for leakage through FCV 333 A1. Leakage _______. Acceptable leakage 2 scc/min.	_____	__________
35.9 Close V 334, disconnect the tube and rotameter and cap the valve tag FCV 333 A1 & A2 and V 334 closed.	_____	__________
36. Check FCV 343 A1 & A2 and V 344 in the following manner. HP coverage and gas masks are required. The RC should be at 20 psig.		
(Liquid Waste Cell)		
36.1 Connect a 0-10 cc/min rotameter to V 344 (rotameter outlet to the valve and the valve closed).	_____	__________
36.2 Connect the instrument air line with a pressure regulator having a gauge of 0-50 psi minimum range to the rotameter.	_____	__________

	Init.	Date & Time
(Transmitter Room)		
36.3 Open FCV 343 A2.	_____	__________
(Liquid Waste Cell)		
36.4 Pressurize V 344 with air to 20 psig. Leakage _______. Acceptable leakage 2 scc/min.	_____	__________
(Transmitter Room)		
36.5 Close FCV 343 A2	_____	__________
(Liquid Waste Cell)		
36.6 Open V 344. This pressurizes FCV 343 A2. Leakage _______. Acceptable leakage 2 scc/min.	_____	__________
36.7 Close V 344, disconnect the air line and reverse the rotameter connection.	_____	__________
36.8 Connect a 1/4" copper tube to the rotameter and extend it into the ventilation duct pullout.	_____	__________
36.9 Slowly open V 344 to relieve the pressure then read the rotameter for leakage through FCV 343 A1. Leakage _______. Acceptable leakage 2 scc/min.	_____	__________
36.10 Close V 344, disconnect the tube and rotameter and cap the valve. Tag FCV 343, A1 & A2 and V 344 closed.	_____	__________
(West Tunnel)		
37. Check CV 965 in the following manner. Check while the RC is at 20 psig. HP coverage and gas masks required.		
37.1 Connect a 0-10 cc/min rotameter to the tap upstream of CV 965 with a tube leading from the rotameter to the ventilation duct.	_____	__________
37.2 Read the rotameter for leakage. Leakage _______. Acceptable leakage 2 scc/min.	_____	__________

		Init.	Date & Time
37.3	Disconnect the rotameter, 1/4" tube, and cap the tap.	______	__________
37.4	Check lines RCC-6, RCC-10, and LT RC-c with leak detector solutions. No leakage acceptable.	______	__________

(Electric Service Area)

38.	Check CV 966 in the following manner while the cell is at 20 psig. HP coverage required.	______	__________
38.1	Connect a 0-10 cc/min rotameter to the tap upstream of CV 966 with a tube leading from the rotameter to the ventilation duct.	______	__________
38.2	Read the rotameter for leakage. Leakage _______. Acceptable leakage 2 scc/min.	______	__________
38.3	Disconnect the rotameter, tube, and cap the tap.	______	__________
38.4	Check lines DTC-6 and DTC-10 and LT DTC with leak detector solution. No leakage acceptable.	______	__________

39. The following lines, valves, and containment items will be leak checked periodically with the RC and DTC at 20 psig. (Par. 40 through Par. 51)

(Special Equipment Room)

40. Check CV's 516 A & B, ESV 516 A1, ESV 516 A2 and Cont. Encl. No. 1 in the following manner. HP coverage and gas masks required.

40.1	Open V CE-1 and check the valve outlet with leak detector solution. No leakage acceptable. Leakage may come from the helium supply or RC which is at 20 psig.	______	__________
40.2	If leakage occurs open CE No. 1 and leak check the valves fitting and connections leading to the RC with leak detector solutions.	______	__________

		Init.	Date & Time
40.3	Repair the Leaks.	_____	_____
(Diesel House)			
40.4	Close V 500 G and allow the pressure downstream to relieve itself.	_____	_____
(Special Equipment Room)			
40.5	Close V 516.	_____	_____
40.6	Remove CV's 516 A & B from the system and bench test at 40 psig with He. Leakage _______. Acceptable leakage 1 scc/min.	_____	_____
40.7	Reinstall CV's 516 A & B and break line 516 upstream of ESV 516 A1 and downstream of ESV 516 A2.	_____	_____
40.8	Connect a He cyl.. to the downstream side of ESV 516 A2 with a regulator and 0-50 psi minimum range gauge, and connect a 0-10 cc/min rotameter to the inlet side of ESV 516 A1.	_____	_____
40.9	Pressurize downstream of ESV 516 A2 to 40 psig and read the rotameter. Acceptable leakage 1 scc/min. Leakage _______.	_____	_____
40.10	Reconnect all lines.	_____	_____
(Diesel House)			
40.11	Open V 500 G.	_____	_____
40.12	Check to see that FCV 516 is open or partially open.	_____	_____
40.13	Check line 516 (all valves fittings etc.) from ESV 516 A1 to V 516 with leak detector solutions. No leakage acceptable. The cover gas supply must be in operation at this time and pressure on this section of the line. See Section 4.4 of the MSRE Operating Procedures.	_____	_____
40.14	Open V 516 and close CE No. 1.	_____	_____
40.15	Connect the helium line to V CE-1 and pressurize CE No. 1 to 20 psig.	_____	_____

	Init.	Date & Time
40.16 Check the entire enclosure and V CE-1 with leak detector solution. No leakage acceptable.	____	________
40.17 Close V CE-1 while the enclosure is pressurized and disconnect the line.	____	________
40.18 Check the outlet of V CE-1 for leaks with leak detector solutions. No leakage acceptable.	____	________
40.19 Open V CE-1 to relieve the pressure. Close V CE-1 and tag closed.	____	________
41. Check CV's 592 A & B, CV's 593 A & B, CV's 596 A & B, CV's 589 A & B, CV's 599 A & B, CV's 600 A & B, HCV's 593 B1, 593 B2 and 593 B3, HCV's 599 B1, 599 B2, and 599 B3 and Containment Enclosure No. 2 which contains the above valves, in the following manner. HP coverage and gas masks are required.		
(Special Equipment Room)		
41.1 Open V CE-2 and check the valve outlet with leak detector solution. No leakage acceptable. Leakage may come from the helium supply or RC which is at 20 psig.	____	________
41.2 If leakage occurs open CE No. 2 and leak check the valves, fittings, and connections leading to the RC to locate the leaks with leak detector solution.	____	________
41.3 Repair the leaks.	____	________
(Transmitter Room)		
41.4 Close V 501.	____	________
(Special Equipment Room)		
41.5 Close V 589 C, V 592 C, V 593 C, V 596 C, V 599 C, and V 600 C.	____	________
(Control Room)		
41.6 Close HCV's 593 B1, B2, B3, and open HCV's 593 B4, and B5 (S36 in OFF position).	____	________

		Init.	Date & Time
(Special Equipment Room)			
41.7	Remove CV's 589 A & B, 592 A & B, 593 A & B, 596 A & B, 599 A & B, and 600 A & B from the system but do not break the connection between the A & B valves.		
41.8	Disconnect line 593 at the upstream side of V 593 C and connect the He CYL., with regulator and gauge used in step 40.6, to line 593.		
41.9	Pressurize through line 593 to 20 psig. This pressurizes the downstream side of HCV 593 B1, B2, and B3.		
41.10	Connect a short piece of plastic tube to the upstream side of HCV 593 B1 and check the open end of this tube with leak detector solution. No leakage acceptable.		
41.11	Repeat step 41.10 on HCV 593 B2. No leakage acceptable.		
41.12	Repeat step 41.10 on HCV 593 B3. No leakage acceptable.		
41.13	Disconnect the He cyl. from line 593 and reconnect the line to V 593 C.		
41.14	Disconnect line 589 upstream of V 589 C and connect the He cyl. with regulator and gauge to it.		
(Transmitter Room)			
41.15	Hold S38 in Ref. Block position.		
(Special Equipment Room)			
41.16	Pressurize line 589 to 20 psig and repeat step 41.10 on HCV 599 B2. No leakage acceptable.		
41.17	Disconnect the He cyl. and reconnect line 589. Disconnect line 599 upstream of V 599 C and connect the He cyl. to this line.		

Init. Date & Time

(Transmitter Room)

41.18 Hold S38 in the No. 1 Block position.

(Special Equipment Room)

41.19 Pressurize line 599 to 20 psig and repeat step 41.10 on HCV 599 B1. No leakage acceptable.

41.20 Disconnect the He cyl. and reconnect line 599. Disconnect line 600 upstream of V 599 C and connect the He cyl. to this line.

(Transmitter Room)

41.21 Hold S38 in No. 2 Block position.

(Transmitter Room)

41.22 Pressurize line 600 to 20 psig and repeat step 41.10 for HCV 599 B3. No leakage acceptable.

41.23 Disconnect the He cyl. and reconnect the line.

41.24 Check CV's 589 A & B simultaneously by connecting the He cyl. with regulator and gauge to the downstream side of CV 589 B and pressurizing to 20 psig. Connect a short piece of plastic tube to the upstream side of CV 589 A. Check for leakage over the entire assembly with leak detector solution. No leakage acceptable.

41.25 Check CV's 592 A & B in the same manner as used on CV's 589 A & B. No leakage acceptable.

41.26 Check CV's 593 A & B in the same manner as used on CV's 589 A & B. No leakage acceptable.

41.27 Check CV's 596 A & B in the same manner as used on CV's 589 A & B. No leakage acceptable.

	Init.	Date & Time
41.28 Check CV's 599 A & B in the same manner as used on CV's 589 A & B. No leakage acceptable..	____	____
41.29 Check CV's 600 A & B in the same manner as used on CV's 589 A & B. No leakage acceptable..	____	____
41.30 Install the check valves tested in 41.24 through 41.29 back in the containment enclosure.	____	____
(Transmitter Room)		
41.31 Open V 501.	____	____
41.32 Set S38 in the OFF position.	____	____
(Control Room)		
41.33 Set S36 in the No. 1 position.	____	____
(Special Equipment Room)		
41.34 Leak test all valves, fittings, and connections in CE No. 2 with leak detector solution. No leakage acceptable.	____	____
41.35 Open V 589 C, 592 C, 593 C, 596 C, 599 C, and 600 C.	____	____
41.36 Close CE No. 2 and connect the He cy. 1 with regulator and gauge to V CE-2.	____	____
41.37 Pressurize the CE No. 2 to 20 psig and check all possible sources of leaks with leak detector solution. No leakage acceptable.	____	____
41.38 Close V CE-2 while the enclosure is pressurized and disconnect the He cyl.. Test V CE-2 inlet for leakage with leak detector solution. No leakage acceptable.	____	____
41.39 Open V CE-2 to relieve the pressure, reclose and tag the valve closed.	____	____

(N. Elec. Ser. Area)

42. Check CV's 519 A & B, HCV's 519 A & B and Containment Enclosure No. 6 in the following manner. HP coverage and gas masks are required.

		Init.	Date & Time
42.1	Open V CE-6 and check the outlet of this valve with leak detector solution. No leakage acceptable. Leakage may come from the helium supply or RC which is at 20 psig.	_____	_____________
42.2	If leakage occurs, open CE No. 6 and leak check the valves, fittings, and connection leading to the RC with leak detector solution.	_____	_____________
42.3	Repair the leaks.	_____	_____________
42.4	Close V 519 A and V 519 B.	_____	_____________
42.5	Close HCV's 519 A and B.	_____	_____________
(N. Elec. Service Area)			
42.6	Connect a He cyl. with regulator and a gauge having a 0-50 psi minimum range to the tap upstream of V 519 B.	_____	_____________
42.7	Break line 519 at the downstream side of HCV 519 B, at the upstream side of HCV 519 A and between HCV 519 A and B.	_____	_____________
42.8	Connect a small piece of plastic tubing to line 519 coming from the check valves. Pressurize the check valves to 20 psig and check for leakage at the plastic tubing with leak detector solution. Leakage ______. Acceptable leakage 1 scc/min.	_____	_____________
42.9	Connect the He cyl. with regulator and gauge to the downstream side of HCV 519 B and connect the short piece of plastic tube to the upstream side. Pressurize HCV 519 B to 20 psig and check for leakage at the plastic tube with leak detector solution. No leakage acceptable.	_____	_____________

	Init.	Date & Time
42.10 Connect the He cyl. regulator and gauge to the downstream side of HCV 519 A and the plastic tube with leak detector solution. No leakage acceptable.	_____	__________
42.11 Reconnect all breaks in line 519 and cap the tap. Open V 519 A.	_____	__________
42.12 Open HCV's 519 A and B.	_____	__________
(N. Elec. Service Area)		
42.13 Check all connections, valves, and fittings from V 519 A to V 519 B with leak detector solution. No leakage acceptable.	_____	__________
42.14 Close V 519 A, close HCV's 519 A and B, open V 519 B, and close CE No. 6.	_____	__________
42.15 Connect the He cyl. with regulator and gauge to V CE-6 and pressurize to 20 psig.	_____	__________
42.16 Check CE No. 6 for leaks with leak detector solution. No leakage acceptable.	_____	__________
42.17 Close V CE-6 with the enclosure pressurized and disconnect the He cyl.	_____	__________
42.18 Check V CE-6 outlet for leaks with leak detector solution. No leakage acceptable.	_____	__________
42.19 Open V CE-6 to relieve the pressure, close V CE-6 and tag closed.	_____	__________
43. Check CV's 572 A & B and CE No. 3 in the following manner. HP coverage and gas masks required.		
(Control Room)		
43.1 Open HCV 573 A1 and set PIC 517 A for 5 psig.	_____	__________
(N. Elec. Ser. Area)		
43.2 Open V 517.	_____	__________
43.3 Open HCV 572 A1 by operating HCV 572 A2 with a jumper from the 48v DC supply 1P3. Leave open for 5 minutes and then close.	_____	__________

		Init.	Date & Time
43.4	Close V 517.		
43.5	Open V CE-3, CE No. 3 and close V 572.		
43.6	Disconnect PT 572 B and connect the He cyl. with regulator and gauge to line 572 at this point. Uncap the tap upstream of CV 572 A.		
43.7	Pressurize the line to 20 psig and check for leaks at the tap with leak detector solution. No leakage acceptable.		
43.8	Disconnect the He cyl. and reconnect PT 572 B.		
43.9	Open V 517.		
(Control Room)			
43.10	Set PIC 517 A for 20 psig.		
(N. Elec. Ser. Area)			
43.11	Open HCV 572 A1 by operating HCV 572 A2 with a jumper from the 48 VDC supply IP3.		
43.12	Check all valves and fittings from HCV 572 A1 to V 572 with leak detector solution. No leakage acceptable.		
43.13	Close HCV 572 A1, open V 572 and close the containment enclosure.		
43.14	Connect the He cyl. with regulator and gauge to V CE-3 and pressurize CE No. 3 to 20 psig.		
43.15	Check the CE with leak detector solution. No leakage acceptable.		
43.16	Close V CE-3 while the CE is pressurized and disconnect the He cyl.. Check the outlet of VCE-3 with leak detector solution. No leakage acceptable.		
43.17	Open V CE-3 to relieve the pressure then close and tag closed.		

	Init.	Date & Time
44. Check CV's 574 A & B and CE No. 4 in the following manner. HP coverage and gas masks required.		
(Control Room)		
44.1 Open HCV 575 A1 and set PIC 517 A for 5 psi.	____	________
(N. Elec. Ser. Area)		
44.2 Open V 517.	____	________
44.3 Open HCV 574 A1 by operating HCV 574 A2 with a jumper from the 48 V DC supply 1P3. Leave open for 5 minutes and then close.	____	________
44.4 Close V 517.	____	________
44.5 Open V CE-4, CE No. 4 and close V 574.	____	________
44.6 Disconnect PT 574 B and connect the He cyl. with regulator and gauge to line 574 at this point. Uncap the tap upstream of CV 574 A.	____	________
44.7 Pressurize the line to 20 psig and check for leaks at the tap with leak detector solution. No leakage acceptable.	____	________
44.8 Disconnect the He cyl. and reconnect PT 574 B.	____	________
44.9 Open V 517.	____	________
(Control Room)		
44.10 Set PIC 517 A for 20 psig.	____	________
(N. Elec. Serv. Area)		
44.11 Open HCV 574 A1 by operating HCV 574 A2 with a jumper from the 48V DC supply 1P3.	____	________
44.12 Check all valves and fittings from HCV 574 A1 to V 574 with leak detector solution. No leakage acceptable.	____	________
44.13 Close HCV 574 A1, open V 574 and close CE No. 4.	____	________
44.14 Connect the He cyl. with regulator and gauge to V CE-4 and pressurize the CE to 20 psig.	____	________

	Init.	Date & Time
44.15 Check the CE with leak detector solution. No leakage acceptable.	____	________
44.16 Close V CE-4 while the CE is pressurized and disconnect the He cyl. Check the outlet of V CE-4 with leak detector solution. No leakage acceptable.	____	________
44.17 Open V CE-4 to relieve the pressure then close and tag closed.	____	________
45. Check CV's 576 A & B and CE No. 5 in the following manner. HP coverage and gas masks required.	____	________
(Control Room)		
45.1 Open HCV 577 A1 and set PIC 517 A for 5 psi.	____	________
(N. Elec. Serv. Area)		
45.2 Open V 517.	____	________
45.3 Open HCV 576 A1 by operating HCV 576 A2 with a jumper from the 48V DC supply 1P3. Leave open for 5 minutes and then close.	____	________
45.4 Close V 517.	____	________
45.5 Open V CE-5, CE No. 5 and close V 576.	____	________
45.6 Disconnect PT 576 B and connect the He cyl. with regulator and gauge to line 576 at this point. Uncap the tap upstream of CV 576 A.	____	________
45.7 Pressurize the line to 20 psig and check for leak at the tap with leak detector solution. No leakage acceptable.	____	________
45.8 Disconnect the He cyl. and reconnect PT 576 B.	____	________
45.9 Open V 517.	____	________
(Control Room)		
45.10 Set PIC 517 A for 20 psig.	____	________
(N. Elec. Serv. Area)		
45.11 Open HCV 576 A1 by operating HCV 576 A2 with a jumper from the 48V DC supply 1P3.	____	________

	Init.	Date & Time
45.12 Check all valves and fittings from HCV 576 A1 to V 576 with leak detector solution. No leakage acceptable.	____	________
45.13 Close HCV 576 A1, open V 576 and close CE No. 5.	____	________
45.14 Connect the He cyl. with regulator and gauge to V CE-5 and pressurize the CE to 20 psig.	____	________
45.15 Check the CE with leak detector solution. No leakage acceptable.	____	________
45.16 Close V CE-5 while the CE is pressurized and disconnect the He cyl. Check the outlet of V CE-5 with leak detector solution. No leakage acceptable.	____	________
45.17 Open V CE-5 to relieve the pressure then close and tag closed.	____	________
46. Tables 4.1 and 4.2 of the MSRE Design and Operations Report lists all the penetrations of the RC and DTC. Using a copy of these tables as a check sheet, check each line through these penetrations at the point where it leaves the penetration, except lines 200 in penetrations XII, and 201 in XIX, and check all accessible penetration welds with leak detector solution while the cells are at 20 psig for leak testing.	____	________
47. Check the blind flange on line 918 in the following manner. Gas masks and HP coverage required. (Special Equipment Room)		
47.1 With the RC at 20 psig check the flange with leak detector solution. No leakage acceptable.	____	________
48. Check HCV 565 A1 in the following manner. HP coverage and gas masks required. This test is made while the RC is at 20 psig.		

	Init.	Date & Time
(Control Room)		
48.1 Close HCV 656 A1 by HS 565 A.	_____	_____
(Vent House)		
48.2 Open V 566.	_____	_____
48.3 Connect a 0-10 cc/min rotameter to V 565 B (rotameter inlet to valve) and open V 565 B. Read the rotameter. Acceptable leakage 5 scc/min.		
48.4 Disconnect the rotameter and cap V 565 B, open V 566.	_____	_____
49. Check CV's 802, 803 in the following manner when the vapor condensing system is at 20 psig.	_____	_____
(Water Room)		
49.1 Close V 802 A, 803, 883.	_____	_____
49.2 Open V 802 B.	_____	_____
49.3 Remove the cap on the tap upstream of V 803 and catch the leakage through CV 802. Acceptable leakage 5 cc/min. Leakage ______.	_____	_____
49.4 Close V 802 B and open V 803.	_____	_____
49.5 Catch the leakage through CV 803 at the tap upstream of V 803. Acceptable leakage 5 cc/min. Leakage _______.	_____	_____
49.6 Close V 803, cap the tap and open V 802 A.	_____	_____
50. Check HSV RC E 1, HSV RC E 2, PT RC A, PdT RC E and the equalizing valve across PdT RC E in the following manner. HP coverage and gas masks are required.		
50.1 Open HSV RC E 1, HSV RC E 2 and the equalizing valve across PdT RC E.	_____	_____
50.2 Check with leak detector solution all connections in the piping connecting HSV RC E 1, HSV RC E 2, PT RC A, PdT RC E and the equalizing valve across PdT RC E and check the above item where leakage is possible. No leakage acceptable.	_____	_____

	Init.	Date & Time
51. Check HV RC B, HV RC G, HV RC F the CV's in series with these valves, PxM RC B, PxM RC F, PxM RC G, PSS RC B, PSS RC F, PSS RC G, PI RC B, PI RC F, and PI RC G in the following manner. HP coverage and gas masks required.		
51.1 Close HV RC B, HV RC G, and HV RC F.	_____	__________
51.2 Disconnect the lines to these valves at the upstream side and check with leak detector solution. No leakage acceptable.	_____	__________
52. Check leakage from the thermocouple pressurization headers when the reactor and drain tank cells are at 20 psig. Proceed as follows:		
52.1 Close inlet valves to each header.	_____	__________
52.2 Open each vent to bleed off pressure.	_____	__________
52.3 Close vents and record pressure and time.	_____	__________
52.4 After 4 hours record pressures and calculate leak rate.	_____	__________

	Init.	Date & Time
53. Check 9020-1 Block Valve in NESA and the vent lines connected to it in the following manner. The fuel system must be empty, HP coverage and gas mask required.		
(Control Room)		
53.1 Jumper the block valve closed.	______	______________
(NESA)		
53.2 Connect an N_2 cylinder to the tap upstream of the block valve with a regulator and 0-50 psi minimum range pressure gauge and pressurize the header to 20 psig.	______	______________
53.3 Check the following lines with leak detector solution from the header to the penetrations. No leakage acceptable.		
Line 544-4	______	______________
Line 545-4	______	______________
Line 546-4	______	______________
Line 573-4	______	______________
Line 575-4	______	______________
Line 577-4	______	______________
Line FFT C1 - 5	______	______________
Line FFT C2 - 5	______	______________
Line FD 1 C1 - 5	______	______________
Line FD1 C2 - 5	______	______________
Line FD2 C1 - 5	______	______________
Line FD2 C2 - 5	______	______________
53.4 Disconnect line 9020-1 where it joins the ventilation duct and connect a 0-10 cc/min rotameter to it with line 9020-1 at 20 psig upstream of the block valve.	______	______________
53.5 Read the rotameter. Acceptable leakage 10 scc/min. Leakage _______.	______	______________
53.6 Disconnect the N_2 cyl., cap the tap, and reconnect line 9020-1 to the ventilation duct.	______	______________

	Init.	Date & Time
54. Check 9020-1 block valve in SESA and the vent lines connected to it in the following manner. The fuel system must be empty, HP coverage and gas masks are required.		
(Control Room)		
54.1 Jumper (the block valve) closed.	____	________
(SESA)		
54.2 Connect an N_2 cylinder to the tap upstream of the block valve with a regulator and 0-50 psi minimum range pressure gauge and pressurize the header to 20 psig.	____	________
54.3 Check the following lines with leak detector solution from the header to the penetrations. No leakage acceptable.		
Line 903-4	____	________
Line 915-4	____	________
Line 523-4	____	________
Line 956-4	____	________
Line 961-4	____	________
Line 962-4	____	________
Line 963-4	____	________
54.4 Disconnect line 9020-1 where it joins the ventilation duct and connect a 0-10 cc/min rotameter to it with line 9020-1 at 20 psig upstream of the block valve.	____	________
54.5 Read the rotameter. Acceptable leakage 10 scc/min. Leakage ______.	____	________
54.6 Disconnect the N_2 cylinder, cap the tap and reconnect line 9020-1 to the ventilation duct.	____	________
55. Check the fuel pump and coolant pump oil system for containment in the following manner. HP coverage and gas masks are required.		
(Service Tunnel)		
55.1 Close V 513A, V 711, V 703A, V 762 A, B, & C, V 716, V 706, V 590, V 535.	____	________

	Init.	Date & Time
55.2 Connect a He cyl. with regulator and 0-50 psi minimum range pressure gauge to the tap upstream of PCV 513 A2.	____	________
55.3 Connect a 0-10 cc/min rotameter to the tap upstream of CV 513.	____	________
(Control Room)		
55.4 Set PIC 513 A for 25 psig.	____	________
(Service Tunnel)		
55.5 Open V 513 B and V 535 A.	____	________
55.6 Pressurize OT-1 to 20 psig with the He.	____	________
55.7 Read the rotameter upstream of CV 513. Acceptable leakage 5 scc/min. Leakage __.	____	________
55.8 Open V 711 and check the disconnect upstream of CV 711 for leakage with leak detector solution. No leakage acceptable. Reclose V 711.	____	________
55.9 Check V 716, 703C & D, 762 B & C for visible oil leakage. No leakage acceptable.	____	________
55.10 Connect a 0-10 cc/min rotameter to the tap downstream of PCV 513 A2.	____	________
55.11 Read the rotameter. Acceptable leakage 5 scc/min. Leakage _______.	____	________
55.12 Turn off the He, disconnect the rotameter downstream of PCV 513 A2 and cap the tap. Open V 535 B to relieve the pressure and close V 535 B.	____	________
55.13 Disconnect the He cyl. and reinstall the rotameter downstream of PCV 513 A2.	____	________
(Control Room)		
55.14 Set PIC 513 A for 0 psig.	____	________
(Service Tunnel)		
55.15 Open V 513 A, read the rotameter downstream of PCV 513 A2. This is the leakage through PCV 513 A1 from the He supply line 510 at		

		Init.	Date & Time
55.15	(Continued) 40 psig. Acceptable leakage 10 scc/min. Leakage ______.	_____	__________
55.16	Close V 513 A, open V 535 B to relieve the pressure then close V 535 B.	_____	__________
55.17	Close V 510 A, V 761, V 753, V 766, V 756, V 591, V 534 B.	_____	__________
55.18	Connect a He cyl. with regulator and a 0-50 psi minimum range pressure gauge to the tap upstream of CV 510.	_____	__________
55.19	Connect a 0-10 cc/min rotameter to the tap upstream of CV 510.	_____	__________
(Control Room)			
55.20	Set PIC 510 A for 25 psig.	_____	__________
(Service Tunnel)			
55.21	Open V 510 B and V 534 A.	_____	__________
55.22	Pressurize OT-2 to 20 psig with the He.	_____	__________
55.23	Read the rotameter upstream of CV 510. Acceptable leakage 5 scc/min. Leakage ____.	_____	__________
55.24	Open V 761 and check the disconnect upstream of CV 761 for leakage with leak detector solution. No leakage acceptable. Reclose V 761.	_____	__________
55.25	Check V 766, V 753 D for visible oil leakage. No leakage acceptable.	_____	__________
55.26	Connect a 0-10 cc/min rotameter to the tap downstream of PCV 510 A2.	_____	__________
55.27	Read the rotameter. Acceptable leakage 5 scc/min. Leakage ______.	_____	__________
55.28	Turn off the He, disconnect the rotameter downstream of PCV 510 A2 and cap the tap. Open V 534 to relieve the pressure and close V 535 B.	_____	__________

		Init.	Date & Time
55.29	Disconnect the He cyl. and reinstall the rotameter downstream of PCV 510 A2.	____	________
(Control Room)			
55.30	Set PIC 510 A for 0 psig.	____	________
55.31	Open V 510 A, read the rotameter downstream of PCV 510 A2. This is the leakage through PCV 510 A1 from the He supply at 40 psig. Acceptable leakage 10 scc/min. Leave the rotameter connected to check CV 534. Leakage _______.	____	________
55.32	Close V 510 A, open V 534 B to relieve the pressure then close V 534 B.	____	________
55.33	Close V's 534 A & B and 535 A.	____	________
(Vent House)			
55.34	Close V 560 B, connect a He cyl. with regulator and a 0-50 psi minimum range gauge to V 560 A.	____	________
55.35	Open V 560 A and pressurize the line to 20 psig.	____	________
(Service Tunnel)			
55.36	Open V 534 B and read the rotameter downstream of PCV 510 A2. Acceptable leakage 5 scc/min. Leakage _______.	____	________
55.37	Close V 534 B disconnect the rotameter. Cap the tap and open V 534 B.	____	________
55.38	Connect the rotameter to the tap upstream of CV 535 and open V 535 B.	____	________
55.39	Read the rotameter for leakage through CV 535. Acceptable leakage 5 scc/min. Leakage _______.	____	________
55.40	Close V 535 B. Disconnect the rotameter, cap the tap and open V 535 B.	____	________

	Init.	Date & Time
(Vent House)		
55.41 Close V 560A, disconnect the He cyl., cap the valve outlet and open V 560 B.	_____	__________
56. Check the following valves, fittings, lines, etc., with the RC at atmospheric pressure.		
57. To check HSV FD1 C1 A and line to WT FD1 C1 the fuel systems must be empty. HP coverage and gas masks are required.		
(ESA)		
57.1 Disconnect line FD1 C1-27 at HSV FD1 C1 A and plug the line temporarily to stop air leakage.	_____	__________
(Transmitter Room)		
57.2 Disconnect line FD1 C1-1 at TB 3 x 30.	_____	__________
57.3 Connect a 0-10 cc/min rotameter and N_2 cyl. with regulator and 0-50 psig minimum range gauge to the end of the line to HSV FD1 C1 A and pressurize to 40 psig.	_____	__________
57.4 Read the rotameter. Acceptable leakage 4 scc/min. Leakage ______.	_____	__________
(ESA)		
57.5 Reconnect line FD1 C1-27 to HSV FD1 C1 A while line FD1 C1-1 is at 40 psig. Leak check line FD1 C1-1 from HSV FD1 C1 A to the penetration with leak detector solution. No leakage acceptable.	_____	__________
(Transmitter Room)		
57.6 Disconnect N_2 cyl. and reconnect line FD1 C1-1.	_____	__________
58. To check HSV FD1 C1 B and line to WT FD1 C1 the fuel system must be empty. HP coverage and gas masks are required.		

	Init.	Date & Time
(ESA)		
58.1 Disconnect line FD1 C1-28 at HSV FD1 C1 B and plug the line temporarily to stop air leakage.	____	________
58.2 Disconnect line FD1 C1-2 at TD3 x 29.	____	________
58.3 Connect a 0-10 cc/min rotameter and N_2 cyl. with regulator and 0-50 psig minimum range gauge to the end of the line to HSV FD1 C1 B and pressurize to 40 psig.	____	________
58.4 Read the rotameter. Acceptable leakage 4 scc/min. Leakage ______.	____	________
58.5 Reconnect line FD1 C1-28 to HSV FD1 C1 B while Line FD1 C1-2 is at 40 psig. Leak check line FD1 C1-2 from HSV FD1 C1 B to the penetration with leak detector solution. No leakage acceptable.	____	________
(Transmitter Room)		
58.6 Disconnect the N_2 cyl. and reconnect line FD1 C1-2.	____	________
59. To check HSV FD1 C1 C and line to FD1 the fuel systems must be empty. HP coverage and gas masks are required.		
(ESA)		
59.1 Disconnect line FD1 C1-29 at HSV FD 1 C1 C and plug the line temporarily to stop air leakage.	____	________
(Transmitter Room)		
59.2 Disconnect line FD1 C1-3 at TB3 x 28.	____	________
59.3 Connect a 0-10 cc/min rotameter and N_2 cyl. with regulator and 0-50 psig minimum range gauge to the end of the line to HSV FD1 C1 C and pressurize to 40 psig.	____	________
59.4 Read the rotameter. Acceptable leakage 4 scc/min. Leakage ______.	____	________

	Init.	Date & Time
(ESA)		
59.5 Reconnect line FD1 C1-29 to HSV FD1 C1 C while line FD1 C1-3 is at 40 psig. Leak check line FD1 C1-3 from HSV FD1 C1 C to the penetration with leak detector solution. No leakage acceptable.	_____	__________
(Transmitter Room)		
59.6 Disconnect the N_2 cyl. and reconnect line FD1 C1-3.	_____	__________
60. To check HSV FD1 C1 D and line to WT FD1 C1 the fuel system must be empty. HP coverage and gas masks are required.		
(ESA)		
60.1 Disconnect line FD1 C1-30 at HSV FD1 C1 D and plug the line temporarily to stop air leakage.	_____	__________
60.2 Connect a 0-10 cc/min rotameter and N_2 cyl. with regulator and 0-50 psig minimum range gauge to the outlet of HSV FD1 C1 D and pressurize to 40 psig.	_____	__________
60.3 Read the rotameter. Acceptable leakage 4 scc/min. Leakage _______.	_____	__________
60.4 Reconnect line FD1 C1-30 to HSV FD1 C1 D while line FD1 C1-8 is at 40 psig. Leak check line FD1 C1-8 from HSV FD1 C1 D to the penetration with leak detector solution. No leakage acceptable.	_____	__________
61. To check HSV FD1 C2 A and line to WT FD1 C2 the fuel system must be empty. HP coverage and gas masks are required.		
(ESA)		
61.1 Disconnect line FD1 C2-12 at HSV FD1 C2 A and plug the line temporarily to stop air leakage.	_____	__________

Init. Date & Time

(Transmitter Room)

61.2 Disconnect line FD1 C2-1 at TB3 x 24. ______ ______

61.3 Connect a 0-10 cc/min rotameter and N_2 cyl. with regulator and 0-50 psig minimum range gauge to the end of the line to HSV FD1 C2 A and pressurize to 40 psig. ______ ______

61.4 Read the rotameter. Acceptable leakage 4 scc/min. Leakage ________. ______ ______

(ESA)

61.5 Reconnect line FD1 C2-12 to HSV FD1 C2 A while line FD1 C2-1 is at 40 psig. Leak check line FD1 C2-1 from HSV FD1 C2 A to the penetration with leak detector solution. No leakage acceptable. ______ ______

(Transmitter Room)

61.6 Disconnect N_2 cyl. and reconnect line FD1 C2-1. ______ ______

62. To check HSV FD1 C2 B and line to WT FD1 C2 the fuel system must be empty. HP coverage and gas masks are required.

(ESA)

62.1 Disconnect line FD1 C2-13 at HSV FD1 C2 B and plug the line temporarily to stop air leakage. ______ ______

	Init.	Date & Time
(Transmitter Room)		
62.2 Disconnect line FD1 C2-2 at TB3 x 26.	____	________
62.3 Connect a 0-10 cc/min rotameter and N_2 cyl. with regulator and 0-50 psig minimum range gauge to the end of the line to HSV FD1 C2 B and pressurize to 40 psig.	____	________
62.4 Read the rotameter. Acceptable leakage 4 scc/min. Leakage _____.	____	________
(ESA)		
62.5 Reconnect line FD1 C2-13 to HSV FD1 C2 B while line FD1 C2-2 is at 40 psig. Leak check line FD1 C2-2 from HSV FD1 C2 B to the penetration with leak detector solution. No leakage acceptable.	____	________
(Transmitter Room)		
62.6 Disconnect the N_2 cyl. and reconnect line FD1 C2-2.	____	________
63. To check HSV FD1 C2 C and line to WT FD1 C2 the fuel system must be empty HP coverage and gas masks are required.		
(ESA)		
63.1 Disconnect line FD1 C2-14 at HSV FD1 C2 C and plug the line temporarily to stop air leakage.	____	________
(Transmitter Room)		
63.2 Disconnect line FD3 C2-3 at TB3 x 25.	____	________
63.3 Connect a 0-10 cc/min rotameter and N_2 cyl. with regulator and 0-50 psig minimum range gauge to the end of the line to HSV FD1 C2 C and pressurize to 40 psig.	____	________
63.4 Read the rotameter. Acceptable leakage 4 scc/min. Leakage _______.	____	________

	Init.	Date & Time
(ESA)		
63.5 Reconnect line FD1 C2-14 to HSV FD1 C2 C while line FD1 C2-3 is at 40 psig. Leak check line FD1 C2-3 from HSV FD1 C2 C to the penetration with leak detector solution. No leakage acceptable.	____	________
(Transmitter Room)		
63.6 Disconnect N_2 cyl. and reconnect line FD1 C2-3.	____	________
64. To check HSV FD1 C2 D and lines to WT FD1 C2 the fuel system must be empty. HP coverage and gas masks are required.		
(ESA)		
64.1 Disconnect line FD1 C2-31 at HSV FD1 C2 D and plug the line temporarily to stop air leakage.	____	________
64.2 Connect a 0-10 cc/min rotameter and N_2 with regulator and 0-50 psig minimum range gauge to the outlet of HSV FD1 C2 D and pressurize to 40 psig.	____	________
64.3 Read the rotameter. Acceptable leakage 4 scc/min. Leakage ________	____	________
64.4 Reconnect line FD1 C2-31 to HSV FD1 C2 D while line FD1 C2-8 is at 40 psig. Leak check line FD1 C2-8 from HSV FD1 C2 D to the penetration with leak detector solution. No leakage acceptable.	____	________
65. To check HSV FD2 C1 A and line to WT FD2 4 the fuel system must be empty. HP coverage and gas masks are required.		
(ESA)		
65.1 Disconnect line FD2 C1-27 at HSV FD 2 C1 A and plug the line temporarily to stop air leakage.	____	________

	Init.	Date & Time
(Transmitter Room)		
65.2 Disconnect line FD2 Cl-1 at TB3 x 24.	____	________
65.3 Connect a 0-10 cc/min rotameter and N_2 cyl. with regulator and 0-50 psig minimum range gauge to the end of the line to HSV FD2 Cl A and pressurize to 40 psig.	____	________
65.4 Read the rotameter. Acceptable leakage 4 scc/min. Leakage ______.	____	________
65.5 Reconnect line FD2 Cl-27 to HSV FD2 Cl A while line FD2 Cl-1 is at 40 psig. Leak check line FD2 Cl-1 from HSV FD2 Cl A to the penetration with leak detector solution. No leakage acceptable.	____	________
(Transmitter Room)		
65.6 Disconnect the N_2 cyl. and reconnect line FD2 Cl-1.	____	________
66. To check HSV FD2 Cl B and line to WT FD2 Cl the fuel system must be empty. HP coverage and gas masks are required.		
(ESA)		
66.1 Disconnect line FD2 C2-28 at HSV and plug the line temporarily to stop air leakage.	____	________
(Transmitter Room)		
66.2 Disconnect line FD2 Cl-2 at TB3 x 23.	____	________
66.3 Connect a 0-10 cc/min rotameter and N_2 cyl. with regulator and 0-50 psig minimum range gauge to the end of the line to HSV FD2 Cl B and pressurize to 40 psig.		
66.4 Read the rotameter. Acceptable leakage 4 scc/min. Leakage ______.	____	________
66.5 Reconnect line FD2 Cl-28 to HSV FD2 Cl B while line FD2 Cl-2 is at 40 psig. Leak check line FD2 Cl-2 from HSV FD2 Cl B to the penetration with leak detector solution. No leakage acceptable.	____	________

Init. Date & Time

(Transmitter Room)

66.6 Disconnect N_2 cyl. and reconnect line FD2 C1-2. ____ ____

67. To check HSV FD2 C1 C and line to WT FD2 C1 the fuel system must be empty. HP coverage and gas masks are required.

(ESA)

67.1 Disconnect line FD2 C1-29 at HSV FD2 C1 C and plug the line temporarily to stop air leakage. ____ ____

(Transmitter Room)

67.2 Disconnect line FD2 C1-3 at TB 3 x 22. ____ ____

67.3 Connect a 0-10 cc/min rotameter and N_2 cyl. with regulator and 0-50 psig minimum range gauge to the end of the line to HSV FD2 C1 C and pressurize to 40 psig. ____ ____

67.4 Read the rotameter. Acceptable leakage 4 scc/min. Leakage ________. ____ ____

(ESA)

67.5 Reconnect line FD2 C1-29 to HSV FD2 C1 C while line FD2 C1-3 is at 40 psig. Leak check line FD2 C1-3 from HSV FD2 C1 C to the penetration with leak detector solution. No leakage acceptable. ____ ____

(Transmitter Room)

67.6 Disconnect N_2 cyl. and reconnect line FD2 C1-3. ____ ____

68. To check HSV FD2 C1 D and line to WT FD2 C1 the fuel system must be empty. HP coverage and gas masks are required.

(ESA)

68.1 Disconnect line FD2 C1-30 at HSV FD2 C1 D and plug the line temporarily to stop air leakage. ____ ____

		Init.	Date & Time
68.2	Connect a 0-10 cc/min rotameter and N_2 cyl. with regulator and 0-50 psig minimum range gauge to the outlet of HSV FD2 Cl D and pressurize to 40 psig.	____	________
68.3	Read the rotameter. Acceptable leakage 4 scc/min. Leakage ______.	____	________
68.4	Reconnect line FD2 Cl-30 to HSV FD2 Cl D while line FD2 Cl-8 is at 40 psig. Leak check line FD2 Cl-8 from HSV FD2 Cl D to the penetration with leak detector solution. No leakage acceptable.	____	________

69. To check HSV FD2 C2 A and line to WT FD2 C2 the fuel system must be empty. HP coverage and gas masks are required.

(ESA)

		Init.	Date & Time
69.1	Disconnect line FD2 C2-12 at HSV FD2 C2 A and plug the line temporarily to stop air leakage.	____	________
	(Transmitter Room)		
69.2	Disconnect line FD2 C2-1 at TB3 x 21.	____	________
69.3	Connect a 0-10 cc/min rotameter and N_2 cyl. with regulator and 0-50 psig minimum range gauge to the end of the line to HSV FD2 C2 A and pressurize to 40 psig.	____	________
69.4	Read the rotameter. Acceptable leakage 4 scc/min. Leakage ______.	____	________
	(ESA)		
69.5	Reconnect line FD2 C2-12 to HSV FD2 C2 A while line FD2 C2-1 is at 40 psig. Leak check line FD2 C2-1 from HSV FD2 C2 A to the penetration with leak detector solution. No leakage acceptable.	____	________
	(Transmitter Room)		
69.6	Disconnect N_2 cyl. and reconnect line FD2 C2-1.	____	________

	Init.	Date & Time
70. To check HSV FD2 C2 B and line to WT FD2 C2 the fuel system must be empty. HP coverage and gas masks are required.		
(ESA)		
70.1 Disconnect line FD2 C2-13 at HSV FD2 C2 B and plug the line temporarily to stop air leakage.	____	________
(Transmitter Room)		
70.2 Disconnect line FD2 C2-2 at TB3 x 20.	____	________
70.3 Connect a 0-10 cc/min rotameter and N_2 cyl. with regulator and 0-50 psig minimum range gauge to the end of the line to HSV FD2 C2 B and pressurize to 40 psig.	____	________
70.4 Read the rotameter. Acceptable leakage 4 scc/min. Leakage _______.	____	________
(ESA)		
70.5 Reconnect line FD2 C2-13 to HSV FD2 C2 B while line FD2 C2-2 is at 40 psig. Leak check line FD2 C2-2 from HSV FD2 C2 B to the penetration with leak detector solution. No leakage acceptable.	____	________
(Transmitter Room)		
70.6 Disconnect N_2 cyl. and reconnect line FD2 C2 .	____	________
71. To check HSV FD2 C2 C and line to WT FD2 C2 the fuel system must be empty. HP coverage and gas masks are required.		
(ESA)		
71.1 Disconnect line FD2 C2-29 at HSV FD2 C2 C and plug the line temporarily to stop air leakage.	____	________
(Transmitter Room)		
71.2 Disconnect line FD2 C2-3 at TB3 x 19.	____	________

		Init.	Date & Time
71.3	Connect a 0-10 cc/min rotameter and N_2 cyl. with regulator and 0-50 psig minimum range gauge to the end of the line to HSV FD2 C2 C and pressurize to 40 psig.	____	________
71.4	Read the rotameter. Acceptable leakage 4 scc/min. Leakage ______.	____	________
(ESA)			
71.5	Reconnect line FD2 C2-29 to HSV FD2 C2 C while line FD2 C2-3 is at 40 psig. Leak check line FD2 C2-3 from HSV FD2 C2 C and pressurize to 40 psig.	____	________
(Transmitter Room)			
71.6	Disconnect N_2 cyl. and reconnect line FD2 C2-3.	____	________

72. To check HSV FD2 C2 D and line to WT FD2 C2 the fuel system must be empty. HP coverage and gas masks are required.

		Init.	Date & Time
(ESA)			
72.1	Disconnect line FD2 C2-31 at HSV FD2 C2 D and plug the line temporarily to stop air leakage.	____	________
72.2	Connect a 0-10 cc/min rotameter and N_2 cyl. with regulator and 0-50 psig minimum range gauge to the end of the line to HSV FFT C1 A and pressurize to 40 psig.	____	________
72.3	Read the rotameter. Acceptable leakage 4 scc/min. Leakage _____.	____	________
72.4	Reconnect line FD2 C2-31 to HSV FD2 C2D while line FD2 C2-8 is at 40 psig. Leak check line FD2 C2-8 from HSV FD2 D to the penetration with leak detector solution. No leakage acceptable.	____	________

	Init.	Date & Time
73. To check HSV FFT Cl A and line to WT FFT Cl the fuel system must be empty. HP coverage and gas masks are required.		
(ESA)		
73.1 Disconnect line FFT Cl-17 at HSV FFT Cl A and plug the line temporarily to stop air leakage.	____	________
(Transmitter Room)		
73.2 Disconnect line FFT Cl-1 at TB 3 x 16.	____	________
73.3 Connect a 0-10 cc/min rotameter and N_2 cyl. with regulator and 0-50 psig minimum range gauge to the end of the line to HSV FFT Cl A and pressurize to 40 psig.	____	________
73.4 Read the rotameter. Acceptable leakage 4 scc/min. Leakage ________.	____	________
73.5 Reconnect line FFT Cl-17 to HSV FFT Cl A while line FFT Cl-1 is at 40 psig. Leak check line FFT Cl-1 from HSV FFT Cl A to the penetration with leak detector solution. No leakage acceptable.	____	________
73.6 Disconnect N_2 cyl. and reconnect line FFT Cl-1.	____	________
74. To check HSV FFT Cl B and line to WT FFT Cl the fuel system must be empty. HP coverage and gas masks are required.		
(ESA)		
74.1 Disconnect line FFT Cl-18 at HSV FFT Cl B and plug the line temporarily to stop air leakage.	____	________
(Transmitter Room)		
74.2 Disconnect line FFT Cl-2 at TB 3 x 18.	____	________
74.3 Connect a 0-10 cc/min rotameter and N_2 cyl. with regulator and 0-50 psig minimum range gauge to the end of the line to HSV FFT Cl B and pressurize to 40 psig.	____	________

	Init.	Date & Time
74.4 Read the rotameter. Acceptable leakage 4 scc/min. Leakage ________.	____	________
(ESA)		
74.5 Reconnect line FFT Cl-18 to HSV FFT Cl B while line FFT Cl-2 is at 40 psig. Leak check line FFT Cl-2 from HSV FFT Cl B to the penetration with leak detector solution. No leakage acceptable.	____	________
(Transmitter Room)		
74.6 Disconnect N_2 cyl. and reconnect line FFT Cl-1.	____	________
75. To check HSV FFT Cl C and line to WT FFT Cl, the fuel system must be empty. HP coverage and gas masks are required.		
(ESA)		
75.1 Disconnect line FFT Cl-19 at HSV and plug the line temporarily to stop air leakage.	____	________
(Transmitter Room)		
75.2 Disconnect line FFT Cl-3 at TB3 x 17.	____	________
75.3 Connect a 0-10 cc/min rotameter and N_2 cyl. with regulator and 0-50 psig minimum range gauge to the end of the line to HSV FFT Cl C and pressurize to 40 psig.	____	________
75.4 Read the rotameter. Acceptable leakage 4 scc/min. Leakage ________.	____	________
(ESA)		
75.5 Reconnect line FFT Cl-19 to HSV FFT Cl C while line FFT Cl-3 is at 40 psig. Leak check line FFT Cl-3 from HSV FFT Cl C to the penetration with leak detector solution. No leakage acceptable.	____	________
(Transmitter Room)		
75.6 Disconnect the N_2 cyl. and reconnect line FFT Cl-3.	____	________

	Init.	Date & Time
76. To check HSV FFT C1 D and line to WT FFT C1 the fuel system must be empty. HP coverage and gas masks are required.		
(ESA)		
76.1 Disconnect line FFT C1-20 at HSV FFT C1 D and plug the line temporarily to stop air leakage.	____	________
76.2 Connect a 0-10 cc/min rotameter and N_2 cyl. with regulator and 0-50 psig minimum range gauge to the outlet of HSV FFT C1 D and pressurize to 40 psig.	____	________
76.3 Read the rotameter. Acceptable leakage 4 scc/min. Leakage ______.	____	________
76.4 Reconnect line FFT C1-20 to HSV FFT C1 D while line FFT C1-8 is at 40 psig. Leak check line FFT C1-8 from HSV FFT C1 D to the penetration with leak detector solution. No leakage acceptable.	____	________
77. To check HSV FFT C2 A and line to WT FFT C2 the fuel system must be empty. HP coverage and gas masks are required.		
(ESA)		
77.1 Disconnect line FFT C2-12 at HSV FFT C2 A and plug the line temporarily to stop air leakage.	____	________
(Transmitter Room)		
77.2 Disconnect line FFT C2-1 at TB3 x 13.	____	________
77.3 Connect a 0-10 cc/min rotameter and N_2 cyl. with regulator and 0-50 psig minimum range gauge to the end of the line to HSV FFT C2 A and pressurize to 40 psig.	____	________
77.4 Read the rotameter. Acceptable leakage 4 scc/min. Leakage ______.	____	________

	Init.	Date & Time

(ESA)

77.5 Reconnect line FFT C2-12 to HSV FFT C2 A while line FFT C2-1 is at 40 psig. Leak check line FFT C2-1 from HSV FFT C2 A to the penetration with leak detector solution. No leakage acceptable. ______ ____________

(Transmitter Room)

77.6 Disconnect the N_2 cyl. and reconnect line FFT C2 1. ______ ____________

78. To check HSV FFT C2 B and line to WT FFT C2 the fuel system must be empty. HP coverage and gas masks are required. ______ ____________

(ESA)

78.1 Disconnect line FFT C2-13 at HSV FFT C2 B and plug the line temporarily to stop air leakage. ______ ____________

(Transmitter Room)

78.2 Disconnect line FFT C2-2 at TB3 x 15. ______ ____________

78.3 Connect a 0-10 cc/min rotameter and N_2 cyl. with regulator and 0-50 psig minimum range gauge to the end of the line to HSV FFT C2 B and pressurize to 40 psig. ______ ____________

78.4 Read the rotameter. Acceptable leakage 4 scc/min. Leakage _______. ______ ____________

(ESA)

78.5 Reconnect line FFT C2-13 to HSV FFT C2 B while line FFT C2-2 is at 40 psig. Leak check line FFT C2-2 from HSV FFT C2 B to the penetration with leak detector solution. No leakage acceptable. ______ ____________

(Transmitter Room)

78.6 Disconnect the N_2 cyl. and reconnect line FFT C2-2. ______ ____________

	Init.	Date & Time
79. To check HSV FFT C2 C and line to WT FFT C2 the fuel system must be empty. HP coverage and gas masks are required.		
(ESA)		
79.1 Disconnect line FFT C2-14 at HSV FFT C2 6 and plug the line temporarily to stop air leakage.	____	________
(Transmitter Room)		
79.2 Disconnect line FFT C2-3 at TB3 x 14.	____	________
79.3 Connect a 0-10 cc/min rotameter and N_2 cyl. with regulator and 0-50 psig minimum range gauge to the end of the line to HSV FFT C2 C and pressurize to 40 psig.	____	________
79.4 Read the rotameter. Acceptable leakage 4 scc/min. Leakage _______.	____	________
(ESA)		
79.5 Reconnect line FFT C2-14 to HSV FFT C2 C while line FFT C2-3 is at 40 psig. Leak check line FFT C2-3 from HSV FFT C2 C to the penetration with leak detector solution. No leakage acceptable.	____	________
(Transmitter Room)		
79.6 Disconnect N_2 cyl. and reconnect line FFT C2-3.	____	________
80. To check HSV FFT C2 D and line to WT FFT C2 the fuel system must be empty. HP coverage and gas masks are required.		
(ESA)		
80.1 Disconnect line FFT C2-21 at HSV FFT C2 D and plug the line temporarily to stop air leakage.	____	________
80.2 Connect a 0-10 cc/min rotameter and 0-50 psig minimum range gauge to the outlet of HSV FFT C2 D and pressurize to 40 psig.	____	________

		Init.	Date & Time
80.3	Read the rotameter. Acceptable leakage 4 scc/min. Leakage _______.	_____	___________
80.4	Reconnect line FFT C2 21 to HSV FFT C2 D while line FFT C2-8 is at 40 psig. Leak check line FFT C2-8 from HSV FFT C2 D to the penetration with leak detector solution. No leakage acceptable.	_____	___________

81. To check HSV 544 A and lines to HSV 544 A1 the fuel system must be empty. HP coverage and gas masks are required.

(ESA)

		Init.	Date & Time
81.1	Disconnect line 544-3 at HSV 544 A and plug the line temporarily to stop air leakage.	_____	___________
	(Transmitter Room)		
81.2	Close the valve in line 544-1 off header 9007-4 and disconnect line 544-2 at SR x 26.	_____	___________
81.3	Connect a 0-10 cc/min rotameter and N_2 cyl. with regulator and 0-50 psig minimum range gauge to the end of the line to HSV 544 A and pressurize to 40 psig.	_____	___________
81.4	Read the rotameter. Acceptable leakage 4 scc/min. Leakage _______.	_____	___________
	(ESA)		
81.5	Reconnect line 544-3 to HSV 544 A while line 544-2 is at 40 psig. Leak check line 544-2 from HSV 544 A to the penetration with leak detector solution. No leakage acceptable.	_____	___________
	(Transmitter Room)		
81.6	Disconnect the N_2 cyl., reconnect line 544-2 and open the valve in line 544-1 off header 9007-4.	_____	___________

	Init.	Date & Time
82. To check HSV 545 A and lines to HCV 545 the fuel system must be empty. HP coverage and gas masks are required.		
(ESA)		
82.1 Disconnect line 545-3 at HSV 545 A and plug the line temporarily to stop air leakage.	_____	_____
(Transmitter Room)		
82.2 Close the valve in line 545-1 off header 9007-4 and disconnect line 545-2 at SR x 29.	_____	_____
82.3 Connect a 0-10 cc/min rotameter and N_2 cyl. with regulator and 0-50 psig minimum range gauge to the end of the line to HSV 545 A and pressurize to 40 psig.	_____	_____
82.4 Read the rotameter. Acceptable leakage 4 scc/min. Leakage ______.	_____	_____
(ESA)		
82.5 Reconnect line 545-3 to HSV 545 A while line 545-2 is at 40 psig. Leak check line 545-2 from HSV 545 A to the penetration with leak detector solution. No leakage acceptable.	_____	_____
(Transmitter Room)		
82.6 Disconnect N_2 cyl., reconnect line 545-2, and open the valve in line 545-1 off header 9007-4	_____	_____
83. To check HSV 546 A and lines to HCV 546 A1 the fuel system must be empty. HP coverage and gas masks are required.		
(ESA)		
83.1 Disconnect line 546-3 at HSV 546 A and plug the line temporarily to stop air leakage.	_____	_____
(Transmitter Room)		
83.2 Close the valve in line 546-1 off header 9007-4 and disconnect line 546-2 at SR x 23.	_____	_____

Init. Date & Time

83.3 Connect a 0-10 cc/min rotameter and N_2 cyl. with regulator and 0-50 psig minimum range gauge to the end of the line to HSV 546 A and pressurize to 40 psig. _____ __________

83.4 Read the rotameter. Acceptable leakage 4 scc/min. Leakage ________. _____ __________

(ESA)

83.5 Reconnect line 546-3 to HSV 546 A while line 546-2 is at 40 psig. Leak check line 546-2 from HSV 546 A to the penetration with leak detector solution. No leakage acceptable. _____ __________

(Transmitter Room)

83.6 Disconnect the N_2 cyl., reconnect line 546-2 and open the valve in line 546-1 off header 9007-4. _____ __________

84. To check HSV 573 A and lines to HCV 573 A1 the fuel system must be empty. HP coverage and gas masks are required.

(ESA)

84.1 Disconnect line 573-3 at HSV and plug the line temporarily to stop air leakage. _____ __________

(Transmitter Room)

84.2 Close the valve in line 573-1 off header 9007-4 and disconnect line 573-2 at SR x 32. _____ __________

84.3 Connect a 0-10 cc/min rotameter and N_2 cyl. with regulator and 0-50 psig minimum range gauge to the end of the line to HSV 573 A and pressurize to 40 psig. _____ __________

84.4 Read the rotameter. Acceptable leakage 4 scc/min. Leakage ________. _____ __________

	Init.	Date & Time
(ESA)		
84.5 Reconnect line 573-3 to HSV 573 A while line 573-2 is at 40 psig. Leak check line 573-2 from HSV 573 A to the penetration with leak detector solution. No leakage acceptable.	____	________
84.6 Disconnect N_2 cyl.. Reconnect line 573-2 and open the valve in line 573-1 off header 9007-4.	____	________
85. To check HSV 575 A and line to HCV 575 the fuel system must be empty. HP coverage and gas masks are required.		
(ESA)		
85.1 Disconnect line 575-3 at HSV 575 A and plug the line temporarily to stop air leakage.	____	________
(Transmitter Room)		
85.2 Close the valve in line 575-1 off header 9007-4 and disconnect line 575-2 at SR x 35.	____	________
85.3 Connect a 0-10 cc/min rotameter and N_2 cyl. with regulator and 0-50 psig minimum range gauge to the end of the line to HSV 575 A and pressurize to 40 psig.	____	________
85.4 Read the rotameter. Acceptable leakage 4 scc/min. Leakage ______.	____	________
86. To check HSV 577 A and lines to HCV 577 A1, the fuel system must be empty. HP coverage and gas masks are required.		
(ESA)		
86.1 Disconnect line 577-3 at HSV 577 A and plug the line temporarily to stop air leakage.	____	________
(Service Room)		
86.2 Close the valve in line 577-1 off header 9007-4 and disconnect line 577-2 at SR x 38.	____	________
86.3 Connect a 0-10 cc/min rotameter and N_2 cyl. with regulator and 0-50 psig minimum range		

		Init.	Date & Time
86.3	(Continued) gauge to the end of the line to HSV 577 A and pressurize to 40 psig.	_____	__________
86.4	Read the rotameter. Acceptable leakage 4 scc/min. Leakage _______.	_____	__________
(ESA)			
86.5	Reconnect line 577-3 to HSV 577 A while line 577-2 is at 40 psig. Leak check line 577-2 from HSV 577 A to the penetration with leak detector solution. No leakage acceptable.	_____	__________
(Transmitter Room)			
86.6	Disconnect the N_2 cyl., reconnect line 577-2, and open the valve in line 577-1 off header 9007-4.	_____	__________

87. To check HSV 903 A and lines to HCV 903 the fuel system must be empty. HP coverage and gas masks are required.

		Init.	Date & Time
(SESA)			
87.1	Disconnect line 903-3 at HSV 903 A and plug the line temporarily to stop air leakage.	_____	__________
(Transmitter Room)			
87.2	Close the valve in line 903-1 off header 9008-2 and disconnect line 903-2 at TB6 x 6.	_____	__________
87.3	Connect 0-10 cc/min rotameter and N_2 cyl. with regulator and 0-50 psig minimum range gauge to the end of the line to HSV-903-A and pressurize to 40 psig.	_____	__________
87.4	Read the rotameter. Acceptable leakage 4 scc/min. Leakage _______.	_____	__________
(SESA)			
87.5	Reconnect line 903-3 to HSV 903 A while line 903-2 is at 40 psig. Leak check line 903-2 from HSV 903 A to the penetration with leak detector solution. No leakage acceptable.	_____	__________

	Init.	Date & Time
(Transmitter Room)		
87.6 Disconnect N_2 cyl., reconnect line 903-2; open valve in line 903-1 off header 9008-2.	_____	__________
88. To check HSV 915 A and lines to HCV 915 A the fuel system must be empty. HP coverage and gas masks are required.		
(ESA)		
88.1 Disconnect line 915-5 at HSV 915 A and plug the line temporarily to stop air leakage.	_____	__________
(Transmitter Room)		
88.2 Close the valve in line 915-1 off header 9008-2 and disconnect line 915-3 at TB 6 x 12.	_____	__________
88.3 Connect a 0-10 cc/min rotameter and N_2 cyl. with regulator and 0-50 psig minimum range gauge to the end of the line to HSV 915 A and pressurize to 40 psig.	_____	__________
88.4 Read the rotameter. Acceptable leakage 4 scc/min. Leakage _______.	_____	__________
(ESA)		
88.5 Reconnect line 915-5 to HSV 915A while line 915-3 is at 40 psig. Leak check line 915-3 from HSV 915 A to the penetration with leak detector solution. No leakage acceptable.	_____	__________
(Transmitter Room)		
88.6 Disconnect N_2 cyl., reconnect line line 915-3 and open the valve in line 915-1 off header 9008-2.	_____	__________
89. To check HSV 956 A and line to HCV 956A the fuel system must be empty. HP coverage and gas masks are required.		
(ESA)		
89.1 Disconnect line 956-3 at HSV 956 A and plug the line temporarily to stop air leakage.	_____	__________

	Init.	Date & Time
(Transmitter Room)		
89.2 Close the valve in line 956-1		
89.3 Connect a 0-10 cc/min rotameter and N_2 cyl. with regulator and 0-50 psig minimum range gauge to the end of the line to HSV 956 A and pressurize to 40 psig.	____	________
89.4 Read the rotameter. Acceptable leakage 4 scc/min. Leakage ______.	____	________
(ESA)		
89.5 Reconnect line 956-3 to HSV 956-2 while line 956-2 is at 40 psig. Leak check line 956-2 from HSV 956 A to the penetration with leak detector solution. No leakage acceptable.	____	________
(Transmitter Room)		
89.6 Disconnect N_2 cyl. Reconnect line 956-2 and open valve in line 956-1 off header 9008-2.	____	________
90. To check HSV 960 A1, HSV 960 A2, FE 960 A and line to these items, the fuel system must be empty. HP coverage and gas masks are required.		
(SESA)		
90.1 Disconnect line 960-7 at HSV 960 A1 and plug the line temporarily to stop air leakage.	____	________
90.2 Disconnect line 960-12 at SR x 74.	____	________
90.3 Connect a 0-10 cc/min rotameter and N_2 cyl. with regulator and 0-50 psig minimum range gauge to the end of the line to HSV 960 A1 and pressurize to 40 psig.	____	________

Init. | Date & Time

90.4 Read the rotameter. Acceptable leakage 4 scc/min. Leakage _______.

(SESA)

90.5 Reconnect line 960-7 to HSV 960 A1 while line 960-13 is at 40 psig. Leak check line 960-12 from HSV 960 A1 to the penetration with leak detector solution. No leakage acceptable.

90.6 While line 960-12 is at 40 psig, check line 960-9, FE 960 A, line 960-10 and line 960-8 with leak detector solution. No leakage acceptable.

90.7 Disconnect the line from HSV 960 A2 to header 9020-1 at the valve and connect a 0-10 cc/min rotameter to the valve while line 960-12 is at 40 psig.

90.8 Read the rotameter. Acceptable leakage 4 scc/min. Leakage ________.

(SESA and Transmitter Room)

90.9 Disconnect the N_2 cyl. and reconnect lines 960-12 and the line from HSV 960 A_2 to header 9020-1

91. To check HSV 961 A and lines to HCV 961 A1 the fuel system must be empty. HP coverage and gas masks are required.

(SESA)

91.1 Disconnect line 961-3 at HSV 961 A and plug the line temporarily to stop air leakage.

(Transmitter Room)

91.2 Close the valve in line 961-1 off header 9008-2 and disconnect line 961-1 at TB 5 x 8.

	Init.	Date & Time
91.3 Connect a 0-10 cc/min rotameter and N_2 cyl. with regulator and 0-50 psig minimum range pressure gauge to the end of the line to HSV 961 A and pressurize the line to 40 psig.	_____	_____
91.4 Read the rotameter. Acceptable leakage 4 scc/min. Leakage _________.	_____	_____
(SESA)		
91.5 Reconnect line 961-3 to HSV 961 A while line 961-2 is at 40 psig.	_____	_____
91.6 Leak check line 961-2 from HSV 961 A to the penetration with leak detector solution. No leakage acceptable.	_____	_____
(Transmitter Room)		
91.7 Disconnect N_2 cyl. Reconnect line 961-2 and open valve in line 961-1 off header 9008-2.	_____	_____
92. To check HSV 919 A1, HSV 919 A2, FE 919 A, HSV 919 B1, HSV 919 B2, and FE 919 B the fuel system must be empty. HP coverage and gas masks are required.	_____	_____
(Control Room)		
92.1 Close the B port of HCV 919 A2.	_____	_____
(Transmitter Room)		
92.2 Disconnect line 919-6 at TB7 x 3.	_____	_____
(SESA)		
92.3 Disconnect line 919-7 at HSV 919 A1 and temporarily plug the line to stop air leakage.	_____	_____
(Transmitter Room)		
92.4 Connect a 0-10 cc/min rotameter and N_2 cyl. with regulator and 0-50 psig minimum range pressure gauge to the end of line 919-6 going to HSV 919 A1 and pressurize to 40 psig.	_____	_____

		Init.	Date & Time
92.5	Read the rotameter. Acceptable leakage 4 scc/min. Leakage ______.	______	______
(Transmitter Room and ESA)			
92.6	Relieve the pressure on line 919-6, reconnect line 919-7 to the valve, and disconnect line 919-18 from HSV 919 A2. Cap the line temporarily to stop air leakage.	______	______
92.7	Pressurize HSV 919 A2 through line 919-6 to 40 psig. Read the rotameter. Acceptable leakage 4 scc/min. Leakage ______.	______	______
92.8	Check FE 919 A, lines 919-15, 919-16, 919-6 from HSV 919 A1 to the penetration and 919-8 from HSV 919 A2 to the penetration with leak detector solution while pressurized to 40 psig. in step 92.7. No leakage acceptable.	______	______
92.9	Disconnect the N_2 cyl. and reconnect all lines.	______	______
(Control Room)			
92.10	Close the B port of HCV 919 B2 by setting S3 in the drain position.	______	______
(Transmitter Room)			
92.11	Disconnect line 919-10 at SR x 65.	______	______
(SESA)			
92.12	Disconnect line 919-17 at HSV 919 B1 and temporarily plug the line to stop air leakage.	______	______
(Transmitter Room)			
92.13	Connect a 0-10 cc/min rotameter and N_2 cyl. with regulator and 0-50 psig minimum range pressure gauge to the end of line 919-10 going to HSV 919 B1 and pressurize to 40 psig.	______	______

	Init.	Date & Time
92.14 Read the rotameter. Acceptable leakage 4 scc/min. Leakage _______.	_____	___________
(SESA & Transmitter Room)		
92.15 Relieve the pressure on line 919-10, reconnect line 919-17 to the valve, and disconnect line 919-19 from HSV 919-B2. Cap the line temporarily to stop air leakage.	_____	___________
(Transmitter Room)		
92.16 Pressurize HSV 919 B2 through line 919-10 to 40 psig. Read the rotameter. Acceptable leakage 4 scc/min. Leakage _______.	_____	___________
(SESA)		
92.17 Check FE 919 B, line 919-13, 919-14, 919-11 from HSV 919 B1 to the penetration and 919-12 from HSV 919 B2 to the penetration with leak detector solution. No leakage acceptable.	_____	___________
(Transmitter Room and SESA)		
92.18 Disconnect the N_2 cyl. and reconnect all lines. To check HSV 962 A and lines to HCV 962 A the fuel system must be empty. HP coverage and gas masks are required.	_____	___________
(ESA)		
92.19 Disconnect line 962-3 at HSV 962 A and plug the line temporarily to stop air leakage.	_____	___________
(Transmitter Room)		
92.20 Close the valve in line 962-1 off header 9008-2 and disconnect line 962-2 at TB5 x 7.	_____	___________
92.21 Connect a 0-10 cc/min rotameter and N_2 cyl. with regulator and 0-50 psig minimum range gauge to the end of the line to HSV 962 A and pressurize to 40 psig.	_____	___________
92.22 Read the rotameter. Acceptable leakage 4 scc/min. Leakage _______.	_____	___________

	Init.	Date & Time
(ESA)		
92.23 Reconnect line 962-3 to HSV 962 A while line 962-1 is at 40 psig. Leak check line 962-2 at TB 5 x 6.	_____	__________
(Transmitter Room)		
92.24 Disconnect N_2 cylinder. Reconnect line 962-2 and open valve in line 962-1 off header 9008-2.	_____	__________
93. To check HSV 963 A and line to HCV 963 A the fuel system must be empty. HP coverage and gas masks are required.		
(ESA)		
93.1 Disconnect line 963-3 at HSV 962 A and plug the line temporarily to stop air leakage.	_____	__________
(Transmitter Room)		
93.2 Close the valve in line 963-1 off header 9008-2 and disconnect line 963-2 at TB 5 x 6.	_____	__________
93.3 Connect a 0-10 cc/min rotameter and N_2 cyl. with regulator and 0-50 psig minimum range gauge to the end of the line to HSV 963 A and pressurize to 40 psig.	_____	__________
93.4 Read the rotameter. Acceptable leakage 4 scc/min. Leakage _______.	_____	__________
(ESA)		
93.5 Reconnect line 963-3 to HSV 963 A while line 963-2 is at 40 psig. Leak check line 963-2 from HSV 963 A to the penetration with leak detector solution. No leakage acceptable.	_____	__________
(Transmitter Room)		
93.6 Disconnect N_2 cyl..., reconnect 962-2 and open valve in line 963-1 of header 9008-2.	_____	__________

	Init.	Date & Time
94. Check CV 524, CV 557 A & B, CV 560 D, CV 562, HCV 557 C, V 557 C, CV 565, and CV 566 in the following manner. HP coverage and gas masks required.		
(Special Equipment Room)		
94.1 Close V's 500 J and V 524 A.	____	________
(Vent House)		
94.2 Close V's 522 B, 561, 620, 621, 622, 623.	____	________
94.3 Connect a 0-10 cc/min rotameter to the sample pt. at V 524 B.	____	________
94.4 Connect a He Cylinder with regulator and 0-50 psi minimum range gauge to the sample point at V 518 F.	____	________
94.5 Open V's 518 E, 518 D, 518 F, 524 B.	____	________
94.6 Slowly pressurize the line with He to 40 psig while observing the rotameter. Constant surveillance by the HP at the rotameter outlet is required. If the activity reaches 2 mr/hr close V 524 B immediately. The acceptable leakage is 5 scc/min at 40 psig. If this limit is reached before the 40 psig He pressure is reached discontinue the test. Leakage ________.	____	________
94.7 Close the valve on the He cylinder. Close V 524 B. Disconnect the rotameter and cap the valve outlet.	____	________
94.8 Open V's 620, 621, and 561.	____	________
94.9 Open V 522 B, V 500 J if it was open when step 1 was performed and V 524 A.	____	________
94.10 Close V's 518 F, 518 D, and 518E. Disconnect the He Cyl. and cap the sample point.	____	________

		Init.	Date & Time
(Diesel House)			
94.11	Check to see if the He supply from line 500 to all systems downstream of V 500 H may be discontinued. When this condition is met close V 500 H.	____	________
(Service Tunnel)			
94.12	Close V 534 B and V 535 B.	____	________
(Control Room)			
94.13	Jumper K4, K5, and K6.	____	________
94.14	Set S 95 in the no drain position.	____	________
94.15	Close HCV's 536 and 547 with HS 536 A and HS 547 A respectively.	____	________
94.16	Set PRC 528 A for 5 psig.	____	________
(Vent House, Valve Pit)			
94.17	Close V's 562 A, 624, 625, 626, and 627.	____	________
(Vent House)			
94.18	Close V's 557 B, 560 B, and 562 C.	____	________
(Control Room)			
94.19	Close HCV 557 C1 with HS 557 C.	____	________
(Vent House)			
94.20	Remove CV 557 B from the system and connect a 0-10 cc/min rotameter to V 557 C (rotameter outlet to valve). Connect a He cyl. with regulator and a 0-50 psi minimum range gauge to the rotameter.	____	________
94.21	Open V 557 C and pressurize line 557 to 40 psig with the He cyl.	____	________
94.22	Read the rotameter. Practically all of this leakage will be through HCV 557 C. Acceptable leakage 10 scc/min. Leakage ____.	____	________
94.23	Open V 557 B. Uncap the outlet on V 557 A and open the valve. Read the rotameter at V 557 C. Subtract the leakage in step 22 above. Acceptable leakage 10 scc/min. Leakage through CV 557 A ______.	____	________

	Init.	Date & Time
94.24 Close and cap V 557 A, close V 557 B.	______	______________
94.25 Open V 560 B. Uncap and open V 560 A. Read the rotameter at V 557 C. Subtract the leakage in step 23. Acceptable leakage 10 scc/min. Leakage through CV 560 __________.	______	______________
94.26 Close and cap V 560 A, close V 560 B.	______	______________
94.27 Open V 562 C, uncap and open V 562 B. Read the rotameter at V 557 C. Subtract the leakage in step 23. Acceptable leakage 10 scc/min. Leakage through CV 562 _____.	______	______________
94.28 Close V 557 C and read the rotameter. Acceptable leakage 5 scc/min. Leakage through V 557 C _______.	______	______________
94.29 Close and cap V 562 B, close V 562 C.	______	______________
94.30 Close V 557 C and disconnect the He cyl., reinstall CV 557 B.	______	______________
94.31 Connect the He cyl. with regulator, gauge and rotameter to CV 557 B.	______	______________
(Control Room)		
94.32 Open HCV 557 C1 by HS 557 C.	______	______________
(Vent House)		
94.33 Pressurize CV 557 to 40 psig and read the rotameter. Acceptable leakage 5 scc/min. Leakage ________.	______	______________
94.34 Disconnect the He cyl. and rotameter and cap CV 557 B.	______	______________
94.35 Open V's 557 B, 560 B, and 562.	______	______________
(Vent House Pit)		
94.36 Open V's 562 A, 624, 625.	______	______________
(Service Tunnel)		
94.37 Open V 534 B and V 535 B.	______	______________
(Diesel House)		
94.38 Open V 500 H.	______	______________

	Init.	Date & Time
(Control Room)		
94.39 Stop the component cooling blowers.	____	________
(Vent House)		
94.40 Close V's 565 A, 565 C, HCV 565 and V 566.	____	________
94.41 Remove CV's 565 and 566 from the system and bench check at 20 psig. Acceptable leakage 5 scc/min. Leakage CV 565 ______. Leakage CV 566 ______.	____	________
95. Check CV 511 and CV 512 in the following manner. HP coverage and gas masks required.		
(Control Room)		
95.1 Set FIC 512 A for 0 psig.	____	________
(Coolant Cell)		
95.2 Close V's 511 A & B and V 512.	____	________
95.3 Remove CV 511 and CV 512 from the system and bench check at 40 psig. Acceptable leakage 5 scc/min. Leakage CV 511 _____.	____	________
(Coolant Cell)		
95.4 Reinstall CV's 511 & 512 and open V's 511 A & B and V 512.	____	________
95.5 Check the valves with leak detector solution (supply pressure must be on line 511). No leakage acceptable.	____	________
96. Check CV's 594, 595, 598, and HCV's 959 B1, B2, and B3 in the following manner. HP coverage and gas masks required. He supply pressure must be on line 501.		
(Transmitter Room)		
96.1 Close V 594 A, 595 A, V 598 A.	____	________
(Control Room)		
96.2 Set S 39 for LT 598 C.	____	________
(Coolant Cell)		
96.3 Remove CV 595 from the system and connect a 0-10 cc/min rotameter to the upstream side of HCV 595 B2.	____	________

	Init.	Date & Time
(Transmitter Room)		
96.4 Open V 594 A.	_____	__________
(Coolant Cell)		
96.5 Read the rotameter for leakage through HCV 595 B2. Acceptable leakage 2 scc/min. Leakage _______.	_____	__________
96.6 Bench check CV 595 at 40 psig. Acceptable Leakage 2 scc/min. Leakage _______.	_____	__________
(Coolant Cell)		
96.7 Reinstall CV 595.	_____	__________
(Control Room)		
96.8 Set S 39 for LT 595 C.	_____	__________
(Coolant Cell)		
96.9 Remove CV 598 from the system and attach the 0-10 cc/min rotameter to the upstream side of HCV 595 B3.	_____	__________
96.10 Read the rotameter for leakage through HCV 595 B3. Acceptable leakage 2 scc/min. Leakage _______.	_____	__________
96.11 Bench check CV 598 at 40 psig. Acceptable leakage 2 scc/min. Leakage _______.	_____	__________
96.12 Reinstall CV 598.	_____	__________
(Transmitter Room)		
96.13 Close V 594 A.	_____	__________
96.14 Open V 595 A.	_____	__________
(Control Room)		
96.15 Set S 39 in LE CP A position.	_____	__________
(Coolant Cell)		
96.16 Check all connections from CV's 594, 595, and 598 to V's 594 C, 595 C, and 598 C. No leakage acceptable.	_____	__________
96.17 Open V's 594 C, 595 C, and 598 C.	_____	__________

		Init.	Date & Time
97.	Check CV's 830, 836, 838, 840, 844, 845, 846; FSV's 837 A1, 841 A1, 844 A1, 846 A1, 847 A1, in the following manner.		
	(Control Room)		
97.1	Stop the TWP's No. 1 & 2.	____	________
	(Water Room)		
97.2	Close V 830 A & B and V 844 A & B.	____	________
	(Blower House)		
97.3	Close V 847 A.	____	________
97.4	Open V 831 and V 845.	____	________
97.5	Close the valve in the air line to FSV 847 A2 which comes off air supply leader 9011-4.	____	________
97.6	Break line 855 at the relief valve and connect a small positive displacement pump (Sprague or similar) to the end which leads to line 847 with a 0-25 psi minimum range pressure gauge.	____	________
97.7	Pressurize to 15 psig with water from the treated water system and hold this pressure.	____	________
	(Water Room)		
97.8	Open V 830 C and collect the leakage through CV 830. Acceptable leakage 3 cc/min. Leakage _______.	____	________
97.9	Close V 830 C, open V 844 C and collect the leakage through CV 844. Acceptable leakage 3 cc/min. Leakage _______.	____	________
97.10	Close V 844 C, open V 847 B and collect the leakage through FSV 847 A1. Acceptable leakage 3 cc/min. Leakage _______.	____	________
	(Blower House)		
97.11	Disconnect the pressurizing pump from line 855, leave the line open, and connect the pump to V 847 B.	____	________

		Init.	Date & Time
97.12	Open the valve in the air line to FSV 847 A2 and check FSV 847 A1 to see that it is open.	_____	__________
97.13	Pressurize through V 847 B to 15 psig and collect the leakage through CV 847 at the relief valve in line 855. Acceptable leakage 3 cc/min. Leakage _______.	_____	__________
(Water Room)			
97.14	Check to see that FSV 844 has closed due to the pressure imposed on line 847.	_____	__________
(Control Room)			
97.15	Start TWP No. 1.	_____	__________
(Water Room)			
97.16	Open V 844 A & B and collect the leakage through FSV 844 A1 at V 844 C.	_____	__________
97.17	Acceptable leakage 10 scc/min. Leakage ____.	_____	__________
(Control Room)			
97.18	Stop TWP No. 1	_____	__________
(Water Room)			
97.19	Close V's 836 B and 837 B.	_____	__________
(Blower House)			
97.20	Open V 837 A.	_____	__________
97.21	Connect the small positive displacement pump to V 837 C, open V 837 C and pressurize to 20 psig with treated water and hold the pressure.	_____	__________
(Water Room)			
97.22	Open V 836 C and collect the leakage through CV 836. Acceptable leakage 5 cc/min. Leakage _______.	_____	__________
(Water Room & Blower House)			
97.23	Close V 836 C and disconnect the pump from V 837 C, leave V 837 C open.	_____	__________
(Water Room)			
97.24	Open V 836 A & B.	_____	__________

	Init.	Date & Time
(Blower House)		
97.25 Close the valve in the air line to FSV 837 A2 off header 9011-4 and check to see that FSV 837 A1 closed.	_____	_____
(Water Room and Blower House)		
97.26 Start TWP No. 1 and collect the leakage at V 837 C. Acceptable leakage 20 cc/min through FSV 837 A1. Leakage _______.	_____	_____
97.27 Close V 837 C and stop TWP No. 1.	_____	_____
97.28 Open V 837 A and the valve in the air line to FSV 837 A2.	_____	_____
(Water Room)		
97.29 Close V's 838 B and 841 B.	_____	_____
(Blower House)		
97.30 Open V 841 A.	_____	_____
97.31 Connect the pressurizing pump to V 841 C, open V 841 C and pressurize to 20 psig with treated water and hold the pressure.	_____	_____
(Water Room)		
97.32 Open V 838 C and collect the leakage through CV 838. Acceptable leakage 4 cc/min. Leakage _______.	_____	_____
(Water Room and Blower House)		
97.33 Close V 838 C and disconnect the pump from V 841 C, leave V 841 C open.	_____	_____
(Water Room)		
97.34 Open V's 838 A and B.	_____	_____
(Blower House)		
97.35 Close the valve in the air line to FSV 841 A2 off header 9011-4 and check to see that FSV 841 A1 is closed.	_____	_____

Init. Date & Time

(Water Room & Blower House)

97.36 Start TWP No. 1 and collect the leakage at V 841 C. Acceptable leakage 20 cc/min through FSV 841 A1. Leakage _______. _____ ___________

97.37 Close V 841 C. _____ ___________

(Control Room)

97.38 Stop TWP No. 1. _____ ___________

(Blower House)

97.39 Open V 841 A and the valve in the air line to FSV 841 A2. _____ ___________

(Water Room)

97.40 Close V's 840 B and 846 B. _____ ___________

(Blower House)

97.41 Close the valve in the air line to FSV 846 A2 off header 9011-4 and check to see that FSV 846 A1 closes. _____ ___________

(Control Room)

97.42 Start TWP No. 1 _____ ___________

(Blower House)

97.43 Collect the leakage through FSV 846 A1 at V 846 C. Acceptable leakage 20 cc/min. Leakage _______. _____ ___________

97.44 Close V 846 C, open V 846 A and open the valve in the air line to FSV 846 A1. _____ ___________

(Control Room)

97.45 Stop TWP No. 1. _____ ___________

98. Check CV 825, ESV ST A, and solution addition point in the following manner. _____ ___________

(Control Room)

98.1 Stop the TWP's No. 1 and No. 2 _____ ___________

(Water Room)

98.2 Close V's 802 A, 825 A, 827 C, D, & E and 834. _____ ___________

		Init.	Date & Time
98.3	Open V's 802 B, 803, 825 B, 883, V ST D, and LCV 825 by increasing the setting of LC ST A, to drain lines 802, 803, 825, and 883.	____	________
98.4	Close V's 802 B, 803, 883, and ESV ST A by disconnecting one lead wire.	____	________
98.5	Connect an instrument air line with 0-50 psi minimum range pressure gauge and pressure regulator to V ST A.	____	________
98.6	Pressurize the surge tank with instrument air by opening V ST A and V ST C to 20 psig and hold the pressure.	____	________
98.7	Connect a 0-10 cc/min range rotameter to the tap upstream of V 803. Open V 883 and read the rotameter for leakage through CV 825. Acceptable leakage 5 cc/min. Leakage _____.	____	________
98.8	Close V 883 and cap the tap, connect the rotameter to ESV ST A and read the rotameter to ESV ST A and read the rotameter for leakage through this valve. Acceptable leakage 2 scc/min. Leakage _______.	____	________
98.9	Move the rotameter to the solution addition point and read the meter for leakage through this valve. Acceptable leakage 2 scc/min. Leakage _______.	____	________
98.10	Close V ST A and disconnect the air line. Vent the pressure through ESV ST A by reconnecting the lead wire to open the valve. Leave the valve open.	____	________
98.11	Open V's 802 A, 825 A, 827 C, D, & E and reset LC ST to its original position.	____	________

Approved by R V Huyman

4F VENTILATION SYSTEM
STARTUP CHECK LIST

The ventilation system provides adequate flow of air from the less hazardous to more hazardous areas to prevent spread of radioactive contamination or beryllium. This check list covers the valve and damper settings normally used. Different auxiliary cell conditions may require deviations from the procedure as written. All deviations should be noted and approved by the shift supervisor.

	Init.	Date/Time
1 STACK FAN AND FILTERS		
(Stack Area)		
1.1 Tag the three dampers in the inlet and the three dampers in the outlet of the stack filters open (Line 927).	____	________
1.2 Check that top of filter pit is closed and caulked.	____	________
NOTE: Caulking shall be done as follows: Set the shield blocks so that the crevice between them is 1/2 inch or less. Caulk with a 5/8 inch dia. nylon rope, inserting the rope 1 inch below the block surface. Leave 12 inches of one end of each rope extending out of the crevice. Fill the crevice above the rope with "Atlas CK Weatherproof Sealing Compound" or equal. Pour hot and flush with the top of the blocks.		
(Control Room)		
1.3 Start stack fan No. 1 by pushing start button on MB-3.	____	________
1.4 Place stack fan No. 2 in standby by pushing start button on MB-3.	____	________
(Stack Area)		
1.5 Perform standby fan operational check by closing hand valve in line to PS-927, and open vent to raise pressure indication.		

Approved by [signature]

	Init.	Date/Time
1.5 (continued) Check that PS-927A stops Fan No. 1, closes FCO-925A completely, starts Fan No. 2, and opens FCO-926A, all automatically. Record PI-927A at which fan switching occurs, ______ in H_2O. Check that this agrees with switch tabulation.	____	______
(Control Room)		
1.6 Stop Fan No. 2.	____	______
1.7 Start Fan No. 1.	____	______
1.8 Place Fan No. 2 on standby by pushing start button.	____	______
(Remote Maintenance Cell)		
1.9 Start the waste blower in the remote maintenance cell.		

2 AREA PREPARATION

	Init.	Date/Time
2.1 Shield blocks should be in place and caulked on the following cells or areas:		
(High Bay)		
Coolant cell (penthouse)	____	______
Fuel processing cell	____	______
Liquid waste cell	____	______
Transmitter room (Between transmitter room and high bay)	____	______
Special equipment room	____	______
(Transmitter Room)		
South electric service (between south electric service area and transmitter room)	____	______
(Vent House Area)		
Charcoal bed cell	____	______
2.2 Check that blocks are in place if needed for existing conditions in the following areas:		

	Init.	Date/Time
2.2 (continued)		
(High Bay)		
Equipment storage cell	____	______
Remote maintenance cell	____	______
Decontamination cell	____	______
Spare cell	____	______
Vent house	____	______
(Coolant Cell)		
2.3 All openings into the coolant and coolant drain tank cell have been closed, caulked, and tagged to keep closed during operation. Warnings are posted of electrical power and for presence of Beryllium or activity.	____	______
(High Bay)		
2.4 All doors and openings into the high-bay are closed. Each door except through the hot change room has a sign on the outside and inside, stating that it is an emergency exit only. Entrance and exit should always be through the hot change room.	____	______
3 VENTILATION DISTRIBUTION		
(Supply Air Filter House)		
3.1 Tag open the damper in line 953 and check that the two gravity dampers in the inlet air filter house are free to operate.	____	______
3.2 Set the dampers or valves in the following lines as indicated:		
(Vent House Area)		
933 Tag open.	____	______
934 Tag open.	____	______
(Service Tunnel)		
931 Tag open.	____	______
HCV-930A Tag closed.	____	______
HCV-930B Tag closed.	____	______

Approved by [signature]

	Init.	Date/Time
(Transmitter Room)		
938 - 939 Tag open to south electric service area.	____	______
(Control Room)		
HCV-935A Tag open.	____	______
HCV-930A Tag closed.	____	______
HCV-930B Tag closed.	____	______
(High Bay)		
935 Diverter - Set to split flow approximately equal.	____	______
944 Tag open.	____	______
940 Tag open.	____	______
937 Tag open.	____	______
3.3 Check that ventilation is adequate for existing conditions in the following areas. Dampers in exhaust lines should be closed and tagged as far as possible to give additional ventilation to other areas.		
Equipment storage cell (Line 942)	____	______
Decontamination cell (Line 943)	____	______
Spare cell (Line 941)	____	______
3.4 Adjust damper in Line 953 at the inlet filter house until the high bay pressure PI HBA is 0.2 in. of water.	____	______
3.5 Check that the following read less than atmospheric pressure and record reading:		
(High Bay)		
PdI-946A - ________ in. H_2O	____	______
PdI-945A - ________ in. H_2O	____	______
PdI-943A - ________ in. H_2O	____	______
PdI-942A - ________ in. H_2O	____	______
PdI-941A - ________ in. H_2O	____	______
PdI-940A - ________ in. H_2O	____	______
PdI FPC - ________ in. H_2O	____	______
(Service Tunnel)		
PI STD - ________ in. H_2O	____	______

Approved by [signature]

3.5 (continued) Init. Date/Time

(Transmitter Room)

PdI-937A - __________ in. H_2O _____ _________

PdI-938A - __________ in. H_2O _____ _________

(Vent House)

PdI 950A - __________ in. H_2O _____ _________

PdI VH A - __________ in. H_2O _____ _________

(Above SER)

PdI SER A - __________ in. H_2O _____ _________

PdI 933 - __________ in. H_2O _____ _________

If any of the above pressures are greater than −0.1 in. H_2O, list below and obtain shift supervisor's approval of these.

Instrument No.	S. S. Init.

3.6 Check that stack flow FI S1A is greater than 19,000 cfm. Record FI S1A ________. _____ _________

3.7 Pressure drop through the roughing filter should be less than 1.0 in. H_2O. Record the following:

(Stack Area)

PdI FI A1 ________ in. H_2O

PdI F2 A1 ________ in. H_2O

PdI P3 A1 ________ in. H_2O _____ _________

3.8 Pressure drop through the absolute filters should be less than 3.0 in. H_2O. Record the following:

Approved by [signature]

3.8 (continued) — Init. | Date/Time

(Stack Area)

PdI FI A2 ________ in. H_2O

PdI F2 A2 ________ in. H_2O

PdI P3 A3 ________ in. H_2O ______ ______

3.9 Over-all pressure drop through filters should be less than 4.0 in. H_2O. Record the following:

(Stack Area)

PdI 927 Bl ________ in. H_2O

PdI 927 B2 ________ in. H_2O ______ ______

(Auxiliary Control Room)

3.10 Ventilation suction as indicated by PI-927A (at stack area) should be greater than 1.5 in. H_2O. Record PI-927A _____ in. H_2O. ______ ______

3.11 If necessary to re-adjust flows, recheck 3.3 through 3.11. ______ ______

3.12 Start the 10 blowers that ventilate the salt piping electric power induction regulators. ______ ______

3.13 Start the exhaust blower for the battery room. ______ ______

3.14 Start the exhaust blower that ventilates the "Sump Room." ______ ______

3.15 Start the exhaust fan that ventilates the room that contains MG #1 and MG #4. ______ ______

3.16 Start the exhaust fan that ventilates the main disconnect panel in the "Motor Control Center." ______ ______

3.17 Start the exhaust fan that ventilates the "Remote Maintenance Area." ______ ______

ALL ITEMS IN VENTILATION SYSTEM CHECK LIST ARE COMPLETE.

Shift Supervisor ____________________ Date ____________________

Approved by [signature]

4G LEAK-DETECTOR STARTUP CHECK LIST

Before the reactor is started, complete the following check list to ensure proper operation of the leak-detector system.

1 MAIN LEAK-DETECTOR SYSTEM	Init.	Date/Time
1.1 Helium Supply		
(Transmitter Room)		
1.1.1 Check V-514B ____ and V-514A open ____.	____	____
1.1.2 Check closed: V-514C ___, V-514D ____, V-514E ____, V-514E (capped) _____.	____	____
1.1.3 Check PI-514 reading 100 psig. Adjust PSV-514 if necessary.	____	____
1.2 Line 400		
1.2.1 Check V-400 open. Open 403A and 403B.	____	____
1.2.1.A Check Ann. XA-4000-4 clear.	____	____
1.2.2 Check the following valves closed: V-401B ____, V-402B ____, V-403B _____, V-404B ____, V-405B ____, V-406B _____, V-407B ____, V-408B ____.	____	____
1.3 Headers - Front of Panels		
1.3.1 Header 401. Check V-401A open ____. Check that PI-401 is between 90 and 100 psig. _____. Check all used LD line valves open _____. Check all spare LD line valves closed ______.	____	____
1.3.2 Header 402. Check V-402A open _____. Check that PI-402 is between 90 and 100 psig _____. Check all used LD line valves open ______. Check all spare LD line valves closed ________.	____	____

Approved by ______ √ MAL

7/28/65

	Init.	Date & Time

1.3.3 Header 403. Check V 403A open. ____

Check that PI 403 is between 90 and 100 psig. ____

Check all used LD line valves open. ____

Check all spare LD line valves closed. ____ ____ ____

1.3.4 Header 404. Check V 404A open. ____

Check that PI 404 is between 90 and 100 psig. ____

Check all used LD line valves open. ____

Check all spare LD line valves closed. ____ ____ ____

1.3.5 Header 405. Check V 405A open. ____

Check that PI 405 is between 90 and 100 psig. ____

Check all used LD line valves open. ____

Check all spare LD line valves closed. ____ ____ ____

1.3.6 Header 406. Check V 406A open. ____

Check that PI 406 is between 90 and 100 psig. ____

Check all used LD line valves open. ____

Check all spare LD line valves closed. ____ ____ ____

1.3.7 Header 407. Check V 407A open. ____

Check that PI 407 is between 90 and 100 psig. ____

Check all used LD line valves open. ____

Check all spare LD line valves closed. ____ ____ ____

1.3.8 Header 408. Check V 408A open. ____

Check that PI 408 is between 90 and 100 psig. ____

Check all used LD line valves open. ____

Check all spare LD line valves closed. ____ ____ ____

1.4 Headers, Back of Panel

1.4.1 Header 402. Check all LD line "B" valves open. ____

1.4.2 Header 404. Check all LD line "B" valves open. ____

1.4.3 Header 405. Check all LD line "B" valves open. ____

1.4.4 Header 407. Check all LD line "B" valves open. ____

1.4.5 Header 401. Check all LD line "B" valves open. ____

____ ____

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4G-3
7/28/65

Init. Date & Time

2 LUBE OIL SYSTEM LEAK DETECTORS

2.1 Check the following LD lines capped and no indication of oil leakage:

Fuel Lube Oil Package	Location		Init.	Date & Time
L 4100	L 714	____		
L 4101	FOP-1	____		
L 4102	L 701	____		
L 4103	L 713	____		
L 4104	FOP-2	____		
L 4105	L 702	____		
L 4106	Inlet OF 1	____		
L 4107	OF 1	____		
L 4108	Cap OF 1	____		
L 4109	Outlet OF 1	____		
L 4110	FSV 703	____	____	____

Coolant Lube Oil Package	Location		Init.	Date & Time
L 4150	Line 764	____		
L 4151	COP-1	____		
L 4152	L 751	____		
L 4153	L 763	____		
L 4154	COP-2	____		
L 4155	L 752	____		
L 4156	Inlet, OF 2	____		
L 4157	OF 2	____		
L 4158	Cap, OF 2	____		
L 4159	Outlet, OF 2	____		
L 4160	FSV 753	____	____	____

Approved by [signature]		4G-4 7/28/65
	Init.	Date & Time

2.2 If any flanges in either lube oil system have been opened, they should be leak checked as outlined below.

		Init.	Date & Time
2.2.1	Connect the protable leak-detector rig to the leak-detection nipple. (The rig consists of a helium cylinder, pressure regulator, Hoke type 482 block valve, and 0-to 100 psig pressure gauge connected with 1/4-in., .035-in. wall tubing.)	_____	_____
2.2.2	Pressurize the leak-detector line to 100 psig.	_____	_____
2.2.3	Soap check leak-detector line connection.	_____	_____
2.2.4	Close block valve and check pressure over an 8-hour period.	_____	_____
2.2.5	Record initial and final pressure. A pressure drop of < 1 psi/hr is acceptable (.04 to .05 cc of He/min.).	_____	_____
2.2.6	Disconnect leak-detector rig and cap leak-detector nipple.	_____	_____

ALL ITEMS ON THE LEAK-DETECTOR STARTUP CHECK LIST ARE COMPLETE   Shift Supervisor _______________ Date _______________

4H INSTRUMENTATION
STARTUP CHECK LIST

Detailed procedures are given in this section for testing each instrument and each control circuit. Where possible, abnormal conditions are simulated and the control or alarm action is allowed to occur. Some of these tests can only be done at specific stages of operation, and this fact is cross-referenced here and in other parts of the operating procedures:

a. Steps of this section (4H) which can be done at any time:
1, 2, 3, 4, 5, 8, 9, 13, 14, 15, 16, 18, 19, 20, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 45, 46, 47, 48, 52, 53, 54, 55, 56, 57, 58, 59, 60, 63, 64, 65, 66, 68, 69, 72, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 99.

b. Steps of this section which can be done only after the reactor and drain tank cells are sealed:
6, 7, 17, 21, 61, 62.

c. Steps which should be done before systems are heated:
10, 11, 75, 100

d. Steps which require Operations Chief approval before starting:
44, 49, 50, 51, 74.

e. Steps which can be done with the salt systems at temperature but empty:
12, 67, 70, 71, 98

f. Steps which can be done only with salt circulating:
73, 74.

Not all portions of this check list will be done at each startup; however, the need for doing each one will be carefully considered before omission.

Details are also given for putting each instrument into service and assuring that the alarm and interlock setpoints are properly set.

Approved by [signature]

	Init.	Date/Time

1 STEAM SUPPLY

1.1 Close the 15 psig steam supply valve (3 in. gate valve) to the water room located on the 840' level just west of column E-4 and note that PS-SX10 annunciates on XA-4016-3 per switch tabultion. (It may also be necessary to open the condenser steam inlet valve.) Open the 15 psig steam supply valve previously closed and note that annunciation clears. ____ ______

2 INSTRUMENT AIR SYSTEM

2.1 Check that the Instrument Department has checked the following prior to placing the air compressors in operation:

Compressor No. 1 Unloading Valve ____
Compressor No. 1 Temp. Sw. AC1-A ____
Compressor No. 1 Temp. Sw. AC1-B ____
Compressor No. 1 Oil Press. Sw. AC1-C____
Compressor No. 2 Unloading Valve ____
Compressor No. 2 Temp. Sw. AC2-A ____
Compressor No. 2 Temp. Sw. AC2-B ____
Compressor No. 2 Oil Press. Sw. AC2-C____
Compressor No. 3 Temp. Sw. AC3-A ____
Compressor No. 3 Oil Press. Sw. AC3-B____
Compressor No. 3 Unloading Valve AC3-C____ ____ ______

2.2 With the instrument air system in normal operation, close all HV's on the emergency nitrogen cylinders. Leave HV's in line 9006 open. While observing PI-9006-2, slowly raise the setpoint on PIC-9006-1 and note that PS-9006-1 annunciates on XA-4001-2 per Sw. Tab. ____. Record PI-9006-2 ______. ____ ______

Approved by ____________

	Init.	Date/Time
2.3 Continue to relieve pressure and note that PS-9006-2 annunciates on XA-4001-3 per Sw. Tab _____. Record PI-9006-2 _____.	_____	__________
2.4 Lower the setpoint on PIC-9006-1 to its previous value. Open cylinder valves and note that both alarms clear ______. Low final clear _____psig, PI-9006-2. Low initial clear _______psig PI-9006-2.	_____	__________
2.5 Close HV-9119 and/or HV-9129, whichever is open, at the air dryer outlet filter and note that PS-900-1 annunciates on XA-4030-9 and XA-4000-2 per Sw. Tab _____. Record PI-9000 _____. PS-900-2 should start standby compressor per Sw. Tab _____. Record PI-9000 _____. Open HV-9119 and/or HV-9129, previously closed. Reset Rochester alarm units and note that annunciators clear. Stop the standby compressor by pushing the stop button on MB-12.	_____	__________
2.6 At the instrument air reducing station in the transmitter room, close the HV in line 9013-1 upstream of PI-9013-1 _____. While observing PI-9013-1 note that PS-9013-1 annunciates on XA-4030-10 per Sw. Tab _____. Record PI-9013-1 _____. Allow the pressure indicated on PI-9013-1 to continue to decrease and note that PS-9013-2 annunciates on XA-4002-5 per Sw. Tab _____. Record PI-9013-1, _______. Open HV in line 9013-1 upstream of PI-9013-1 and note that both alarms clear.	_____	__________

NOTE: After closing HV in line 9013-1 upstream of PI-9013-1, it may be necessary to crack the vent HV in order to obtain a decrease in pressure in line 9013-1.

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2.7 Close the HV ahead of the pressure-reducing valve in each instrument air line and note that alarms occur as indicated in Table 4H-1. Open HV, reset Rochester alarm units and note that annunciation clears. XA-4000-2 will also annunciate and clear each time.

Table 4H-1

LOCATION	LINE No.	SERVICE (psig)	SWITCH No.	St.pt Sw.tb	ALARM No.	ALARM PI-No.	AT psig	Alm. clrd	Init.
Control Room	9007-1	20-Emerg	PS-9007-3		XA-4031-1	PI-9007-4			
	9007-4	30-Emerg	PS-9007-4		XA-4031-2	PI-9007-5			
	9007-1	60-Emerg	PS-9007-1		XA-4031-3	PI-9007-2			
	9001-1	20-Norm	PS-9001-1		XA-4030-1	PI-9001-2			
Blower House	9011-2	15-Emerg	PS-9011-2		XA-4031-9	PI-9011-3			
	9011-3	20-Emerg	PS-9011-3		XA-4031-10	PI-9011-4			
	9011-4	30-Emerg	PS-9011-4		XA-4031-11	PI-9011-5			
	9011-5	20-Emerg	PS-9011-5		XA-4031-12	PI-9011-6			
	9011-1	60-Emerg	PS-9011-1		XA-4031-8	PI-9011-2			
	9005-2	20-Norm	PS-9005-2		XA-4030-7	PI-9055-3			
	9005-1	60-Norm	PS-9005-1		XA-4030-8	PI-9005-2			
Trans-mitter Room	9008-1	20-Emerg	PS-9008-1		XA-4031-4	PI-9008-2			
	9002-4	20-Norm	PS-9002-4		XA-4030-4	PI-9002-5			
	9002-3	20-Norm	PS-9002-3		XA-4030-3	PI-9002-4			
	9002-1	30-Norm	PS-9002-1		XA-4030-2	PI-9002-2			
Service Room	9010-2	20-Emerg	PS-9010-2		XA-4031-7	PI-9010-3			
	9010-1	30-Emerg	PS-9010-1		XA-4031-6	PI-9010-2			
	9004-1	20-Norm	PS-9004-1		XA-4030-6	PI-9004-2			
Sampler Enricher	9009-1	30-Emerg	PS-9009-1		XA-4031-5	PI-9009-2			
Maint. Control Room	9003-1	20-Norm	PS-9003-1		XA-4030-5	PI-9003-2			

Approved by [signature]

		Init.	Date/Time
3	With No. 1 stack fan in operation and No. 2 stack fan in "stand-by" (Start button depressed), slowly close hand dampers on down-stream side of filters and note that PdS-936-A annunciates on XA-4017-2 per Sw. Tab. _____. Record PI-927-A _____(located on Containment Air Panel 1). Note that PS-HB-A1 annunciates on XA-4017-1 and XA-4000-6 per Sw. Tab. ____. Record PI-HB-A _____(located on Aux. Board 1) and PI-927-A _____(located on Containment Air Panel 1). Note that FS-S1-A annunciates on XA-4017-4 and XA-4000-6 per Sw. Tab. _______. Record FI-S1-A ____(located on Main Panel 3). PS-927-A1 and A2 start No. 2 stack fan and stop No. 1 stack fan per Sw. Tab. _____. Record PI-927-A ____ when stack Fan No. 2 starts. Note that PdS-927-B annunciates on XA-4017-3 and XA-4000-6 per Sw. Tab. _____. Record PdI-927-B2 ______ (on Containment Air Panel 1). Open dampers ______. Stop stack fan No. 2 _____. Start stack fan No. 1 _____. Place stack fan No. 2 in stand-by by depressing start button. _______.	_____	_____
4	Apply a slight vacuum to high bay tap of PT-HB-A and note that PS-HB-A2 annuncaites on XA-4017-1 and XA-4000-6 annunciates per Sw. Tab. ______. Record PI-HB-A _____ (located on Aux. Board 1). Remove vacuum and note that alarms clear. _____.	_____	_____
5	At the containment block valve header (located in the North Electric Service Area), note that PI-9013-1A1 through 1A6 all indicate greater than 50 psi ______. Slowly open HV-RC-B to increase pressure on PI-RC-B (do not exceed 5 psi) until HCV-9013-1A1 and 9013-1A2 operate ______. Record PI-RC-B _____. Note that PI-9013-1A5 drops to zero _____ and all other pressure gauges in the		

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Init. Date/Time

5 (continued)

9013 series do not change ____. Close HV-RC-B ____ and note that all 9013 series pressure gauges are greater than 70 psi ____. Slowly open HV-RC-F to increase pressure on PI-RC-F (Do not exceed 5 psi) until HCV-9013-1B1 and 9013-1B2 operate ____. Record PI-RC-F ____. Note that PI-9013-1A1 drops to zero ____ and all other pressure gauges in the 9013 series do not change ____. Close HV-RC-F ____ and note that all 9013 series pressure gauges are greater than 70 psi ____.

Slowly open HV-RC-G to increase pressure on PI-RC-G (do not exceed 5 psi) until HCV-9013-1C1 and 9013-1C2 operate ____. Record PI-RC-G ____. Note that PI-9013-1A4 drops to zero ____. All other pressure gauges in the 9013 series do not change ____.

Slowly open HV-RC-B to increase pressure on PI-RC-B (do not exceed 5 psi) until HCV-9013-1A1 and 9013-1A2 operate ____. Record PI-RC-B ____. Note that PS-9013-2 annunciates on XA-4002-5 per Sw. Tab. ____. Record PI-9013-1A6 at time of alarm ____. Note that PI-9013-1A4, 1A5, and 1A6 drop to zero ____. Note that PI-9013-1A1, 1A2, and 1A3 do not change ____. Close HV-RC-B ____. Note that annunciator XA-4002-5 clears ____.

Slowly open HV-RC-F to increase pressure on PI-RC-F (do not exceed 5 psi) until HCV-9013-1B1 and 9013-1B2 operate ____. Record PI-RC-F ____. Note that PS-9013-2 annunciates on XA-4002-5 per Sw. Tab. ____. Record PI-9013-1A6 at time of alarm ____. Note that PI-9013-1A1, 1A3, 1A4, 1A5, and 1A6 drop to zero ____. Note that PI-9013-1A2 does not change. ____. Close HV-RC-G ____. Note that annunciator XA-4002-5 clears ____.

Slowly open HV-RC-B to increase pressure on PI-RC-B (do not exceed 5 psi) until HCV-9013-1A1 and 9013-1A2 operate ____. Record PI-RC-B ____. Note that PS-9013-2 annunciates on XA-4002-5 per Sw. Tab. ____. Record PI-9013-1A6 at time of alarm ____. Note that PI-9013-1A1, 1A2, 1A3, 1A4,

Init. Date/Time

5 (continued)

1A5, and 1A6 all drop to zero _____. Close HV-RC-F _____. Note that annunciator XA-4002-5 clears _____ . Close HV-RC-B._____. Note that all pressure gauges in the 9013 series read about 50 psig _____.

Slowly open HV-RC-K and raise the pressure on PSS-RC-K. Slowly open HV-RC-H and raise the pressure on PSS-RC-H. Note that the following actions occur:

XA-4002-5 alarms _______

CCP #1 or CCP #2 stops _______

Reactor cell evacuation valve HCV-565-A1 closes _______. _____ _______

Close HV-RC-H and note that XA-4002-5 clears _____. Start CCP #1 or #2 _____. Slowly open HV-RC-J and raise pressure on PSS-RC-J. Note that the following actions occur:

XA-4002-5 alarms _______

CCP #1 or CCP #2 stops _______

Reactor cell evacuation valve HCV-565-A1 closes _______. _____ _______

Close HV-RC-K and note that XA-4002-5 clears _____. Start CCP #1 or #2 _____. Slowly open HV-RC-H and raise pressure on PSS-RC-H. Note that the following actions occur:

XA-4002-5 alarms _______

CCP#1 or CCP #2 stops _______

Reactor cell evacuation valve HCV-565-A1 closes _______. _____ _______

Close HV-RC-J and note that XA-4002-5 clears _______. Close HV-RC-H _____. _____ _______

6 When the reactor and drain tank cells are pressurized for leak testing:

Note that PS-RC-A1 annunciates on XA-4002-6 per

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	Init.	Date/Time
6 (continued) Sw. Tab. _____. Record PI-RC-A _____(on Main Panel 3). Check that FCV-333-A1, FCV-333-A2, FCV-343-A1, and FCV-343-A2 can not be opened. (This can be done in the transmitter room by turning their switches to the "on" position, one at a time and feeling the solenoid valve to determine if they are energized. NOTE: Be sure all switches are returned to the "off" position when check is completed.	_____	_____
7 When cell is evacuated, check that PS-RC-A2 annunciates on XA-4002-6 per Sw. Tab. _____. Record PI-RC-A _____ (on main board 3).	_____	_____
8 EVACUATION ALARM		
8.1 Announce a test of the building evacuation alarm on the PA system, and notify plant supervisor that tests are to be made on the evacuation alarm system.	_____	_____
8.2 Close the nitrogen supply valves at all four evacuation horn stations.	_____	_____
8.3 Operate building evacuation alarm using switch 109 on console.	_____	_____
8.4 Make sure all evacuation horn solenoid valves are closed after above test.	_____	_____
8.5 Check that monitrons and CAM's actuate the building evacuation alarm as follows:		
8.5.1 Pressurize the lines up to the solenoid valves at each horn station by opening the nitrogen supply valves momentarily and then closing them.	_____	_____
8.5.2 Actuate the building evacuation system with a radioactive source in the following way: (See also Step 43.)		

	Init.	Date/Time
8.5.2.1 Using the source, alarm the monitron in the CR.		
8.5.2.2 Acknowledge the alarm, but do not reset the CR monitron alarm module.		
8.5.2.3 Using the source, alarm the monitron in the HB (west). (This should actuate the evacuation horns.)		
8.5.2.4 Acknowledge the alarm, reset the HB (west) monitron alarm module, but do not reset the CR monitron alarm module.		
8.5.2.5 Check that the solenoid valves at the horn stations are closed.		
8.5.2.6 Repeat steps 8.5.1 through 8.5.2.5 substituting the following combinations of monitrons and CAM's for CR and HB (west).		
MONITRONS		
a. CR and HB (south)		
b. CR and HCP		
c. CR and TR		
d. CR and Horn Hall. (Reset CR module, but not the Horn Hall module)		
e. Horn Hall and TR		
f. Horn Hall and HCP		
g. Horn Hall and HB (south)		
h. Horn Hall and HB (west) (Reset Horn Hall module, but not HB (west) module).		
i. HB (west) and TR		
j. HB (west) and HCP		
k. HB (west) and HB (south) (Reset HB (west) module, but not HB (south) module.)		

Approved by [signature]

	Init.	Date/Time
MONITRONS (continued)		
l. HB (south) and TR		
m. HB (south) and HCP (Reset HB (south) module, but not HCP module.)		
n. HCP and TR. (Reset both modules.)		
CAM's		
o. CR (located in hallway of 7503 office area) and 840 level (north).		
p. CR and TR		
q. CR and Service Tunnel (Reset CR module, but not Service Tunnel module.)		
r. Service Tunnel and TR		
s. Service Tunnel and 840 level (north) (Reset Service Tunnel module, but not 840 level (north) module.)		
t. 840 level (north) and TR (Reset both modules)		
8.6 After the above tests have been completed, check that all evacuation horn solenoid valves are closed and that all alarm modules have been reset.		
8.7 Open nitrogen supply valves to all evacuation horns.		
8.8 Test building evacuation alarm system by pushing button in ACR and allow cylinders to completely run down. Check that alarm can be heard in all areas.		
8.9 Reset alarm and check that all solenoid valves at horns are closed.		
8.10 Replace nitrogen cylinders at all horn stations and check that supply valves are open.		
8.11 Announce completion of test over PA system and notify plant shift supervisor.		
8.12 Announce a test of the building evacuation siren over the PA system.		

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	Init.	Date/Time
8.13 Test evacuation siren by turning switch 111 on console to "On". Check that siren can be heard in all areas.	____	________
8.14 Announce completion of test over PA system.	____	________

9 THERMOCOUPLE ELEMENTS

9.1 The instrument department will periodically test the resistance to ground and to each lead of all thermocouples. The results will be kept in the instrument department Thermocouple Resistance Log Book. This log should be reviewed by the shift supervisor and any thermocouple failures noted in the operations department "Thermocouple Tabulation Log Book." Initial when this is complete.	____	________
9.2 Check that each thermocouple is plugged in as indicated in the Thermocouple Tabulation Log Book (both sections). Check that the listing in the Thermocouple Tabulation Log Book has been approved by the Operations Chief.	____	________
9.3 Check that the Instrument Department has checked out the temperature scanners and has completed the scanner check lists and set the following switches per switch tabulation: TS-5001-A ______ TS-5002-A ______ TS-5003-A ______ TS-5004-A ______ TS-5005-A ______	____	________
9.4 Check that the nitrogen flows to the scanner switches are as indicated on the building log.	____	________

9.5 Check that the proper range and alarm points have been selected for each scanner. (See

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Init. Date/Time

9.5 (continued)
Shift Supervisor.) (Details of startup and operation of the scanner are given in the scanner Alignment and Calibration Procedures.) _____ _____

9.6 The Instrument Department has checked out the logger; all calibration and cross checks have been made in accordance with the logger check list. The readout and setpoints are as given in the logger tabulation. _____ _____

NOTE: The logger tabulation should be approved by the Analysis Chief before starting the tests. _____ _____

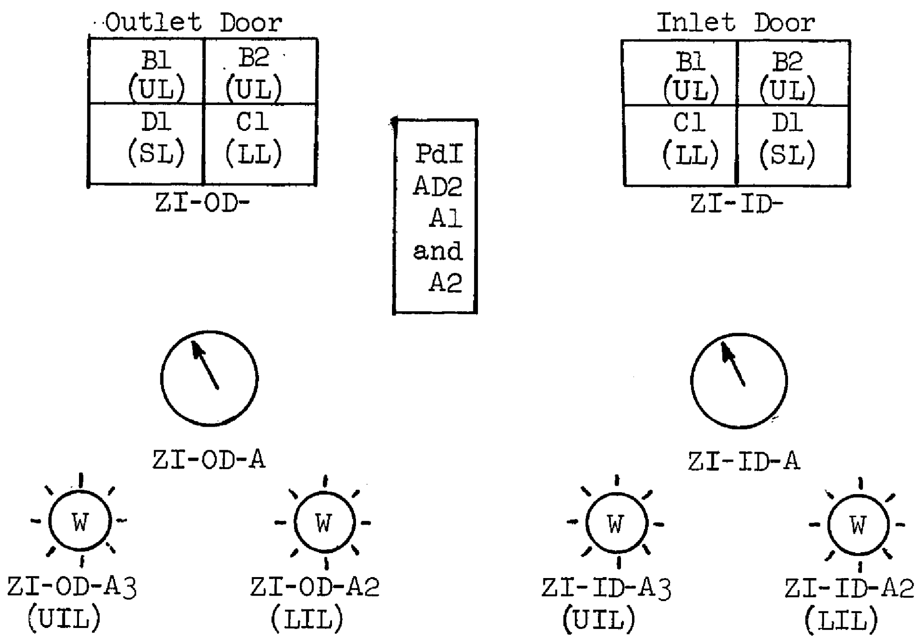
10 RADIATOR DOORS

With no salt in the coolant system and with no heat on the radiator, perform the following tests on the radiator doors:

10.1 Insert jumpers in circuits 162 and 164. _____ _____

10.2 The door position indicators on MB-13 (Console Panel III) are as follows:

10.2 (continued)



and on MB-4 are:

	Init.	Date/Time

10.3 Check both doors closed:

10.3.1 Inlet Door

Switch No.	Position Indicator Light	ZI-ID-A, in.	Init.	Date/Time
ZS-ID-D1 and D2	ZI-ID-D1 on ______	______		
ZS-ID-C1 and C2	ZI-ID-C1 on ______	______		
ZS-ID-D1 and D2	ZI-ID-D2 on ______	______	______	______

10.3.2 Outlet Door

Switch No.	Position Indicator Light	ZI-OD-A, in.	Init.	Date/Time
ZS-OD-D1 and D2	ZI-OD-D1 on ______	______		
ZS-OD-C1 and C2	ZI-OD-C1 on ______	______		
ZS-OD-D1 and D2	ZI-OD-D2 on ______	______	______	______

10.4 Slowly raise the inlet door and record ZI-ID-A when the following occur:

Switch No.	Position Indicator Light	ZI-ID-A in. Raising	ZI-ID-A in. Lowering	Init.	Date/Time
ZS-ID-D1 and D2	ZI-ID-B1 off ______	______	______		
ZS-ID-C1 and C2	ZI-ID-C1 off ______	______	______		
ZS-ID-D1 and D2	ZI-ID-D2 off ______	______	______		
ZS-ID-A1	ZI-ID-A2 on ______	______	______		
ZS-ID-A2	ZI-ID-A3 on ______	______	______		
ZS-ID-B2	ZI-ID-B3 on ______	______	______		
ZS-ID-B1	ZI-ID-B1 on ______	______	______		
ZS-ID-B2	ZI-ID-B2 on ______	______	______	______	______

10.5 Slowly lower the inlet door and record ZI-ID-A (Above) when position indicator lights change aspect. ______ ______

Approved by [signature]

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10.6 Repeat Steps 11.4 and 11.5 for the outlet door: Init. Date/Time

Switch No.	Position Indicator Light	ZI-OD-A, in. Raising	ZI-OD-A, in. Lowering	Init.	Date/Time
ZS-OD-D1 and D2	ZI-OD-D1 off ______	______	______		
ZS-OD-C1 and C2	ZI-OD-C1 off ______	______	______		
ZS-OD-D1 and D2	ZI-OD-D2 off ______	______	______		
ZS-OD-A1	ZI-OD-A2 on ______	______	______		
ZS-OD-A2	ZI-OD-A3 on ______	______	______		
ZS-OD-B2	ZI-OD-B3 on ______	______	______		
ZS-OD-B1	ZI-OD-B1 on ______	______	______		
ZS-OD-B2	ZI-OD-B2 on ______	______	______	______	______

10.7 Leave doors closed. ______ ______

11 BYPASS DAMPER

11.1 Check bypass damper closed:

Switch No.	Position Indicator Light	PdM-AD2-A1, %	PdI-AD2-A3,%	Init.	Date/Time
ZS-AD2-A2	ZI-AD2-A2 (green light) on___	______	______		
ZS-AD2-A1	ZI-AD2-A1 (red light) off____	______	______	______	______

11.2 Slowly open bypass damper and record damper position when following actions occur:

Switch No.	Position Indicator Light	PdM-AD2-A1,%	PdI-AD2-A3,%
ZS-AD2-A1	ZI-AD2-A1 comes on ______	______	______
ZS-AD2-A2	ZI-AD2-A2 goes off ______	______	______

11.3 Slowly close the bypass damper and record damper position when following actions occur:

Switch No.	Position Indicator Light	PdM-AD2-A1,%	PdI-AD2-A3,%	Init.	Date/Time
ZS-AD2-A2	ZI-AD2-A2 comes on ______	______	______		
ZS-AD2-A1	ZI-AD2-A1 goes off ______	______	______	______	______

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Init. Date/Time

11.4 Leave bypass damper open. ______ ______

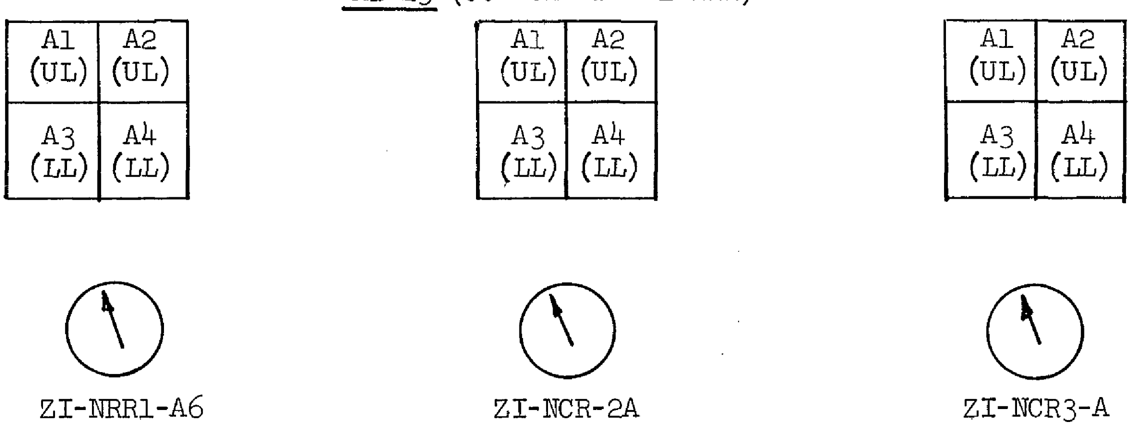
12 CONTROL RODS

The following list should be done only when there is no fuel or flush salt in the reactor and with the nuclear instruments in service.

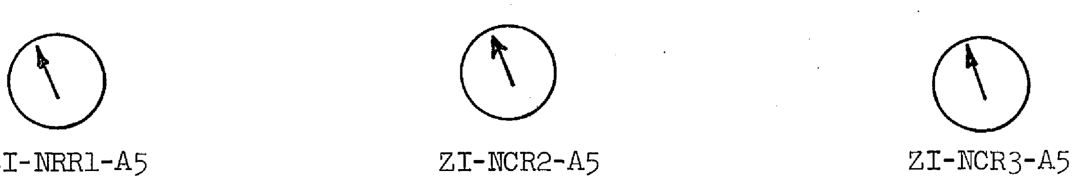
12.1 Check that all control rods are fully inserted. ______ ______

12.2 Slowly raise one rod and record rod positions when upper and lower limit lights change aspect. Lower the rod and again record rod positions when the lights change. Repeat for the other two rods and enter results in table below. The position indicator locations are as follows:

MB-13 (Console Panel III)



MB-7



Rod	Condition	Switch No.	Position Indicator Light	Rod Position, in.
1	Inserted	ZS-NRR1-A1	ZI-NRR1-A1 off ____	ZI-NRR1-A5 ____, -A6 ____
1	"	" -A2	" -A2 off ____	" -A5 ____, _A6 ____
1	"	" -A3	" -A3 on ____	" ____, " ____
1	"	" -A4	" -A4 on ____	" ____, " ____
1	Raising	" -A3	" -A3 off ____	" ____, " ____
1	"	" -A4	" -A4 off ____	" ____, " ____
1	"	" -A1	" -A1 on ____	" ____, " ____
1	"	" -A2	" -A2 on ____	" ____, " ____
1	Lowering	" -A1	" -A1 off ____	" ____, " ____
1	"	" -A2	" -A2 off ____	" ____, " ____
1	"	" -A3	" -A3 on ____	" ____, " ____
1	"	" -A4	" -A3 on ____	" ____, " ____
2	Inserted	ZS-NCR2-A1	ZI-NCR2-A1 off ____	ZI-NCR2-A5 ____, -A ____
2	"	" -A2	" -A2 off ____	" ____, " ____
2	"	" -A3	" -A3 on ____	" ____, " ____
2	"	" -A4	" -A4 on ____	" ____, " ____
2	Raising	" -A3	" -A3 off ____	" ____, " ____
2	"	" -A4	" -A4 off ____	" ____, " ____
2	"	" -A1	" -A1 on ____	" ____, " ____
2	"	" -A2	" -A2 on ____	" ____, " ____
2	Lowering	" -A1	" -A1 off ____	" ____, " ____
2	"	" -A2	" -A2 off ____	" ____, " ____
2	"	" -A3	" -A3 on ____	" ____, " ____
2	"	" -A4	" -A4 on ____	" ____, " ____

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Rod	Condition	Switch No.	Position Indicator Light	Rod Position, in.
3	Inserted	ZS-NCR3-A1	ZI-NCR3-A1 off ____	ZI-NCR3-A5 ____, -A ____
3	"	" -A2	" -A2 off ____	" ____, " ____
3	"	" -A3	" -A4 on ____	" ____, " ____
3	"	" -A4	" -A4 on ____	" ____, " ____
3	Raising	" -A3	" -A3 off ____	" ____, " ____
3	"	" -A4	" -A4 off ____	" ____, " ____
3	"	" -A1	" -A1 on ____	" ____, " ____
3	"	" -A2	" -A2 on ____	" ____, " ____
3	Lowering	" -A1	" -A1 off ____	" ____, " ____
3	"	" -A2	" -A2 off ____	" ____, " ____
3	"	" -A3	" -A3 on ____	" ____, " ____
3	"	" -A4	" -A4 on ____	" ____, " ____

12.3 Check that all rods are fully inserted when test is complete. Init. ____ Date/Time ____

Approved by [signature]

Approved by [signature]

12.4 Before filling system but after heat-up, raise Rod #1 until lights at bottom of ECC 20 and 21 on jumper board go on. Lower rod until lights go out.

Repeat for Rod #2 and Rod #3. Record results in table below and compare with switch tabulation.

Rod #	Rod Position When Light in Ckt. Goes Out			Rod Position When Light in Ckt. Goes on			Initial	Date
	Sw. Tab.	Actual		Sw. Tab.	Actual			
		Ckt. 20	Ckt. 21		Ckt. 20	Ckt. 21		
1								
2								
3								

Init. Date/Time

12.5 With the system hot, but before adding salt, check the control rod reference location. Check that cell air activity is not high: record RM-565-B ______ and RM-565-C ______. Also check radiation level in TR: record CAM ______ and Monitron ______. Do not proceed if cell air activity is >______. The two rods not being tested should be above ______. ______ ______

12.5.1 Set valves as follows:

HV-985-A2 open ______

HV-987-A2 open ______

HV-987-A3 closed ______

HV-986-A open ______ ______ ______

12.5.2 Open HV-986, 987, or 989. Throttle HV-985-A1 and HV-989-A until ZI-987-A indicates approximately 50%. ______ ______

Approved by [signature]

Init. Date/Time

12.5.3 Establish communications between TR and Control Room. ______ ______

12.5.4 Insert Control Rod and determine control rod reference position. ______ ______

Record rod position when maximum dp is obtained. Determine position indications for each rod being inserted and for each being withdrawn.

Rod #	Valve Open	Valves Closed		CONTROL ROD POSITION Should Be	Actual Inserting	Actual Withdrawing	Initial	Date
1	986-A	987-A1	989-A					
2	987-A1	986-A	989-A					
3	989-A	986-A	987-A1					

12.5.5 Open HV-987-A3. ______ ______

12.5.6 Close HV-985-A1, 989-A, 986-A, 987-A1, and 989-A1. ______ ______

12.6 After the system is hot and before adding salt check the drop time of each rod.

12.6.1 Raise #1 rod to 50 inches above the rod position where the first lower indicator light lit up. (13.5) ______ ______

12.6.2 Plug in the rod drop timer and set to zero. ______ ______

12.6.3 Actuate the rod scram switch. ______ ______

12.6.4 Repeat with Rod #2 and Rod #3 and record results in table. ______ ______

Approved by [signature]

Rod #	Starting Position	Rod Drop Time Should Not Exceed 1.0 Sec.	Initial	Date
1				
2				
3				

	Init.	Date/Time
12.7 Raise all three rods 12 to 15".	____	________
12.8 Push HS-100-A1 and A2 and note the 4th light in ECC-174 goes out and first light in ECC-183, 184, and 185 goes on and rods scram.	____	________
12.9 Reset and raise rods. Push HS-100-A1 and A3 and note that 4th light in ECC-174 goes out and first light in ECC-183, 184, and 185 goes on and rods scram. Reset and raise rods.	____	________
12.10 Push HS-100-A2 and A3 and note that 4th light in ECC-174 goes out and first light in ECC-183, 184, and 185 goes on and rods scram. Reset and raise rods.	____	________
12.11 Push trip test switch on RSS-NSC1-A2 and RSS-NSC2-A2 and note that 4th light in ECC-174 goes out and first light in ECC-183, 184, and 185 goes on.	____	________
12.12 Push trip test switch on RSS-NSC1-A2 and RSS-NSC3-A2 and note that 4th light in ECC-174 goes out and first light in ECC-183, 184, and 185 goes on.	____	________
12.13 Push trip test switch on RSS-NSC2-A2 and RSS-NSC3-A2 and note that 4th light in ECC-174 goes out and first light in ECC-183, 184, and 185 goes on.	____	________

Approved by [signature]

	Init.	Date/Time

13 FUEL PUMP, FUEL PUMP OVERFLOW TANK AND COOLANT PUMP BUBBLER SYSTEMS FLOW ALARM CHECKS

13.1 On jumper boards 2, 3, and 4, check that the green lamps are on in circuits 40 ____, 41_____, 128 _____, and 129 _____. _____ _____

13.2 On main panels 6 and 8, check that annunciators XA-4005-4 _____ and XA-4006-6 ______ are clear. _____ _____

13.3 Referring to the following tables, set the fuel-pump selector switch (S-36, on main panel 8), coolant-pump selector switch (S-39, on main panel 6), fuel-pump level test switch (S-37, on transmitter panel 5), fuel-pump overflow tank level test switch (S-38, on transmitter panel 5) and coolant-pump level test switch (S-40, on transmitter panel 6) as indicated, open the indicated supply valve and note when the low flow (or high pressure) alarm occurs. Then, while maintaining the test switch position, close the supply valve. After the supply valve has been closed, return the test switch to the "off" position and note the time required for the flow indicator to drop from 35 psi to 20 psi. Also, record the pressure at which the high flow (or low pressure) alarm occurs. _____ _____

Table 4H-2

FUEL PUMP LEVEL SYSTEM

Selector Switch S-36	Test Switch S-37	Supply Valve Number	Hi & Low Flow Alarm XA-4006-6: Switch Number	Switch Set Point Per Sw Tab	Hi or Low	Flow Indicator Number	Flow Indicator Alarm Reading	Time (sec.) for FI to drop from 35 to 20
Position 3	Position 2	HV 596-B	PS 596-A2		Low	FI 596-A		
			PS 596-A1		Hi			
Position 2	Position 4	HV 592-B	PS 592-A2		Low	FI 592-A		
			PS 592-A1		Hi			
Position 2	Position 5	HV 593-A1	PS 593-A2		Low	FI 593-A		
			PS 593-A1		Hi			

Table 4H-3

FUEL PUMP OVERFLOW TANK LEVEL SYSTEM

Test Switch S-38	Supply Valve Number	Hi & Low Flow Alarm XA-4006-6: Switch Number	Switch Set Point Per Sw Tab	Hi or Low	Flow Indicator Number	Flow Indicator Alarm Reading	Time (sec.) for FI to drop from 35 to 20
Position 2	HV 599-B	PS 599-A2		Low	FI 599-A		
		PS 599-A1		Hi			
Position 4	HV 589-B	PS 589-A2		Low	FI 589-A		
		PS 589-A1		Hi			
Position 5	HV 600-B	PS 600-A2		Low	FI 600-A		
		PS 600-A1		Hi			

Approved by [signature]

Table 4H-4

COOLANT PUMP LEVEL SYSTEM

Selector Switch S-39	Test Switch S-40	Supply Valve Number	Hi & Low Flow Alarm XA-4005-4: Switch Number	Switch Set Point Per Sw Tab	Hi or Low	Flow Indicator Number	Flow Indicator Alarm Reading	Time (sec) for FI to drop from 35 to 20
Position 4	Position 2	HV 598-B	PS 598-A2		Low	FI 598-A	______	
			PS 598-A1		Hi			
Position 4	Position 4	HV 594-B	PS 594-A2		Low	FI 594-A	______	
			PS 594-A1		Hi			
Position 2	Position 5	HV 595-B	PS 595-A2		Low	FI 595-A	______	
			PS 595-A1		Hi			

Init. Date/Time

13.4 Set the fuel pump, fuel pump overflow tank and coolant pump bubbler system gas flows as given in the building log.

Supply Value	Log Value	Actual Reading After Setting	Init.	Date/Time
HV-596-B	______	FI-596-A ______		
HV-592-B	______	FI-592-A ______		
HV-593-B	______	FI-593-A ______		
HV-599-B	______	FI-599-A ______		
HV-589-B	______	FI-589-A ______		
HV-600-B	______	FI-500-A ______		
HV-598-B	______	FI-598-A ______		
HV-594-B	______	FI-594-A ______		
HV-595-B	______	FI-595-A ______	______	______

14 FUEL PUMP OVERFLOW TANK BUBBLER SYSTEM: LEVEL INDICATION AND INTERLOCK CHECKS

NOTE: In order to complete these checks Containment Enclosure 2 must be open.

Approved by [signature]

Init. Date/Time

14.1 Check that annunciator XA-4006-5 is clear. ____ ____

14.2 Check that lights in Circuit 21 on jumper board 2 are burning. ____ ____

14.3 While observing PI-589-A (Aux Panel 8), slowly close HV-589-C (Containment Enclosure 2) and record PI-589-A and FI-589 when the following actions occur:

Switch No.	Sw Tab Setting	Action	PI-589-A	FI-589	Init.	Date/Time
PSS-589-A2	____	Turn out light in Ckt. 21	____	____		
PSS-589-A2	____	Alarm XA-4006-5*	____	____	____	____

*NOTE: If alarm does not occur, check HV-589C closed and slowly open HV-589B to increase pressure on PI-589A.

14.4 Open HV-589C and note that the alarm and circuit lights clear. ____ ____

NOTE: The action of PSS-589-A1 is checked during the routine fuel system pressure tests.

14.5 Check that annunciator XA-4007-2 is clear. ____ ____

14.6 Check that the top light in circuit 19 on jumper board 2 is burning. ____ ____

14.7 Close HV-599B (Transmitter Panel 5) ____ ____

14.8 While observing LI-599-B1 (Auxiliary Panel 8) and LI-599-B2 (Transmitter Panel 5) slowly close HV-599-C and record LI-599-B1 and LI-599-B2 when the following actions occur:

Swch. No.	Sw. Tb. Vl	Action	LI-599-B1	LI-599-B2
LS-599-B	____	Alarm XA-4007-2	____	____
LSS-599-B	____	Turn out top light in Ckt 19	____	____

____ ____

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	Init.	Date/Time
14.9 Open HV-599-C and note that the alarm and circuit light clear.	____	____
14.10 Check that the top light in circuit 18 on jumper board 2 is burning.	____	____
14.11 Close HV-600-B (Transmitter Panel 5).	____	____
14.12 While observing LI-600B1 (Auxiliary Panel 8) and LI-600-B2 (Transmitter Panel 5) slowly close HV-600-C and record LI-600-B1 and LI-600-B2 when the following actions occur:		

Swch. No.	Sw. Tb. Vl	Action	LI-600-B1	LI-600-B2
LS-600-B	____	Alarm XA-4007-2	____	____
LSS-600-B	____	Turn out top light in Ckt 18	____	____

	Init.	Date/Time
	____	____
14.13 Open HV-600-C and note that the alarm and circuit light clear.	____	____
14.14 Set HV-589-B, HV-599-B, and HV-600-B as per building log. (See item 13.4 this procedure.)	____	____

15 FUEL PUMP BUBBLER SYSTEM: LEVEL INDICATION AND INTERLOCK CHECKS

NOTE: In order to complete these checks Containment Enclosure 2 must be open.

	Init.	Date/Time
15.1 Check that the lights in circuit 20 on jumper board 2 are burning.	____	____
15.2 Check that the lights in circuit 129 on jumper board 2 are burning.	____	____
15.3 Check that there is cover gas flow to the fuel pump as indicated by FIC-516-B (Main Panel 9) and Record FIC-516-B ______.	____	____
15.4 Check that annunciators XA-4006-5 ______ and XA-4007-5 ______ are clear.	____	____

Approved by [signature: R. H. Guymon]

Init. Date/Time

15.5 While observing PI-522-A (Sampler Enricher Panel 2), PRC-522-A (Main Panel 8), PI-592-B (Auxiliary Panel 8) and FIC-516-B (Main Panel 8) slowly close HV-592-C (Containment Enclosure 2) and record the data in the following table as the indicated action occurs:

Action	Switch No.	Sw Tab Vl	Record
Turn out lights in Circuit 20	PSS-592-B2	____	PI-522-A ____
			PI-592-B ____
			PRC-522-A ____
Alarm XA-4006-5	PS-522-A2*	____	PI-522-A ____
			PI-592-B ____
			PRC-522-A ____
	PS-592-B*	____	PI-522-A ____
			PI-592-B ____
			PRC-522-A ____
Turn out lights in Circuit 129	PSS-522-A	____	PI-522-A ____
			PI-592-B ____
			PRC-522-A ____
Alarm XA-4007-5	FS-516-B	____	PI-522-A ____
			PI-592-B ____
			PRC-522-A ____
			FIC-516-B ____

____ ____

*An instrument mechanic may be required to determine that both switches cause the alarm.

NOTE: The action of PSS-592-B1 is checked during the routing fuel system pressure test.

15.6 Check that FIC-516-B is indicating zero flow ___ and that FCV-516-B2 (on solenoid rack) is deenergized ______.

____ ____

	Init.	Date/Time
15.7 Slowly open HV-592-C (Containment Enclosure 2) until XA-4007-5 clears and then close HV-592-C _____. Note that the flow, as indicated by FIC-516-B returns to normal _______.	_____	__________
15.8 While observing PI-522-A (Sampler Enricher Panel 2) and PRC-522-A (Main Panel 8) open HV-592-C just enough to produce a slow pressure decrease, and when PS-522-A1 causes XA-4006-5 to alarm record the following: Switch Tabulation value for PS-522-A1 ____, PRC-522-A _____, PI-522-A _____.	_____	__________
15.9 Open HV-592-C fully ______. Set HV-592-B per building log (see item 14.4 this procedure). _____. Check that the annunciators and circuit lights clear ______.	_____	__________
15.10 Check that the Normal Fuel Drain Switch (S-7) on console panel III, is in the "off" position.	_____	__________
15.11 Check that the following freeze valves indicate that they are frozen. FV-103 ______ FV-104 ______ FV-105 ______ FV-106 ______	_____	__________
15.12 Set the fuel-pump selector switch (S-36) on main panel 8, to position 2.	_____	__________

15.13 Check that the following circuits on jumper panel 1 are as follows:

Ckt. 117: Top three (3) white lights burning ______.

Ckt. 118: Top three (3) white lights burning ______.

Ckt. 119: Top three (3) white lights burning ______.

Approved by [signature]

Init. Date/Time

15.13 (continued)

Circuit 138: Top white light burning _____ (jumper "A" may be inserted if required) and the second white light out. ________.

15.14 Check that the top white light in circuit 147 on jumper panel 2 is burning (jumper "A" may be inserted if required) and the second white light is out.

15.15 Insert jumper in top jumper of circuit 150 on jumper panel 4 and check that the first white light is out.

15.16 Note that annunciator XA-4006-4 is in the alarm condition.

15.17 While observing LR-593-C (main panel 8) and LI-596-B (transmitter panel 5), slowly close HV-596-C to allow the fuel pump level indicator to increase very slowly and record LR-593-C, LI-596-B and the switch tabulation valves for the indicated switches as the following actions occur:

Action	LR-593-C	LI-596-B	SW. No.	Sw. Tab Val
Second white light in circuits 138 and 147 comes on and the first white light in circuit 150 comes on.			LSS-593-C1	
Annunciator XA-4006-4 clears			LS-593-C3	
Annunciator XA-4006-4 alarms			LS-593-C2	
Third white light in circuits 117, 118, and 119 goes out.			LSS-593-C2	

Approved by [signature]

Init. Date/Time

15.18 While observing LR-593-C (Main panel 8) and LI-596-B (Transmitter panel 5) slowly open HV-596-C to allow the fuel pump level indication to decrease very slowly and record LR-539-C, LI-596-B and the switch tabulation values for the indicated switches as the following actions occur:

Action	LR-593-C	LI-596-B	Sw. No.	Sw. Tab Vl	Init.	Date/Time
Third white light in Ckts. 117, 118, & 119 comes on	_____	_____	LSS-593-C2	_____		
Annunciator XA-4006-4 clears	_____	_____	LS-593-C2	_____		
Annunciator XA-4006-4 alarms	_____	_____	LS-593-C3	_____		
First white light in ckt. 150 goes out and the second white light in ckts 138 & 147 goes out.	_____	_____	LSS-593-C1	_____	_____	_____

15.19 Open HV-596-C fully _____ and set HV-596-B per building log _____(see item 14.4 of this procedure). _____ _____

15.20 Set the fuel pump selector switch (S-36) on main panel 8 to position 3. _____ _____

15.21 Check that the following circuits on jumper panel 1 are as follows:

Top three (3) white lights burning in circuits 117 _____, 118 _____, and 119 _____.

Top white light burning _____(jumper "A" may be inserted if required) and the second white light out in circuit 138. _____. _____ _____

Approved by [signature]

	Init.	Date/Time
15.22 Check that the top white light in circuit 147 on jumper panel 2 is burning (jumper "A" may be inserted if required) and the second white light is out.	____	________
15.23 Check that the top white light in circuit 150 on jumper panel 4 is out (jumper "A" may be inserted if required).	____	________
15.24 Note that annunciator XA-4006-4 is in the alarm condition.	____	________

15.25 While observing LI-593-C (transmitter panel 5) and LR-593-C (main panel 8) slowly close HV-593-C to allow the fuel pump bowl level indication to increase very slowly and record LR-593-C, LI-593-C and the switch tabulation values indicated as the following actions occur:

Action	LR-593-C	LI-593-C	SW. No.	Sw. Tab. Val.
Second white light in ckts. 138 & 147 comes on and the first white light in ckt. 150 comes on.	________	________	LSS-593-C1	____
Annunciator XA-4006-4 clears	________	________	LS-593-C3	____
Annunciator XA-4006-4 alarms	________	________	LS-593-C2	____
Third white light in ckts. 117, 118, & 119 goes out.	________	________	LSS-593-C2	____

____ ________

15.26 While observing LR-593-C (main panel 8) and LI-593-C (transmitter panel 5) slowly open HV-593-C to allow the fuel pump level indication to decrease very slowly and record LR-593-C, LI-593-C and the switch tabulation values for the indicated switches as the following actions occur:

Approved by [signature]

Action	LR-593-C	LI-596-B	Sw. No.	Sw. Tab Val	Init.	Date/Time
Third white light in ckts. 117, 118, & 119 comes on.	______	______	LSS-593-C2	___		
Annunciator XA-4006-4 clears	______	______	LS-593-C2	___		
Annunciator XA-4006-4 alarms	______	______	LS-593-C3	___		
First white light in ckt. 150 goes out and the second white light in ckts 138 & 147 goes out.	______	______	LSS-593-C1	___		
					____	________

15.27 Open HV-593-C fully _____ and set HV-593-B per building log ______(see item 14.4 this procedure). ____ ________

15.28 Remove the "A" jumpers from ckts 138, 147, and/or 150. ____ ________

16 COOLANT PUMP BUBBLER SYSTEM: LEVEL INDICATION AND INTERLOCK CHECKS

NOTE: In order to complete these checks the coolant cell must be open.

16.1 Set the coolant pump selector switch (S-39) on main panel 6 to position 2 (B2). ____ ________

16.2 Check that the lights in circuit 128 on jumper panel 2 are burning. ____ ________

16.3 Check that there is cover gas flow to the coolant pump as indicated by FIC-512-A (main panel 5) and record FIC-512-A _____. ____ ________

16.4 Check that annunciator XA-4004-3 is clear. ____ ________

16.5 While observing FIC-512-A (main panel 5) and PRC-528-A (main panel 6) slowly close HV-594-C to allow the pressure indicated by PRC-528-A to increase very slowly and record

Init. Date/Time

16.5 (continued)

PRC-528-A, FIC-512-A and the switch tabulation values indicated as the following actions occur:

Action	Switch No.	Sw Tab Val	Record
Annunciator XA-4005-2 clears	PS-528-A2	______	PRC-528-A _____
Annunciator XA-4005-2 alarms	PS-528-A1	______	PRC-528-A _____
Lights in circuit 128 go out	PSS-528-A	______	PRC-528-A _____
Annunciator XA-4004-3 alarms	FS-512-A	______	FIC-512-A _____

_____ _____

16.6 Check that FIC-512-A is indicating zero flow _____ and that FCV-512-A2 (on solenoid rack) is de-energized _____. _____ _____

16.7 While observing PRC-528-A (main panel 6) slowly open HV-594-C (coolant cell) to allow the pressure indicated by PRC-528-A to decrease very slowly and record PRC-528-A, FIC-512-A and the indicated switch tabulation values as the following actions occur:

Action	Switch No.	Sw Tab Val	Record
Annunciator XA-4004-3 clears	PS-512-A	______	FIC-512-A _____
Lights in circuit 128 come on	PSS-528-A	______	PRC-528-A _____
Annunciator XA-4005-2 clears	PS-528-A1	______	PRC-528-A _____
Annunciator XA-4005-2 alarms	PS-528-A2	______	PRC-528-A _____

_____ _____

16.8 Note that the cover gas flow to the coolant pump as indicated by FIC-512-A returns to normal _____ (see item 17.3) and open HV-594-C (coolant cell) fully _____. _____ _____

Approved by [signature]

Init. Date/Time

16.9 Set HV-594-B per building log (see item 14.4 this procedure). ____ ____

16.10 Depress the Off Mode button (S-8) on console panel 1. ____ ____

16.11 Check that the lights on circuit 142 on jumper panel 3 are off. ____ ____

16.12 Check that the top white lights in circuits 121 ____ and 126 ____ on jumper panel 3 are burning. ____ ____

16.13 While observing LR-595-C (main panel 6) and LI-598-C3 (transmitter panel 6) slowly close HV-598-C to allow the level indicated on LR-595-C and LI-598-C3 to increase very slowly and record LR-595-C, LI-598-C3 and the switch tabulation values indicated as the following actions occur:

Action	Switch No.	Sw Tab Value	Record
Annunciator XA-4005-3 clears	LS-595-C2	____	LR-595-C ____ LI-598-C3 ____
Top light in circuit 142 comes on	LSS-595-C1	____	LR-595-C ____ LI-598-C3 ____
Annunciator XA-4005-3 alarms	LS-595-C3	____	LR-595-C ____ LI-598-C3 ____
Lights in circuits 121 & 126 go out	LSS-595-C2	____	LR-595-C ____ LI-598-C3 ____

____ ____

16.14 While observing LR-595-C (main panel) and LI-598-C3 (transmitter panel 6) slowly open HV-598-C (coolant cell) to allow the level indicated on LR-595-C and LI-598-C3 to decrease very slowly and record LR-595-C and

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Init. Date/Time

16.14 (continued)

LI-598-C3 and the switch tabulation values as the following actions occur:

Action	Switch No.	Sw Tab Val	Record
The top lights in ckts. 121 & 126 come on.	LSS-595-C2	______	LR-595-C ______ LI-598-C3______
Annunciator XA-4005-3 clears	LS-595-C3	______	LR-595-C ______ LI-598-C3______
Lights in circuit 142 go out	LSS-595-C1	______	LR-595-C ______ LI-598-C3______
Annunciator XA-4005-3 alarms	LS-595-C2	______	LR-595-C ______ LI-598-C3______

16.15 Open HV-598-C (coolant cell) fully _____ and set HV-598-B (transmitter panel 6) per building log ______. (See item 14.4 this procedure.)

16.16 Set the coolant-pump selector switch (S-39) on main panel 6 to position 4. (B1)

16.17 Check that the top white lights in circuits 121 ____ and 126 ____ on jumper panel 3 are burning.

16.18 While observing LR-595-C (main panel 6) and LI-595-C3 (Transmitter panel 6) slowly close HV-595-C to allow the level indicated on LR-595-C and LI-595-C3 to increase very slowly and record LR-595-C, LI-595-C3 and the switch tabulation values indicated as the following actions occur:

Approved by ______ [signature]

Init. Date/Time

Action	Switch No.	Sw Tab Val	Record
Annunciator XA-4005-3 clears	LS-595-C2	______	LR-595-C ______ LI-595-C3 ______
Top light in circuit 142 comes on	LSS-595-C1	______	LR-595-C ______ LI-595-C3 ______
Annunciator XA-4005-3 alarms	LS-595-C3	______	LR-595-C ______ LI-595-C3 ______
Lights in circuits 121 & 126 go out	LSS-595-C2	______	LR-595-C ______ LI-595-C3 ______

______ ______

16.19 While observing LR-595-C (main panel) and LI-595-C3 (transmitter panel 6), slowly open HV-595-C (coolant cell) to allow the level indicated on LR-595-C and LI-595-C3 to decrease very slowly and record LR-595-C, LI-595-C3 and the switch tabulation values indicated as the following actions occur:

Action	Switch No.	Sw Tab Val	Record
The top white lights in circuits 121 & 126 come on	LSS-595-C2	______	LR-595-C ______ LI-595-C3 ______
Annunciator XA-4005-3 clears	LS-595-C3	______	LR-595-C ______ LI-595-C3 ______
Lights in circuit 142 go out	LSS-595-C1	______	LR-595-C ______ LI-595-C3 ______
Annunciator XA-4005-3 alarms	LS-595-C2	______	LR-595-C ______ LI-595-C3 ______

______ ______

16.20 Open HV-595-C (coolant cell) fully ______ and set HV-595-B (transmitter panel 6) per building log ____(see item 14.4 this procedure.)____ ______

Init. Date/Time

17 If the containment-startup-check-list tests have been completed, check that the following valves are open and install the flanges on the containment enclosures. Test the containment enclosure per containment-startup-check list.

Valve	Init.	Valve	Init.
HV-600C	____	HV-572-A	____
HV-599C	____	HV-574-A	____
HV-589C	____	HV-576-A	____
HV-592C	____	HV-516	____
HV-596C	____	HV-519B	____
HV-593C	____		

____ ________

18 DRAIN, FLUSH AND STORAGE TANK PRESSURES

Check that the drain tank receiver selector switch (S-4) is not switched to FST ___ and reactor is in prefill mode _____. Referring to Table 4H-5, one at a time close the listed HV in the helium supply to the tank. Then slowly add pressure through the listed supply HCV by adjusting the PIC and note that the pressure switches listed cause the control action or annunciation listed per Sw. Tab. Record the pressure readings when these occur. Insert jumper and change drain-tank selector switch where indicated. Remove jumper and change selector switch to the original position before starting next test. Also open HV's in the helium supply to the tanks that were initially closed.

____ ________

19 LOW PRESSURE ALARMS ON DRAIN TANKS, FUEL PUMP AND COOLANT PUMP

The Instrument Department should apply pressure on the reference side of the transmitters listed in Table 4H-6. The low pressure alarms should accur at an equivalent pressure to that given in the Sw. Tab. As the test is made fill out Table 4H-6.

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TABLE 4H-5

	TANK			
	FD-1	FD-2	FFT	CDT
Close HV	572-A	574-A	576-A	511-B
Open HCV	572-A1	574-A1	576-A1	511-A1
Adjust PIC	517A	517A	517A	511-B
PdSS or PSS No.	1000-A1	1000-B1	1000-C1	511-D1
Sw. Tab. Value				
Turn out lights in circuit	687	676	665	121, 126
Pressure indicator	PR-572-B	PR-574-B	PR-576-B	PR-511-D
Pressure reading				
Insert jumper "A" in circuit	115	115	115	
PSS No.	572-B2	574-B2	576-B2	
Sw. Tab. Value				
Turn out lights in circuit	720	709	698	
Pressure indicator	PR-572-B	PR-574-B	PR-576-B	
Pressure reading				
Switch DT selector (S-4) to FST				
PS No.	572-B2	574-B2	576-B2	511-D1
Sw. Tab. Value				
Alarm on XA	4009-2	4009-1	4009-3	4004-6
Pressure indicator	PR-572-B	PR-574-B	PR-576-B	PR-511-D
Pressure reading				
PSS No.	572-B1	574-B1	576-B1	
Sw. Tab. Value				
Turn out lights in circuit	115, 117	115, 118	115, 119	
Pressure indicator	PR-572-B	PR-574-B	PR-576-B	
Open HV	572-A	574-A	576-A	511-B
Remove jumper "A" in circuit	115	115	115	

Approved by [signature]

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TABLE 4H-6

Pressure Transmitter	PS No.	Sw. Tab Val	Annunciator	Pressure Recorder
PT-522-A	522-A1	________	XA-4006-5	PR-522-A ________
PT-572-B	572-B1	________	XA-4009-2	PR-572-B ________
PT-574-B	574-B1	________	XA-4009-1	PR-574-B ________
PT-576-B	576-B1	________	XA-4009-3	PR-576-B ________
PT-528-A	528-A2	________	XA-4005-2	PRC-528-A ________
PT-511-D	511-D2	________	XA-4004-6	PR-511-D ________

20 The Instrument Department has checked that the following rolling diaphragm seals on the transmitter vents are properly set and alarm on XA-4018-4 and the test lines have been capped.

Diaphragm Seal	Sw. No.	Press. Transm.	Alarm on XA-4018-4	Init.
PXM-580	PXS-580	PT-592-B	________	_____
PXM-579	PXS-579	PT-522-A	________	_____
PXM-581	PXS-581	PT-589-A	________	_____
PXM-582	PXS-582	PT-572-B	________	_____
PXM-584	PXS-584	PT-574-B	________	_____
PXM-586	PXS-586	PT-576-B	________	_____

_____ ________

21 Check that all containment enclosures opened for the above tests have been closed and have been tested as described in the containment startup check lists. _____ ________

22. Lower the setting of FIC-516-B and note that FS-516-B annunciates on XA-4007-5 per Sw. Tab. _____. Record FIC-516-B _____. FS-524-B should also annunciate on XA-4007-6 per Sw. Tab. _____. Record FI-524-B ________. _____ ________

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		Init.	Date/Time
23	Lower setting on FIC-512-A and note that FS-512-A annunciates on XA-4004-3 per Sw. Tab. ____. Record FIC-512-A ____. FS-526-C should also annunciate on XA-4004-4 per Sw. Tab. ____. Record FIC-512-A ____. Reset FIC-516-B as found.	____	______
NOTE:	It may be necessary to slowly close HV-512 to get the desired actions. If so, be sure to open it when check is completed. ____		
24	Close HV-500-K and note that PS-500-E annunciates per Sw. Tab. on XA-4028-1. ____. Record PI-500-G1 ____. Open HV-500-K.	____	______
25	Increase PCV-500-G and note that PS-500-B2 annunciates on XA-4028-2, ____, PS-506 annunciates on XA-4028-7 ____, and PS-507 annunciates on XA-4028-8 as per Sw. Tab. ____. Record PI-500-G2 ____. Reduce PCV-500-G and note that annunciations clear and PS-500-B1 reannunciates per Sw. Tab. on XA-4028-2 ____. Record PI-500-G2 ____. Set PCV-500-G as found ____.	____	______
26	Close HV-500-E and note that PS-500-K annunciates on XA-4028-4 and PS-509-A annunciates on XA-4035-1 (at S-E panel) per Sw. Tab. ____. Record PI-500-A. ____.	____	______
27	Note that PS-509-B annunciates on XA-4035-3 (at S-E Panel) per Sw. Tab. ____. Record PI-500-A ____. Install temporary pressure gages and hand valves (per sketch below) on the vents of HV-500-N1, N2, and N3.	____	______

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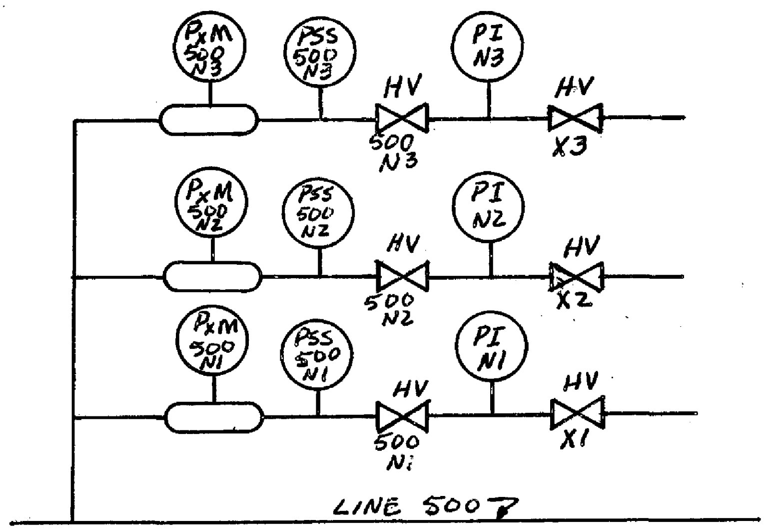

Purge out oxygen, then close HV-X1, X2, and X3, leave HV-500-N1, N2, and N3 open. Open X1 until PI-N1 reads approximately 25 psig. Slowly open temporary HV-X2 and note that PSS-500-N2 turns out lights on ECC-40 and 41 per Sw. Tab. ____. Record PI-N2 ____.

Close HV-X2 and slowly open HV-X3. Note that PSS-500-N3 turns out lights in ECC-40 and 41 per Sw. Tab. ____. Record PI-N3. ____.

Close HV-X1 and slowly open HV-X1. Note that PSS-500-N1 turns out lights in ECC-40 and 41 per Sw. Tab. ____. Record PI-N1 ____. Close HV-400-N1, -N2, and -N3 and tag closed. ____. ____ ________

28 Check that there is flow indicated on FIC-516-B and 512-A and check that there is flow through each bubbler. ____. Record PCV-500-C ____.

Increase PCV-500-C and note that PS-500-L2 annunciates on XA-4028-5 per Sw. Tab. ____.

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28 (continued)

Record PI-500-M ____.

Decrease PCV-500-C and note that PS-500-L1 annunciates on XA-4028-5 per Sw. Tab. ____. Note that lights are out in circuits 40, 41, 115, 116, 126, and 127. Use jumpers as necessary to check this, then remove jumpers.

Note that flow has stopped on the following:

FIC-516-B _____	FI-599-A _____
FIC-512-A _____	FI-589-A _____
FI-596-A _____	FI-600-A _____
FI-592-A _____	FI-598-A _____
FI-593-A _____	FI-595-A _____
	FI-594-A _____

Open HV-519-A and note that PI-519 rises. Close HV-519-A and note that HS-519-A will not open HCV-519-A and B as indicated by the pressure remaining high on PI-519 ____. Close HS-519-A.

Raise setting on PIC-510-A and PIC-513-A and note that pressure does not increase. ____. Return to settings as found. ____.

Raise PCV-500-C to values found at start of test. Set FIC-516-B, 512-A, and bubblers as found. Increase FIC-500-J and note that FS-500-J annunciates on XA-4028-3 per Sw. Tab. ____. Record FIC-400-J ____. ______ ________

NOTE: PS-508-A annunciation on XA-4028-6 is tested during routine system pressure test.

29 Adjust the pressure controllers on the oil supply tanks and note that the alarms occur per Sw. Tab. and record pressures in table below.

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TANK NO.	PIC NO.	PRESSURE SW. NO.	SW. TAB. VALUE	PRESSURE	ANNUN. NO.
OT-1	513-A	513-A2	____	____	XA-4008-4 ____
OT-1	513-A	513-A1	____	____	XA-4008-4 ____
OT-2	510-A	510-A2	____	____	XA-4003-4 ____
OT-2	510-A	510-A1	____	____	XA-4003-4 ____ ____

30 Set TIC-PH1-1 and TIC-O_2R1-1 (TIC-PH2-1 and TIC-O_2R2-1) to turn heat onto preheaters and O_2 removal units. Adjust setpoint on TS-PH1-2, TS-O_2R1-2, TS-PH2-2 and TSO_2R2-2 per Sw. Tab. ____ ____

31 Lower HIC-915-A to zero, open HCV-565-A and note that there is flow through FqI-569-A ____.

Lower the setpoint on RS-565-B and note that lights go out in ECC-18 and ECC-80 ____ annunciation occurs at XA-4010-2 ____, light comes on at monitor panel ____, HCV-565 closes as indicated by light on MB-3 and flow stops through FqI-569-A ____.

While observing temperatures on control rods (R36, 37, 38, 39, 40, or 41), raise setpoint on HIC-915-A. Valve should not open and temperatures should not change. Raise setpoint of RS-565-B and push reset button. ____. Valve should open and temperatures change ____. Reset RS-565-B setpoint as found. ____ ____

32 Open HCV-565-A1. Lower the setpoint on RS-565-C and note that lights go out in ECC-19, ____, annunciation occurs on XA-4010-2 ____, and light comes on at monitor panel ____. Raise setpoint on RS-565-C and push reset button. Note that conditions clear. ____ ____

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33 Lower setpoint on RS-528-B and note that lights in ECC-18 and 147 go out, ____, annunciation occurs on XA-4010-2 ____, and light comes on at monitor panel ____. Raise setpoint to value as found and push reset button. ____. Note that conditions clear. ____ ________

34 Repeat with RS-582-C. ____ ________

35 Check that there is flow indicated on FI-836-A, FI-838-A, FI-840-A, FI-830-A, and FI-844-A. ____ ________

Lower setpoint on RS-827-A and note that annunciation occurs on XA-4010-2 ____ and light comes on at monitor panel ____.

Lower setpoint on RS-827-B and note that flows on FI-836-A, 838-A, 840-A, 830-A, and 844-A go to zero, and ESV-ST-A closes (physically check). Raise setpoint on RS-827-A and push reset. Note that flows start but annunciator does not clear ____.

Lower setpoint on RS-827-C and note that flows stop ____. Raise setpoint on RS-827-B and note that flows start but annunciator does not clear ____.

Lower setpoint on RS-827-A and note that flows stop ____. Physically check that both FSV-847-A1 and FSV-844-A2 are closed ____.

Raise setpoint on RS-827-A and push reset button. Note that flows start but annunciators do not clear. ____. Raise setpoint on RS-827-C and push reset button. Note that annunciators clear. ____ ________

36 Check that HS-557-C is open. Record alarm setpoint on RS-557-A ____. Lower the setpoint on RS-557-A and note that annunciation occurs on

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36 (continued)

XA-4010-2 ____, light comes on at monitor panel ____, and HCV-557-C1 closes as indicated by light on main board and visual observation ____. Visually observe that HCV-510-A2 and HCV-513-A2 do not open when PIC-510-A and PIC-531-A setpoints are lowered. Raise PIC-510 and 513-A setpoint to values as found. ____.

Raise RS-557-A setpoint to value as found and note that conditions clear. ____ ____

37 Repeat with RS-557-B. ____ ____

38 Check that flow is indicated on FI-596, FI-592, FI-593, FI-599, FI-589, and FI-600. Record alarm setpoints on RS-596-A ____, RS-596-B ____ and RS-596-C ____.

Lower the setpoint on RS-596-A and note that annunciation occurs on XA-4010-2 ____ and light comes on at monitor panel ____. ____ ____

Lower setpoint on RS-596-B and note that flows on FI-596, FI-592, FI-593, FI-599, FI-589, and FI-600 go to zero ____. Raise setpoint on RS-596-A and push reset. Note that flows start but annunciation does not clear ____.

Lower setpoint on RS-596-C and note that flows stop (i.e. pressures increase) ____. Raise setpoint on RS-596-B, push reset and note that flows start but annunciator does not clear ____.

Lower setpoint on RS-596-A and note that flows stop. Raise setpoint on RS-596-A and note that flows start but annunciator does not clear ____.

Raise setpoint on RS-596-C and note that annunciators clear. ____ ____

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		Init.	Date/Time
39	Have the instrument mechanic complete the process radiation instrument check list and check out all alarms, setpoints, and control actions using a source at each element.	____	______
40	The process monitors are in service, the primary element is properly located and the setpoint agrees with master copy of process radiation check list. See Table 4H-7.	____	______
41	The Instrument Department has put the neutron instruments in service and has completed the neutron instrument check list.	____	______
42	High level gamma instruments are in service.	____	______
43	The Health Physics Department will check the functioning of each personnel radiation monitor with a source. When this check is made, complete Table 4H-8, checking that each monitor gives a local indication and alarm and causes an alarm in the auxiliary and main control rooms.	____	______
44	NOTE: The following should be approved by the Operations Chief before proceeding. Health Physics personnel should monitor the operations. ____.		
	Open FCV-703 and then drain the oil from OT-1. Note that LS-OT1-A3 annunciates on XA-4008-5 and that LSS-OT1-A3 closes FSV-703 ____ per Sw. Tab. Record LI-OT1-A for each action. ____ ____. Completely drain tank.	____	______
	Add a total of ____ of oil and note that LI-OT-1 reads approximately 55%. Record level OT-1 ____.		
	If lines to the salt pump are empty, add additional oil, which should bring level to 95%. If lines are full, do not add more oil. Record		

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TABLE 4H-7

NO.	LOCATION	POSITION OF MONITOR	SETPOINT	READING	INIT.	DATE
RE-596-A	840' Level					
RE-596-B	840' Level					
RE-596-C	840' Level					
RE-528-B	Vent House					
RE-528-C	Vent House					
RE-500-D	Water Room					
RE-675-A	Sampler					
RE-675-B	Sampler					
RE-DT-1B	Service Tunnel					
RE-DT-2B	Service Tunnel					
RE-565-B	Vent House					
RE-565-C	Vent House					
RE-557-B	Vent House					
RE-557-C	Vent House					
RE-678-A	Sampler					
RE-678-B	Sampler					
RE-827-A	Blower House					
RE-827-B	Blower House					
RE-827-C	Blower House					

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TABLE 4H-8

PERSONNEL RADIATION MONITOR			LOCAL ALARM	LOCAL INDCT.	AUX. CR. ALARM	MCR. ALM. XA-4010-1	DATE
NO.	TYPE	LOCATION					
3	C.A.M.	Control Room					
1	Monitron	Control Room					
2	Monitron	Hi Bay (West)					
3	Monitron	Hi Bay (South)					
1	C.A.M.	Hi Bay (South)					
2	C.A.M.	Hi Bay (West)					
5	Monitron	840' Level (HCP)					
6	Monitron	840' Level (Horn Hall)					
4	C.A.M.	840' Level					
5	C.A.M.	Transmitter Room					
7	Monitron	Transmitter Room					
8	Monitron	Service Tunnel					
6	C.A.M.	Service Tunnel					

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44 (continued)

oil added ____ gal and LI-OT1-A ____.

Tag fill and drain valves closed. ____ ____

45 With FOP-2 in operation, slowly close HV-713 and note that PS-702-B annunciates on XA-4008-6 and FOP-1 starts per Sw. Tab. Record PI-702-A ____. Open HV-713. ____.

Slowly close HV-714 and note that PS-701-B annunciates on XA-4008-6 and FOP-2 starts per Sw. Tab. Record PI-701-A ____. Open HV-714 ____. ____ ____

46 Slowly close HV-703-B and note that FS-703-A annunciates on XA-4007-1 per Sw. Tab. Record FI-703-A ____. FSS-703-A should turn out lights in ECC 147 per Sw. Tab. (Jumpers may be used

		Init.	Date/Time
46	(continued) where needed.) Record FI-703-A ____. Readjust flows and note that alarm clears. ____ Remove jumpers. ____	____	____
47	Slowly close HV-704 and note that FS-704-A annunciates on XA-4007-1 per Sw. Tab. Record FI-704-A ____. FSS-704-A should turn out lights in ECC 147. (Jumpers may be used where needed.) Record FI-704-A ____. Readjust flows and note that alarm clears. ____ Remove jumpers. ____	____	____
48	Repeat test for COP-1 and COP-2.	____	____
49	NOTE: Obtain Operations Chief's permission before doing the following: ____________ Remove temperature switches from all four oil pumps (TS-FOP-1, TS-FOP-2, TS-COP-1, and TS-COP-2) and immerse in an oil bath and check that TS-FOP-1, TS-FOP-2, TS-COP-1, and TS-COP-2 annunciate on XA-4008-3 or 4004-1 per Sw. Tab. Record temperatures. TS-FOP-1 ____ TS-FOP-2 ____ TS-COP-1 ____ TS-COP-2 ____. Reinstall temperature switches and seal. ____	____	____
50	The following should be approved by the Operations Chief before proceeding. ____________ Health Physics coverage should be provided. ____________ Open HV-720-A, 720-B, 525-A and 525-B, and drain OCT-1 to WOR-1 ____. Close 720-B and 525-B. Disconnect 720 line from WOR-1. Attach a temporary line to line 720 and add ____ liters of oil to OCT-1. LI-524-C should indicate ____%, and LS-524-C should cause the light at OCT-1 on MB to burn. Record oil added ____.		

		Init.	Date/Time
50	(continued) Drain oil to WOR-1 until OCT-1 reads 5 to 10%. Record initial and final levels on LI-524 ____ to ____. Tag HV-720-A, HV-720-B, HV-525-A, and HV-525-B closed.	____	____
51	Repeat test for the coolant oil package.	____	____
52	Close HV-825-B and note that LS-ST-A annunciates on XA-4027-7 and XA-4000-3 per Sw. Tab. as level is lowered by removing water from the system at a sample point or other convenient location. (Have HP check for activity in the water.) Record LI-ST-B ____. Close the valve used to lower the level in CST and open HV-825-B. HCV-825-A should close when surge tank level is approximately ____%.	____	____
53	With No. 1 TW pump in operation, throttle HV-829-A and note that PS-829-B annunciates on XA-4026-10 and XA-4000-3 per Sw. Tab. Record PI-829-A ____. Open HV-829-A.	____	____
54	Close HV-890-B and check that water is flowing through FI-810-A. Note that PS-882-B alarms on XA-4026-12. With No. 1 CT pump in service, throttle HV-851-A and note that PS-851-B2 annunciates on XA-4026-11 and flow stops in FI-810-A, indicating that PS-851-B1 has switched HCV-882 to process water. (If No. 2 CT pump is in service, throttle HV-853 for above test).	____	____
	Record PI-851-A ____. Open HV-890-B and note flow is indicated on FI-810-A. Open HV-851-A.		
55	With the cooling tower water system in operation, throttle HV-851-C and note that FS-851-C annunciates on XA-4027-1 and on XA-4000-3 per		

	Init.	Date/Time

55 (continued)

Sw. Tab. Record FI-851-C. ____ ____

Continue throttling HV-851-C and note that high treated water temperature TS-826 annunciates on XA-4026-4 per Sw. Tab. Record TI-829-1 ____. Open HV-851-C. ____ ____

56 With TW system in operation, adjust flows to the following and note that annunciations occur as listed in Table 4H-9. Readjust flows as found and note that alarms clear. XA-4000-3 should also alarm and clear each time. ____ ____

56.1 While observing PI-844 to be sure that it does not exceed 16 psig, close FSV-847 and note that PSS-844-B1 closes FSV-844, FS-844-A alarms on XA-4026-1 and PS-844-B2 alarms on XA-4027-8. ____ ____

56.2 Close HV-830-A and note that FS-830-A operates time-delay relay K-113 to stop FP in circuit 147. Use jumper if necessary. ____ ____

56.3 Slowly close HV-840-A and note that FS-840-A alarms on XA-4026-9. ____ ____

56.4 Slowly close HV-838-A and note that FS-838-A alarms on XA-4026-8. ____ ____

56.5 Close HV-832-A and note that FS-832-A operates time-delay relay K-114 to stop CP in circuit 142. (Use jumper if necessary.) ____ ____

56.6 Slowly close HV-836-A and note that FS-836-A alarms on XA-4026-7. ____ ____

56.7 Open HV-848-A and HV-848-B and slowly add TW to the nuclear instrument penetration until LS-NP alarms on XA-4027-9 ____. Close both valves and remove water from penetration until LS-NP alarms on XA-4027-9. ____ Refill penetration. ____ ____

Approved by [signature]

TABLE 4H-9

SW. NO.	SW. TAB. SETTING	ALARM	ALARMED AT	OTHER ACTION
PSS-844-B1		______	______	Closes FSV-844
FS-844-A		XA-4026-1		
PS-844-B2		XA-4027-8		
FS-830-A		______	______	Stops FP (15 min time delay)
FS-840-A		XA-4026-9		
FS-838-A		XA-4026-8		
FS-832-A		______	______	Stops CP (15 min time delay)
FS-836-A		XA-4026-7		
LS-NP		XA-4027-9		
FS-873-A		XA-4027-2		
FS-875-A		XA-4027-3		
LS-FWT-1A		XA-4027-6		
LS-FWT-2A		XA-4027-6		
FS-821-A		XA-4027-4		
FS-823-A		XA-4027-5		

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56.8 Slowly close HV-873-A and note that FS-873-A alarms on XA-4027-2. ____ ______

56.9 Slowly close HV-875-A and note that FS-875-A alarms on XA-4027-3. ____ ______

56.10 Close HV's between FWT-1 and LT-FWT-1A. Drain water from LT and note that LS-FWT-1A alarms on XA-4027-6. Record level ____. Close drain valve and open HV's and note that alarm clears. Record level ____. ____ ______

56.11 Repeat for FWT-2. Alarms at level ____. Clears at level ____. ____ ______

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56.12 Slowly close HV-821-B and note that FS-821-A alarms on XA-4027-4. ____ ______

56.13 Slowly close HV-823-B and note that FS-823-A alarms on XA-4027-5. ____ ______

56.14 Remove jumpers. ____ ______

57 Check that LI-806-A and 807-A indicate that the steam domes are empty. If not, add water to top leg of each DP cell by opening HV-824 (or HV-828) until level reads zero or until it stops changing, indicating that leg is full. ____.

NOTE: Indicated level will decrease as water level increases until the top leg overflows. The water will then go into the steam dome proper and indicated level will increase.

Close the hand valves in both legs of the DP cells (LT-806 and 807) and open the equalizing valve. These are located in the north electric service area. LI-806 and 807 should indicate that the steam domes are full. Record LIC-806-A ____ and LIC-807-A ____.

Close the two equalizing valves and open the four supply valves to LT-806-A and 807-A.

NOTE: Hold the following tests to a minimum to avoid putting too much water in the steam dome. Have an instrument mechanic apply a millivolt signal to TS-FD1-19B and note that ESV-806-A opens per Sw. Tab. as indicated by LI-FWT-1 or LIC-806-A. Record temperature equivalent to millivolt signal needed. __________.

Remove millivolt signal and repeat, using TS-FD1-20B. Record temperature equivalent ____. Remove millivolt signal and plug TE's back into patch panel. Have a millivolt signal applied to TS-FD2-19B and note that ESV-807-A opens per Sw.

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57 (continued)

Tab., as indicated by LI-FWT-2 or LIC-807-A. Record temperature equivalent to millivolt signal needed. ____.

Remove millivolt signal and repeat using TS-FD2-20B. Record temperature equivalent ____. Remove millivolt signal and plug TE's back into patch panel. ____. Shift supervisor should check that the four TE's are properly installed at the patch panel. Shift Supervisor's initials ____. Raise the setpoint on LIC-806-A and note (physically observe) that LCV-806-A opens. ____ Lower the setpoint. Raise the setpoint on LIC-807-A and note (physically observe) that LCV-807-A opens ____. Lower the setpoint. ____ ____

58.1 With both component coolant pumps running, lower the setpoint on PdIC-960-A and note that PdS-960-A1 alarms on XA-4002-1 per Sw. Tab. ____. Record PdIC-960-A ____. ____ ____

58.2 Check that PdS-960-A2 opens PdCV-960-A2 per Sw. Tab. by turning off both component cooling pumps momentarily ____. Record PdIC-960-A ____. Raise setpoint to value in building log. ____ ____

58.3 Stop CCP-1 and note that PS-791-B alarms on XA-4002-3 ____. Start pump and note that alarm clears ____. ____ ____

58.4 Stop CCP-2 and note that PS-795-B alarms on XA-4002-3 ____. Start pump and note that alarm clears. ____ ____ ____

58.5 Leave CCP-1 running and put CCP-2 in standby. ____ ____

59 Lower the setpoint on PIC-906-B on WP and note that PS-906-B annunciates per Sw. Tab. on XA-4002-2. Record PI-906-B ____. Raise setpoint to value given

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59 (continued)
in building log ____. ____ ____

60 Reduce setpoint on PIC-514, and note that PS-514-A1 annunciates on XA-4000-4 per Sw. Tab. Record PIC-514 ____. Raise setpoint on PIC-514 and note that PS-514-A2 annunciates on XA-4000-4 per Sw. Tab. Record PIC-514 ____. Restore to normal ____.

Reduce pressure on line 400 and note that PS-400-A1 annunciates on XA-4000-4 per Sw. Tab. Record PI-401 ____. Raise pressure on line 400 and note that PS-400-A2 annunciates on XA-4000-4 per Sw. Tab. Record PI-401 ____. Restore to normal. ____ ____

61 With the reactor and drain tank cells at normal operating pressure (12.7 psia), jet both sumps to the waste tank ____. Close HV-332-B and 342, and stop N_2 flow to RC and DTC sump bubblers. Check with Operations Chief before proceeding. Remove the cap from line 332 west of the building. Add water to the sump and note that LS-RC-D annunciates on XA-4029-1 per Sw. Tab. Record water added ____. Do not exceed ____ liters. Replace cap and jet sump. Alarm cleared ____. Check with Operations Chief before proceeding. ________ Remove cap from line 342. Add water to sump and note that LS-DTC-B annunciates on XA-4029-2 per Sw. Tab. Record water added ____. Do not exceed ____ liters. Replace cap and jet sump. Alarm cleared ____.

Increase flow on LI-RC-C or open HV-965 and note that LS-RC-C annunciates on XA-4029-2 per Sw. Tab. Record LI-DTC-A ____. Decrease flow to normal. ____ ____

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62 If possible, add approximately 1 gal. of water to lines 315, 317, 319, and 321, and note that alarms clear.

		Alarms	Clears	Sw. No.	Sw. Tab.		
Liquid Waste Cell Equipment	XA-4029-8	______	______	LS-WTC-A	________		
Storage Cell	XA-4029-6	______	______	LS-SC-A	________		
Spare Cell	XA-4029-7	______	______	LS-TC-A	________		
Fuel Processing Cell	XA-4029-4	______	______	LS-FSC-A	________	____	_______

63 Turn off power to sump pump and pit pump in sump room below special equipment room.

Add water to sump drum and note that LS-PRT annunciates on XA-4029-3. Turn power onto pit pump and note that alarm clears ____.

Add water to sump and note that LS-PRS-B annunciates on XA-4029-5. Turn power onto sump pump and note that alarm clears. _____ ________

64 Check the adjustable low weight alarm by raising the alarm setpoint and checking that XA-4007-4 alarms for FD 1, FD 2, and FFT at the indicated tank weight, that XA-4004-5 alarms for CDT, and XA-4009-5 for FST.

Check the high and low level probes vs the indicated weight as salt is transferred to or from a tank. Record results in Table 4H-10 and 4H-11.

Approved by [signature]

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TANK	SW. NO.	SW. TAB.	WEIGHT AT ALARM
FD-1	WS-FD1-C2		
FD-2	WS-FD2-C2		
FFT	WS-FFT-C3		
CDT	WS-CDT-C1		
FST	WS-FST-C1		

____ ______

65 Remove lines FD1-C1-14 and FD1-C1-31 from output side of WM-FD1-C5 on TB-3 and cap fittings on WM. Tee lines FD1-C1-14 and -31 together and connect ramp generator to other side of tee. Introduce a decreasing signal from ramp generator into system and note that WS-FD1-C4 alarms XA-4007-3 at 46%↓ on WI-FD1-C1 on TB-3 ____. (This corresponds to a dw/dt decrease of 95 lb/min) and that WS-FD1-C3 turns out lights in circuits 116 and 117 at 41%↓ on WI-FD1-C1 _____. (This corresponds to a dw/dt decrease of 140 lb/min.) ____ ______

Restore lines as found. ____ ______

Remove lines FD2-C1-14 and FD2-C1-31 from output side of WM-FD2-CT on TB-3 and cap fittings on WM. Tee lines FD2-C1-14 and FD2-C1-31 together and connect ramp generator to other side of tee. Introduce a decreasing signal from ramp generator into system and note that WS-FD2-C4 alarms XA-4007-3 at 46%↓ on WI-FD2-C1 on TB-3 ____. (This corresponds to a dw/dt decrease of 95 lb/min) and that WS-FD2-C3 turns out lights in circuits 116 and 118 at 41%↓ on WI-FD2-C1 ____. (This corresponds to a dw/dt decrease of 140 lb/min). ____ ______

Restore lines as found. ____ ______

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TABLE 4H-10

Record weight when high level light is actuated on changing level. ____ ______

	FD-1	FD-2	FFT	FST	CDT
Recorder					
Live Manometer					
Tare Manometer					
Decreasing or Increasing Level					
Date					
Initial					

TABLE 4H-11

Record weight when high level light is actuated on changinglevel. ____ ______

	FD-1	FD-2	FFT	FST	CDT
Recorder					
Live Manometer					
Tare Manometer					
Decreasing or Increasing Level					
Date					
Initial					

66 Open HCV-544, 545, and 546. Switch HS-573-A, 575-A, 577-A to open.

Switch receiver selector to FD-1. Introduce a false air signal to the input of WR-FD-1 and note that WSS-FD1-C1 turns on light in ECC 115 per Sw. Tab. ____ Record WR-FD-1 ____. Close HCV-544 and note that ZS-544-A turns light out in ECC 115 and

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66 (continued)

turns light on in ECC 117 ____. Open HCV-544 and reset tare to normal ____.

Switch the receiver selector switch to FD-2. Introduce a false air signal into the input of WR-FD2 and note that WSS-FD2-C1 turns on light in ECC 115 per Sw. Tab. ____. Record WR-FD2 ____. Close HCV-545 and note that ZS-545-A turns light out in ECC 115 and turns light on in ECC 118 ____. Open HCV-545 and reset tare to normal.

Switch the receiver selector to FFT. Introduce a false air signal into the input of WR-FFT and note that WSS-FFD-C1 turns on light in ECC 115 per Sw. Tab. ____. Record WR-FFT ____. Close HCV-546 and note that ZS-546-A turns light out in ECC 115 and turns light on in ECC 119 ____. Open HCV-546 and reset tare to normal. ____. Set HCV-544, 545, 546, 573, 575, and 577 as found. ____ ____

67 With fuel pump on and no salt in fuel system, push calibrate button on SIT-FP-E1 and note that SS-FP-E1 annunciates on XA-4006-2 and SSS-FP-E1 turns lights out in ECC 139 and ECC 150, and turns one light on in ECC 116 ____. Use jumper where required.

Release calibrate button and note that conditions clear ____.

Push calibrate button on SIT-FP-E2 and note that SS-FP-E2 annunciates on XA-4006-2 and SSS-FP-E2 turns lights out in ECC 139 ____.

Release calibrate button and note that conditions clear ____.

Push both calibrate buttons SIT-FP-E1 and SIT-FP-E2 and note that XA-4006-2 alarms and that two lights come on in ECC 116 and lights are out

Init. Date/Time

67 (continued)
in ECC 139 and 150 ____. Remove jumpers. ____ ________

Disconnect the FP's speed element input from SIT-FP-E1 or E2 and connect it to an oscilloscope. If the FP is rotating in the proper direction, the pulses will appear in the following order: long, medium, short.

Reconnect the input to SIT-FP-E1 or E2. ____ ________

68 As various freeze valves are thawed and frozen, note that the interlocks and position indicators function as indicated in Table 4H-12 and Table 4H-12a. Indicate that the interlock functions by the use of check marks. ____ ________

69 Temperature Alarms -- The following tests will be done in conjunction with the instrument department. For each of the alarms listed in Table 4H-13, provide a millivolt signal at the patch panel and note that annunciation occurs at the millivolts equivalent to temperatures listed in the Sw. Tab. Adjust the setpoints if they deviate more than ± 2%. Be sure to plug TE back in when test is complete. Shift Supervisor check TE's properly plugged. ____ ________

70 When system is at temperature, activate test switch HS-100-A1 under TI-100-A1 and note that TS-100-A1 annunciates on XA-4006-3 per Sw. Tab. Record TI-100-A1 ____. Also note that TSS-100-A1-1 turns out safety channel No. 1 light on MB-13 (console). Record TI-100-A1. ____. ____ ________

Activate test switch HS-100-A2 under TI-100-A2 and note that TS-100-A2 annunciates on XA-4006-3 per Sw. Tab. Record TI-100-A2 ____. Also note that TSS-100-A2-1 turns out safety channel No. 2 light on MB-13 (console). Record TI-100-A1 ____.

TABLE 4H-12

Freeze Valve No.	Freeze Valve Condition	Other Conditions Required	Check that Listed Circuit Lights go out as FV completes thawing or freezing	TS No. TS-FV-	Sw. Tab. Value
103	Thawing	In Operate Mode	147-1	1A1, 2A2 & 3A1	
	Freezing	In Operate Mode	116-2	2A1	
104	Thawing	FV-107 & 110 frozen, FV-105 & 106 thawed.	116-A2 & B2, 119-1 120-1, & 134-2	1A1, 2A2 & 3A1	
	Freezing	FV-105 & 106 frozen and S-6 set to FFT	116-C1 & 136-2	1A1, 2A2 & 3A1	
105	Thawing	FV-104 & 106 frozen. FV-108 & 110 thawed.	116-A1 & C1, 118-1 120-1 & 134-2	1A1, 2A2 & 3A1	
	Freezing	FV-104 & 106 frozen & S-6 FV-109 & 110 thawed.	116-B2 120-1 & 134-2	1A1, 2A2 & 3A1	
106	Thawing	FV-104 & 105 frozen, FV-109 & 110 thawed.	116-B2 & C1, 117-1 120-1 & 134-2	1A1, 2A2 & 3A1	
	Freezing	FV-104 & 105 frozen & S-6 set to FD-1	116-A2	1A1, 2A2 & 3A1	
107	Thawing	FV-108 & 109 frozen, FV-104 & 110 thawed, S-4 or S-5 set to FST	115-1, 119-1, 120-1 & 136-1	1A1, 2A1 & 3A1	
	Freezing	S-4 set to FFT, FV-108, 109, 110, 111 frozen	115-3	1A1, 2A1 & 3A1	
		S-5 set to FFT & S-4 not set to FFT. FV-108, 109, 110, 111 frozen	115-4		
108	Thawing	FV-107 & 109 frozen, FV-105 & 110 thawed. S-4 or S-5 set to FST	115-1, 118-1, 120-1 & 136-1	1A1, 2A1 & 3A1	
	Freezing	S-4 set to FD-2, FV-107, 109, 110, 111 frozen	115-3	1A1, 2A1 & 3A1	
		S-5 set to FD-2 & s-4 not set to FD-2. FV-107, 109, 110, 111 frozen	115-4		

TABLE 4H-12 (continued)

Freeze Valve No.	Freeze Valve Condition	Other Conditions Required	Check that Listed Circuit Lights go out as FV completes thawing or freezing	TS No. TS-FV-	Sw. Tab. Value
109	Thawing	FV-107 & 108 frozen, FV-106 & 110 thawed. S-4 or S-5 set for FST	115-1, 117-1, 120-1 & 136-1	1A1, 2A1 & 3A1	
	Freezing	S-4 set to FD-1. FV-107, 108, 110, 111 frozen.	115-3	1A1, 2A1 & 3A1	
		S-5 set to FD-1 & S-4 not set to FD-1, FV-107, 108, 110, 111 frozen.	115-4		
110	Thawing	FV-104, 105, 106, 107, 108, or 109 thawed.	115-1 & 120-1	1A1, 2A1 & 3A1	
	Freezing	S-4 set to FST, FV-107, 108, 109, 111 frozen	115-3	1A1, 2A1 & 3A1	
		S-5 set to FST & S-4 not set to FST. FV-107, 108, 109, 111 frozen.	115-4		
111	Thawing	FV-107, 108, 109, 111 frozen.	115-2	1A1, 2A1 & 3A1	
204	Thawing		142-2	1A1, 2A2 & 3A1	
206	Thawing	FV-204 frozen.	142-3	1A1, 2A2 & 3A1	

Approved by [signature]

TABLE 4H-12a

Position Indicator	Color of Light	Temperature Sw. No.	Sw. Tab. Value
ZI-FV-206-2A	Red	TS-FV-206-2A1	
-2B	Green	-1A1, 3A1	
204-2A	Red	204-2A1	
-2B	Green	-1A1, 3A1	
112-2A	Red	112-2A1	
-2B	Green	-1A1, 3A1	
111-2A	Red	111-2A1	
-2B	Green	-1A1, 3A1	
110-2A	Red	110-2A1	
-2B	Green	-1A1, 3A1	
109-2A	Red	109-2A1	
-2B	Green	-1A1, 3A1	
108-2A	Red	108-2A1	
-2B	Green	-1A1, 3A1	
107-2A	Red	107-2A1	
-2B	Green	-1A1, 3A1	
106-2A	Red	106-2A1	
-2B	Green	-1A1, 3A1	
105-2A	Red	105-2A1	
-2B	Green	-1A1, 3A1	
104-2A	Red	104-2A1	
-2B	Green	-1A1, 3A1	
103-2A	Red	103-2A1	
-2B	Green	-1A1, 3A1	

TABLE 4H-13

TE and TS No.	Switch No.	Sw. Tab. Value	Alarm No.	Alarm Point	Alarm Point Reset to	Date	Init.
FF-100-1	TX-3001-1		XA-4010-4				
FF-100-3	-2		XA-4010-4				
FF-101-1	-3		XA-4010-4				
FF-101-3	-4		XA-4010-4				
FF-102-1	-5		XA-4010-4				
FF-102-3	-6		XA-4010-4				
FF-200-1	-7		XA-4010-4				
FF-200-3	-8		XA-4010-4				
FF-201-1	-9		XA-4010-4				
FF-201-3	-10		XA-4010-4				
R-42B	-11		XA-4010-4				
R-45B	-12		XA-4010-4				
R-33	-13		XA-4010-4				
R-46B	-14		XA-4010-4				
FD1-19B	-15		XA-4010-4				
	-16		XA-4010-4				
FD2-19B	-17		XA-4010-4				
	-18		XA-4010-4				
	-19		XA-4010-4				
	-20		XA-4010-4				
FV-104-5A	TX-3002-1		XA-4020-2				
FV-105-5A	-2		-3				
FV-106-5A	-3		-4				
FV-107-5A	-4		XA-4021-3				
FV-108-5A	-5		-4				
FV-109-5A	-6		XA-4022-1				
FV-110-5A	-7		-2				
FV-111-5A	-8		-3				

TABLE 4H-13
(continued)

TE and TS No.	Switch No.	Sw. Tab. Value	Alarm No.	Alarm Point	Alarm Point Reset to	Date	Init.
FV-112-5A	-9		-4				
FV-204-5A	-10		XA-4021-1				
FD-1-20B	TX-3002-11		None				
	-12						
FD-2-20B	-13		None				
	-14						
705	-15		XA-4018-1				
707	-16		XA-4018-1				
755	-17		-2				
757	-18		XA-4018-2				
OFT-6A	-19						
	-20						
FV-103-1A1	TX-3003-1		XA-4020-1				
FV-103-2A1	-2		XA-4020-1				
FV-103-3A2	-3		XA-4020-1				
FV-204-1A1	-4		XA-4021-1				
FV-204-2A1	-5		XA-4021-1				
FV-204-3A2	-6		XA-4021-1				
FV-206-1A1	-7		XA-4021-2				
FV-206-2A1	-8		XA-4021-2				
FV-206-3A2	-9		XA-4021-2				
AD-3-5B	-10		XA-4003-2				
AD-3-7B	-11		XA-4003-2				
FV-103-1A2	TX-3004-1		XA-4020-1				
FV-103-2A2	-2		XA-4020-1				
FV-103-3A1	-3		XA-4020-1				
FV-204-1A2	-4		XA-4021-1				

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TABLE 4H-13
(continued)

TE and TS No.	Switch No.	Sw. Tab. Value	Alarm No.	Alarm Point	Alarm Point Reset to	Date	Init.
FV-204-2A2	-5		XA-4021-1				
FV-204-3A1	-6		XA-4021-1				
FV-206-1A2	-7		XA-4021-2				
FV-206-2A2	-8		XA-4021-2				
FV-206-3A1	-9		XA-4021-2				
	-10		XA-4021-2				
FV-104-1A1	TX-3005-1		XA-4020-2				
FV-104-2A1	-2		XA-4020-2				
FV-104-3A2	-3		XA-4020-2				
FV-105-1A1	TX-3005-4		XA-4020-3				
FV-105-2A1	-5		XA-4020-3				
FV-105-3A2	-6		XA-4020-3				
FV-106-1A1	-7		XA-4020-4				
FV-106-2A1	-8		XA-4020-4				
FV-106-3A2	-9		XA-4020-4				
FV-104-6A	-10		XA-4020-2				
FV-105-6A	-11		XA-4020-3				
FV-104-1A2	TX-3006-1		XA-4020-2				
FV-104-2A2	-2		XA-4020-2				
FV-104-3A1	-3		XA-4020-2				
FV-105-1A2	-4		XA-4020-3				
FV-105-2A2	-5		XA-4020-3				
FV-105-3A1	-6		XA-4020-3				
FV-106-1A2	-7		XA-4020-4				
FV-106-2A2	-8		XA-4020-4				
FV-106-3A1	-9		XA-4020-4				
	-10						

Approved by [signature]

TABLE 4H-13
(continued)

TE and TS No.	Switch No.	Sw. Tab. Value	Alarm No.	Alarm Point	Alarm Point Reset to	Date	Init.
FV-107-1A1	TX-3007-1		XA-4021-3				
FV-107-2A1	-2		XA-4021-3				
FV-107-3A2	-3		XA-4021-3				
FV-108-1A1	-4		XA-4021-4				
FV-108-2A1	-5		XA-4021-4				
FV-108-3A2	-6		XA-4021-4				
FV-109-1A1	-7		XA-4022-1				
FV-109-2A1	-8		XA-4022-1				
FV-109-3A2	-9		XA-4022-1				
	-10						
FV-107-1A2	TX-3008-1		XA-4021-3				
FV-107-2A2	-2		XA-4021-3				
FV-107-3A1	-3		XA-4021-3				
FV-108-1A2	-4		XA-4021-4				
FV-108-2A2	-5		XA-4021-4				
FV-108-3A1	-6		XA-4021-4				
FV-109-1A2	TX-3008-7		XA-4022-1				
FV-109-2A2	-8		XA-4022-1				
FV-109-3A1	-9		XA-4022-1				
	-10						
FV-110-1A1	TX-3009-1		XA-4022-2				
FV-110-2A1	-2		XA-4022-2				
FV-110-3A2	-3		XA-4022-2				
FV-111-1A1	-4		XA-4022-3				
FV-111-2A1	-5		XA-4022-3				
FV-111-3A2	-6		XA-4022-3				
FV-112-1A1	-7		XA-4022-4				
FV-112-2A1	-8		XA-4022-4				

TABLE 4H-13
(continued)

TE and TS No.	Switch No.	Sw. Tab. Value	Alarm No.	Alarm Point	Alarm Point Reset to	Date	Init.
FV-112-3A2	-9		XA-4022-4				
	-10						
FV-110-1A2	TX-3010-1		XA-4022-2				
FV-110-2A2	-2		XA-4022-2				
FV-110-3A1	-3		XA-4022-2				
FV-111-1A2	-4		XA-4022-3				
FV-111-2A2	-5		XA-4022-3				
FV-111-3A1	-6		XA-4022-3				
FV-112-1A2	-7		XA-4022-4				
FV-112-2A2	-8		XA-4022-4				
FV-112-3A1	-9		XA-4022-4				
	-10						

Init. Date/Time

70 (continued)

Activate test switch HS-100-A3 under TI-100-A3 and note that TS-100-A3 annunciates on XA-4006-3 per Sw. Tab. Record TI-100-A3 ____. Also note that TSS-100-A3-1 turns out safety channel No. 3 light on MB-13 (console). Record TI-100-A3 ____. ____ ________

Check that lights are on in circuits 18, 19, and 176. ____ ________

Simultaneously push two of the test switches and note in Table 4H-14 when the following actions occur:

Approved by [signature]

Init. Date/Time

TABLE 4H-14

Test Switches	Temperature Switches	Turns out Lights in Circuit	Temperature Ind. Readings
HS-100-A1 HS-100-A2	TSS-100-A1-2 TSS-100-A2-2	176	________
HS-100-A1 HS-100-A2	TSS-100-A1-1 TSS-100-A2-1	18 and 19	________
HS-100-A1 HS-100-A3	TSS-100-A1-2 TSS-100-A3-2	176	________
HS-100-A1 HS-100-A3	TSS-100-A1-1 TSS-100-A3-1	18 and 19	________
HS-100-A2 HS-100-A3	TSS-100-A2-2 TSS-100-A3-2	176	________
HS-100-A2 HS-100-A3	TSS-100-A2-1 TSS-100-A3-1	18 and 19	________

____ ______

Unplug TS-100-1 at thermocouple patch panel, feed in a false signal and record temperature when XA-4006-3 alarms ________. ____ ______

71 With the coolant system at temperature, test the low radiator temperature interlocks as follows:

Actuate the test switch HS-202-A under TI-202-A and note that TS-202-A annunciates on XA-4003-3 per Sw. Tab. Record TI-202-A ____.

Actuate the test switch HS-202-B under TI-202-B and note that TS-202-B annunciates on XA-4003-3 per Sw. Tab. Record TI-202-B ____.

Actuate the test switch HS-202-C under TI-202-C and note that TS-202-C annunciates on XA-4003-3 per Sw. Tab. Record TI-202-C ____. ____ ______

Init. Date/Time

71 (continued)

Check that lights are on in circuits 11, 12, 140, and 141. ______ ________

Simultaneously push two of the test switches and note in Table 4H-15 when the following actions occur:

TABLE 4H-15

Test Switches	Temperature Switches	Turns out Lights in Circuits	Temperature Ind. Readings
HS-202-A HS-202-B	TSS-202-A1 TSS-202-B1	11 and 12	________
HS-202-A HS-202-B	TSS-202-A2 TSS-202-B2	140 and 141	________
HS-202-A HS-202-C	TSS-202-A1 TSS-202-C1	11 and 12	________
HS-202-A HS-202-C	TSS-202-A2 TSS-202-C2	140 and 141	________
HS-202-B HS-202-C	TSS-202-B1 TSS-202-C1	11 and 12	________
HS-202-B HS-202-C	TSS-202-B2 TSS-202-C2	140 and 141	________

______ ________

72 The Instrument Department has checked that the following are set per the Sw. Tab. and annunciation occurs as indicated;

Switch	Ann. At.	Initial
FS-201-A	XA-5005-5	______
FSS-201-A	xx	______
XpS-201-A	XA-4005-6	______
FS-201-B	XA-4005-5	______

Approved by [signature]

Init. Date/Time

72 (continued)

Switch	Ann. At.	Initial
FSS-201-B	xx	______
SS-CP-G1	XA-4002-4	______
SS-CP-G2	XA-4002-4	______
SSS-CP-G1	xx	______
SSS-CP-G2	xx	______

Return all circuitry to normal. ____ ______

73 With the coolant salt circulating, activate the calibrate buttons in the following combinations and note that the lights in the circuits listed go out. Clear circuits between each test.

Calibrate Button		ECC	Initial
FSS-201-A,	FSS-201-B	11, 12	______
FSS-201-A,	SSS-CP-G1	11, 12	______
FSS-201-A,	SSS-CP-G2	11, 12, 147	______
FSS-201-B,	SSS-CP-G1	11, 12, 147	______
FSS-201-B	SSS-CP-G2	11, 12	______
SSS-CP-G2		150	______

Return system to normal. ____ ______

Disconnect the CP speed element input from SIT-CP-G and connect it to an oscilloscope. If the CP is rotating in the proper direction, the pulses will appear in the following order: long, medium, short.

Reconnect the input to SIT-CP-G. ____ ______

74 The following requires permission of the Operations Chief ________________.

With coolant salt circulating, raise both the radiator doors a small amount. Actuate HS-201-A and HS-201-B simultaneously. Note that doors drop ____. Return conditions to normal. Raise doors,

	Init.	Date/Time
74 (continued) actuate HS-201-A and HS-201-B simultaneously and note that doors drop ____. Return system to normal.	____	____
75 With no salt in system, have the instrument department set ZS-AD2-A1 and A2 per Sw. Tab. Note that ZI-AD2-A1 (green light) is on ____. Open damper and note that ZI-AD2-A2 (red light) comes on ____. and ZI-AD2-A1 (green light) goes out ____. Close damper and note that ZI-AD2-A2 (red light) goes out and ZI-AD2-A1 (green light) comes on ____. Open by-pass damper fully and adjust $\Delta P_{sp} = 0$. Note that sixth light in ECC 150 is on ____, bottom light in ECC 151 is out ____, and tenth light in ECC 139 is on ____. Increase $\Delta P_{sp} > 0$ and note that there is no change in ECC 150 ____. Increase $\Delta P_{sp} = 100\%$ and note that fourth light in ECC 153 goes out. ____.	____	____
76 SAMPLER		
76.1 Close HV-509-A ____ and PV-509-B ____. Open HV-672 and slowly open PCV-672-A (area 3A purge) and lower the pressure until PS-509-D alarms on XA-4035-3 and XA-4008-2 per switch tabulation. Record PI-509-C ____. Clear XA-4008-2 ____. Also note that PS-683-A alarms on XA-4036-6 and XA-4008-2 per switch tabulation. Record PI-509-C ____. Clear XA-4008-2. Slowly open PV-509-B until PS-509-A alarms on XA-4035-1 and XA-4008-2 per switch tabulation. Record PV-409-B ____. Close HV-672 ____, PCV-672-A ____, and PV-409-B ____. Open HV-509-A ____. Reset PV-509-B to 40 psig ____ and clear alarms.	____	____

Step		Init.	Date/Time
76.2	Check that the permissive lights in the main control room and at the sampler enricher panel are actuated by the permissive switch on MB-8. Leave on. Check that sampler light works.	____	______
76.3	Close capsule access door (HS-651), removal valve (HS-RV), operational valve (HS-OV), and HCV-678. Maintenance valve should be open and cable drive withdrawn. Buffer pressure should be applied to RV, OV, MV and AD.	____	______
76.4	Note that removal valve motor will not operate but that operational valve will operate.	____	______
76.5	Close operational valve. Note that maintenance valve will close. Leave closed. Note that access port will open. Close door. Note that there is a 15 second time delay on HSV-652.	____	______
76.6	Insert capsule rod into sampler access tube and open HCV-666. Note that removal valve can be opened.	____	______
76.7	With removal valve open, note that access port operational valve, and maintenance valve will not open.	____	______
76.8	Close removal valve and note that access port will open. Leave open.	____	______
76.9	Check that removal valve, operational valve, and maintenance valve will not open.	____	______
76.10	Close access port and note that operational and maintenance valves will open. Leave both valves open.	____	______
76.11	Check that removal valve, access port and HCV-678 will not open. Cable drive motor will operate. Withdraw cable.	____	______

	Init.	Date/Time
76.12 Close maintenance valve and note that cable will not operate but HCV-678 will open. Open maintenance valve. HCV-678 should close.	_____	_____
76.13 Close operational valve and note that cable will not operate but HCV-678 will open. Leave open.	_____	_____
76.14 Open HCV-675, HSV-660, and HSV-659 and access door. Activate RS-675-A and RS-675-B with a source and note that HCV-678, HCV-679, HSV-660, HSV-569, and access door close and XA-4037-2 and XA-4008-2 annunciate.	_____	_____
76.15 Remove source and note that none of the valves reopened and access door remains closed.	_____	_____
76.16 Open HCV-678 and note that operational valve will not open.	_____	_____
76.17 Close maintenance valve and note that it will not open.	_____	_____
76.18 Close HCV-678 and open operational valve and maintenance valve.	_____	_____
76.19 Insert cable 4" and note that neither the operational valve nor the maintenance valve will close.	_____	_____
76.20 Insert cable and note that drive automatically stops and green light comes on.	_____	_____
76.21 Remove cable and note that it automatically stops and red light comes on.	_____	_____
76.22 Close operational valve, open HV-657 and pressurize Area 1C until XA-4037-4 alarms.	_____	_____
76.23 Open HCV-678 to relieve pressure.	_____	_____

76.24 Operate the following and note that indicator lights are functioning properly:

HS-RV __________ HCV-679 __________

HS-OV __________ HSV-678 __________

Approved by ________________

Init. Date/Time

76.24 (continued)

HS-MV ________ HCV-677 ________

HCV-666 ________ HCV-667 ________

HCV-675 ________ HCV-678-2 ________ ______ ______

76.25 With manipulator cover on, pressurize area 3A until PS-AR-3A alarms on XA-4037-1 and XA-4008-2 per switch tabulation. Record PR-AR-3A. ______ ______ ______

76.26 With access door closed, pressurize area 1C until PS-1C-3 alarms on XA-4037-1 and XA-4008-2 per switch tabulation. Record PR-1C-E ______. ______ ______

NOTE: Check with Operations Chief before proceeding.

76.27 Close HV-542 in area 3B, open HSV-678-A, HSV-678-B1, HCV-667-A, and ESV-542-A. Pressurize area 1C and note that PSS-542-B and PSS-542-C both operate to close ESV-542-A. Record PR-1C-E ______. ______ ______

NOTE: Check with Operations Chief before proceeding.

76.28 Disconnect line 650 at FE-650-C and slowly back pressurize line 650 until PS-650-C alarms on XA-4035-2 and PS-674-A alarms on XA-4035-4 per switch tabulation. Use a temporary gage and record pressures when above actions occur.

______ ______ ______ ______

76.29 Allow leak detector header No. 2 to decrease in pressure until PS-655-B alarms on XA-4035-6 and XA-4008-2 per switch tabulation. Record PI-644-B ______. ______ ______

76.30 Allow leak detector header No. 1 to decrease in pressure until PS-664-B alarms on XA-4035-5 and XA-4008-2 per switch tabulation. Record PI-664-B ______. ______ ______

76.31 Make a temporary connection to HSV-659-B in area 4A and pressurize area 2B slowly until

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76.31 (continued)

PS-659-A alarms on XA-4037-3 and XA-4008-2 per switch tabulation. Use a temporary gage and record pressure when above action occurs ____. _____ ________

77 As various systems are put into service, check that the following position switches actuate the corresponding position indicators per switch tabulation:

LS-FP-A1	_____	ZS-841-A	_____
LS-FP-A2	_____	ZS-844-A	_____
LS-FST	_____	ZS-846-A	_____
ZS-MB1-A1	_____	ZS-847-A1	_____
ZS-MB1-A2	_____	ZS-847-A2	_____
ZS-MB2-A1	_____	XSS-930-A1	_____
ZS-MB2-A2	_____	XSS-930-A2	_____
ZS-MB3-A1	_____	ZS-930-A1	_____
ZS-MB3-A2	_____	ZS-930-A2	_____
ZS-MB4-A1	_____	ZS-930-A3	_____
ZS-MB4-A2	_____	ZS-930-A4	_____
LS-OT1-A2	_____	ZS-930-A5	_____
LS-OT1-A3	_____	ZS-930-A6	_____
LS-OT2-A2	_____	ZS-930-A7	_____
LS-OT2-A3	_____	ZS-930-A3	_____
LS-PRS-A	_____	XSS-930-B1	_____
LS-PRS-C1	_____	XSS-930-B2	_____
LS-PRS-C2	_____	ZS-930-B1	_____
ZS-511-A	_____	ZS-930-B2	_____
LS-524-C	_____	ZS-930-B3	_____
LS-526-A	_____	ZS-930-B4	_____
ZS-527-A	_____	ZS-930-B5	_____
ZS-533-A	_____	ZS-930-B6	_____
ZS-536-A	_____	ZS-930-B7	_____

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77 (continued)

ZS-547-A ____	ZS-930-B8 ____
ZS-557-C ____	XSS-935-A1 ____
ZS-565-A ____	XSS-935-A2 ____
ZS-572-A ____	ZS-935-A1 ____
ZS-573-A ____	ZS-935-A2 ____
ZS-574-A ____	ZS-935-A3 ____
ZS-575-A ____	ZS-935-A4 ____
ZS-576-A ____	ZS-935-A5 ____
ZS-577-A ____	ZS-935-A6 ____
ZS-837-A1 ____	ZS-935-A7 ____
	ZS-935-A8 ____

____ ____

78 SAFETY INSTRUMENTATION

Check all safety instrumentation per operating procedure 8D. ____ ____

79 TEMPERATURE RECORDER ALARMS

Check that the instrument department has set the following switches per switch tabulation:

TS-3100 ____
TS-3300 ____
TS-3400-A1 ____
TS-3400-A2 ____
TS-3500-A1 ____
TS-3500-A2 ____ ____ ____

80 STACK MONITORS

Check that the stack monitoring group has set the following switches per switch tabulation:

RS-SI-A1 ____
RS-SI-A2 ____ (spare)

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80 (continued)

RS-SI-B1 _____
RS-SI-B2 _____ (spare)
RS-SI-C1 _____
RS-SI-C2 _____ (spare) _____ _____

81 HELIUM DRYERS

Set the following switches at the helium treatment station per switch tabulation:

TIC-DR1-1 _____
TS-DR1-2 _____
TIC-DR2-1 _____
TS-DR2-2 _____ _____ _____

82 FUEL STORAGE TANK

Have an instrument mechanic check the settings on the following switches per switch tabulation:

PSS-608-B1 _____ PS-608-C1 _____
PSS-608-B2 _____ PS-608-C2 _____ _____ _____

83 COMPONENT COOLING SYSTEM

Have an instrument mechanic check the settings on the following switches per switch tabulation:

PS-791-A _____ PS-795-A _____ _____ _____

84 THERMAL SHIELD COOLING WATER

Close HV-855-A, open HV-855-B and slowly apply pressure through HV-855-B and note that PS-855 closes FSV-844 per switch tabulation ____. Record PI-855 ____. Restore valves to proper positions. _____ _____

85 DRAIN TANK CONDENSER COOLING WATER

Slowly close HV-810 and note that FS-810-A alarms on XA-4026-1 per switch tabulation _____. Record FI-810-A ____. Slowly close HV-812 and note that FS-812-A alarms on XA-4026-2 per switch tabulation ____. Record FI-812-A ____. Set flows per building

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85	(continued) log. ____.	____	____
86	SUMMATION OF DRAIN TANK WEIGHTS Raise tare settings on FD-1 and/or FD-2 and note that WqSS-1002 turns lights out in ECC-134 per switch tabulation ____. Record WqI-1002 located behind TB-4 ____. Reset tares ____.	____	____
87	SCANNER NITROGEN PURGE Slowly close PCV-5000-A at scanner panel and note that PS-5000-A alarms per switch tabulation ____. Record PI-5000-A ____. Readjust PCV-5000-A ____.	____	____
88	NORMAL (SCANNER) NITROGEN SUPPLY SYSTEM Close off both nitrogen bank header valves and note that PS-9012-1A alarms on XA-4018-3 per switch tabulation ____ and that PS-9014 alarms on ____ per switch tabulation ____. Put one bank back in service and clear alarm ____. Slowly close PCV-9012-1A and note that PS-9012-1C alarms on XA-4018-3 per switch tabulation ____. Slowly open PCV-9012-1A and note that alarm clears and that PS-9012-1B alarms on XA-4018-3 per switch tabulation ____. Readjust PCV-9012-1A per building log ____. Alarm should clear ____.	____	____
89	Check that the following Foxboro recorders are inking and the settings are per switch tabulation:		

Instru. No.	Location	Setting	Record Set Point	
PRC-528	MB-6	Auto	____ psig	____
XpR-201	MB-6	xxxx	xxxx	____
FR-201	MB-6	xxxx	xxxx	____
WR-CDT	MB-6	Auto	____ lb. below salt wt.	____
TR-100	MB-7	xxxx	xxxx	____

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89 (continued)

Instru. No.	Location	Setting	Record Set Point			
PRC-522	MB-8	Auto	____ psig	____		
WR-FD-2	MB-8	Auto	____ lb below salt wt.	____		
WR-FFT	MB-9	Auto	____ lb below salt wt.	____		
WR-FD1	MB-10	Auto	____ lb below salt wt.	____		
WR-FST	MB-11	Auto	____ lb below salt wt.	____		
PR-669-B	S-E	xxxx	xxxx	____		
PR-3A	S-E	xxxx	xxxx	____		
PR-655-C	S-E	xxxx	xxxx	____	____	____

90 Check that the following Brown recorders are inking, the instrument power, chart drive and light switches are on, and the battery is good. The setpoint should be adjusted by the instrument department per switch tabulation:

Instru. No.	Location	Record Set Point			
RR-8100	MB-7	xxxx	____		
RR-8200	MB-12	xxxx	____		
TRA-3100	MB-12	____ and ____ °F	____		
TRA-3500	AB-2	____ and ____ °F	____		
TR-3600	AB-3	xxxx	____		
A-Be-R-1010	VH	xxxx	____		
LR-CP-A	TB-8	xxxx	____		
TRA-3300	ACP	____ and ____ °F	____		
TRA-3400	ACP	____ and ____ °F	____		
TR-CTSS	HB	____ °F	____	____	____

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91 Check that the following Foxboro indicators are in service and set per switch tabulation:

Instru. No.	Location	Setting	Record Set Point		
PdIC-960-A	MB-3	Auto	_____	psig	_____
PIC-510-A	MB-4	Auto	_____	psig	_____
FIC-512-A	MB-5	Per S.S.	_____	l/m	_____
PIC-511-C	MB-5	Auto	_____	psig	_____
LIC-807-A	MB-8	Auto	_____	%	_____
FIC-516-B	MB-9	Per S.S.	_____	l/m	_____
PIC-517	MB-9	Auto	_____	psig	_____
PIC-513-A	MB-10	Auto	_____	psig	_____
LIC-806-A	MB-10	Auto	_____	%	_____

_____ _______

92 Check that all Rochester units on AB 3 and 4 are in the operate condition. List those which are not and have S.S. approve these.

_____ _____ _____ _____

_____ _____ _____ _____

S.S. approval _______ _____ _______

93 Check that the power switch is on and the reset selector switch on manual reset on all ten Electro System power supply in ACR. _____ _______

94 Check that there are no jumper pins in the jumper board other than those approved in the run or shift instructions. _____ _______

95 Check that all green lights on the jumper board are on except those approved by the S.S.

Circuit	S.S. Approval	Date
_____	_____________	____
_____	_____________	____
_____	_____________	____
_____	_____________	____

Approved by [signature]

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	Init.	Date/Time

95 (continued)

Circuit	S.S. Approval	Date
______	______	______
______	______	______
______	______	______

96 Check that the scanner is in operation and will alarm. ______ ______

97 Check that the logger is in operation and will alarm. ______ ______

98 CONTROL ROD DRIVE TEMPERATURES

With the fuel system at temperature but empty, close HCV-915-A1 (HIC-915-A) and record the length of time it takes for the control rod drive temperatures to rise to the alarm point:

Rod	Annunciator	Time to Alarm	Time to Alarm Should be Less Than
1	XA-4041-1	______	______ min.
2	XA-4041-2	______	______ min.
3	XA-4041-3	______	______ min.

Each also annunciates on XA-4013-1 ____.

Reset HIC-915-A to its previous value ____. ______ ______

99 VAPOR CONDENSING SYSTEM LEVEL

Vapor condensing tank VT1 is equipped with a four-point float-operated level switch. The water level under normal conditions will be midway between the two center switches which are 4 in. apart, and midway between the other pair of switches which are 12 in. apart. Thus, the switches will give alarms locally and on XA-4014-5 if the water level goes 2 in. above, 6 in. above, 2 in. below, or 6 in. below normal. The tank also has a 1/8 in. NPS level dip tube for determining the water level in the tank, but this system will not normally be used.

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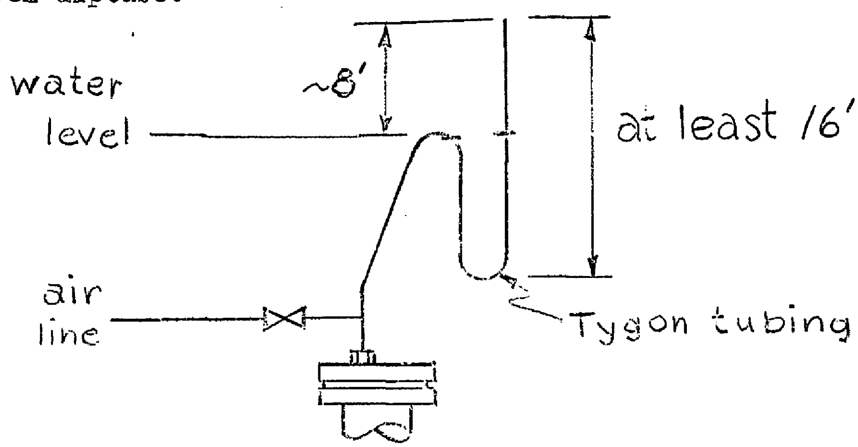
99 (continued)

Water can be added to or removed from the tank by removing the 6 in. blank flange next to the instrument installation. The water will have to be added with a hose and removed by siphoning or by means of a self-priming pump.

Remove the 9/16 in. Autoclave plug from the level diptube in the 6 in. instrument installation flange and connect a temporary airline equipped with a U-tube manometer to the level diptube:



With the water in VTl at the normal level of 14 ft. 11 in., add water to the tank and record the levels when the upper level switches actuate the alarms. Lower the level in the tank and record the levels when the upper alarms clear, and the lower alarms are actuated. Refill tank to normal level and record levels when lower alarms clear.

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						Init.	Date/Time
Adding or Removing Water	Switch	Alarm	Clear	Bubbler Level			
Adding	LS VT1-B3 Lower upper	____		___ ft	___ in.		
Adding	LS VT1-B4 Upper upper	____		___	___		
Removing	LS VT1-B4 Upper upper		____	___	___		
Removing	LS VT1-B3 Lower upper		____	___	___		
Removing	LS VT1-B2 Upper lower	____		___	___		
Removing	LS VT1-B1 Lower lower	____		___	___		
Adding	LS VT1-B1 Lower lower		____	___	___		
Adding	LS VT1-B2 Upper lower		____	___	___	____	____

Remove temporary equipment, replace level diptube plug, replace and leak check 6 in. blank flange. ____ ____

100 Radiator Door Scram Time

With coolant system empty, check the scram time of the radiator doors as follows:

100.1 Raise inlet door to upper limit. Simultaneously start a stop watch and turn switch S-2 (load scram) to scram position.

Stop the stop watch when lower limit lights come on. Record time __________.

100.2 Repeat with outlet door. Record time ______.

Leave doors closed. ____ ____

ALL ITEMS ON THE INSTRUMENTATION STARTUP CHECK LIST ARE COMPLETE. Shift Supervisor __________ Date __________

4I Freeze Valves

The following check list covers the complete startup of each freeze valve and adjusting each so that freezing and thawing can be accomplished using the freeze valve switch on the main control board. This does not need to be done on each valve on each startup. If a number of transfers or additions are to be made, it may be desirable to set up FV-107 through 112 in this manner. However, for a single transfer it may be easier to go directly from deep freeze to the thaw condition using heaters and manual control of the air. When transfers are complete, the valves will be deep frozen.

During a normal startup, FV-104 through 106 will normally be either deep frozen or thawed, and no extensive adjustments are required. The thawing of these is described in Section 5I.

On each startup, FV-103, 204 and 206 must be set up so that they will thaw when required. These are also covered in Section 5I.

The setting of the temperature switches, and freeze valve HIC's and TIC's are covered in Section 4H.

The following is a detailed description of the steps necessary in setting up a freeze valve for automatic operation. Table 4I-1 and 2 should be used for recording the data obtained.

1 DETAILED PROCEDURE

1.1 Obtain shift supervisor's permission to proceed. (Column 1.1)

1.2 Check that the associated lines are heated. Thaw or check that the freeze valve is in the thaw position (Check that interlocks are clear). (Column 1.2)

1.3 Adjust plug control heaters to give the temperature listed. Record final temperatures. (Column 1.3)

1.4 Check that pressure on both sides of FV is balanced. Switch freeze valve to freeze position and set blast air HIC to value given. (Column 1.4)

1.5 When both shoulder thermocouples reach ~ $750^{\circ}F$, the alarm will clear and the cooling air will be reduced from blast to hold. Set TIC's on automatic. Adjust hold air HIC or set TIC to

1.5 (continued)
give the shoulder temperatures listed. Record final HIC setting and shoulder temperatures. (Column 1.5)

1.6 When the freeze valve is thawed, note time required for valve to thaw. Accurate indication of thaw time can only be obtained by salt flow as indicated by rapid change in FV temperatures. Less accurate indications can be obtained from the thermocouples without salt flow. Record any results obtained (Column 1.6).

ALL ITEMS ON THE FREEZE VALVES STARTUP CHECK LIST ARE COMPLETE.

Shift Supervisor ________________ Date ____________

Approved by [signature]

TABLE 4I-1

STARTUP OF FREEZE VALVES 103, 104, 105, 106, 204, and 206

Step No.	DESCRIPTION OF DATA			FV-103	FV-104	FV-105	FV-106	FV-204	FV-206
1.1	Permission to Start (SS Initials)								
1.2	Line Hot and FV in Thaw Position								
1.3	FV Shoulder Heaters	Reactor Side		Note 1	H-FV-104-1	H-FV-105-1	H-FV-106-1	H-FV-204-1	H-FV-206-1
		Drain Tank Side		Note 1	H-FV-104-1A	H-FV-105-1A	H-FV-106-1A	H-FV-204-1A	H-FV-206-1A
	Adjust to Average Temp.	Drain Tk Side TE-A4		1200°F	1200°F	1200°F	1200°F	1200°F	1200°F
		Reactor Side TE-B4		1200°F	1200°F	1200°F	1200°F	1200°F	1200°F
	Final Temp. with Air Off	TE-A4							
		TE-B4							
		TE-1							
		TE-2							
		TE-3							
1.4	Blast Air HIC	HIC No.		919 A-1	908 A-1	909 A-1	910 A-1	906 A-1	907 A-1
		Setting		16	20	20	20	20	20
		Initial							
1.5	Hold Air Controller	Controller No.		TIC 919 A-2	HIC 908 A-2	TIC 909 A-2	TIC 910 A-2	TIC 906 A-2	TIC 907 A-2
		Shoulder Temps. Note 2	TE-1	910°F-992°F	800°F-850°F	800°F-850°F	800°F-850°F	850°F-950°F	850°F-950°F
			TE-3	700°F-764°F	800°F-850°F	800°F-850°F	800°F-850°F	850°F-950°F	850°F-950°F
		Controller Setting		960°F	Note 3	825°F	825°F	825°F	825°F
		Initial							
1.6	Thaw Time (sec) When Temp reaches 850°	TE-1							
		TE-2							
		TE-3							
		When salt							

Note 1:- FV-103 is heated by the reactor vessel heaters.

Note 2:- Record equilibrium values for TE-1 and TE-3.

Note 3:- Record setting necessary to hold shoulder temperatures listed.

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TABLE 4I-2

STARTUP OF FREEZE VALVES 107, 108, 109, 110, 111, and 112

Step No.	DESCRIPTION OF DATA		FV-107	FV-108	FV-109	FV-110	FV-111	FV-112
1.1	Permission to Start (SS Initials)							
1.2	Line Hot and FV in Thaw Position							
1.3	FV Shoulder Heater Controls Both Shoulders		H-FV-107-1	H-FV-108-1	H-FV-109-1	H-FV-110-1	H-FV-111-1	H-FV-112-1
	Adjust to Average Temperature TE-A4 and B4		1200°F	1200°F	1200°F	1200°F	1200°F	1200°F
	Final Temperature With Air Off	TE-A4						
		TE-B4						
		TE-1						
		TE-2						
		TE-3						
1.4	Blast Air HIC	HIC No.	911 A-1	912 A-1	913 A-1	969 A-1	929 A-1	924 A-1
		Setting	0	0	0	0	0	0
		Initial						
1.5	Hold Air Controller	HIC No.	911 A-2	912 A-2	913 A-2	969 A-2	929 A-2	924 A-2
		Shoulder Temps* TE-1	800°F-850°F	800°F-850°F	800°F-850°F	800°F-850°F	800°F-850°F	800°F-850°F
		Shoulder Temps* TE-3	800°F-850°F	800°F-850°F	800°F-850°F	800°F-850°F	800°F-850°F	800°F-850°F
		Controller** Setting						
		Initial						
1.6	Thaw Time (Sec) When Temperature Reaches 850°F	TE-1						
		TE-2						
		TE-3						
		When Salt Flows						

*Record equilibrium values for TE-1 and TE-3.

**Record setting necessary to hold shoulder temperatures listed.

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