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LA-4037-SOP, Rev.

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DATE 3/9/73

Operating Procedures for the Pajarito Site Critical Assembly Facility

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UNITED STATES
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Printed in the United States of America. Available from
National Technical Information Service
U. S. Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22151
Price: Printed Copy $3.00; Microfiche $0.95

LA-4037-SOP, Rev.
UC-46
ISSUED: January 1973

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OPERATING PROCEDURES FOR THE PAJARITO SITE CRITICAL ASSEMBLY FACILITY

by

J. D. Orndoff and H. C. Paxton

I. BACKGROUND FOR PROCEDURES

A. *THE LASL FACILITY*

These Operating Procedures apply to any criticality experiment performed at Pajarito Site, in the facility described by LA-4273, *SAFETY ANALYSIS FOR THE LOS ALAMOS CRITICAL-ASSEMBLY FACILITY*, November 1969. The experiments are conducted in remote-control laboratories, known as Kivas, which are located at some distance from the main laboratory building that houses individual control rooms for each Kiva. All remote controls and indicators, including closed-circuit television receivers, are mounted in the control rooms.

Each Kiva is surrounded by a security fence beyond which is an additional posted area to keep personnel at a safe distance during remote operation. At other times, access within the fence is through a key-actuated gate. The same key actuates a three-position selector switch in the control room, which establishes safety plans appropriate to activities in the Kiva, and controls power to assemblies.

B. *SCOPE OF PROCEDURES*

Pajarito Site operations are conducted in accordance with the American Nuclear Society standard, ANS-STD.1-1967, "A Code of Good Practices for the Performance of Critical Experiments." The rather general requirements of this standard are supplemented by the document "Operating Limits for the Los Alamos Critical-Assembly Facility," revised May 27, 1971,* and are implemented by these Operating Procedures. The procedures, as formulated, are not intended to cover all conceivable aspects of an inherently flexible program, and Experimental Plans (Sec. IIC) extend their scope for special operations. Further, the limitations of safety documentation are recognized. There is no intent of substituting for the principle that safety depends upon people, and that rules, at best, provide guidance for "one skilled in the art."

C. *COGNIZANT SAFETY COMMITTEES*

The LASL Reactor Safety Committee (RSC) is responsible for the general surveillance of Pajarito Site activities. This committee, which represents the Laboratory Director, is concerned with policy as well as technical execution. It reviews modifications of these Operating Procedures and approves policy changes and proposed changes of Operating Limits.

The N-2 Nuclear Safety Committee, appointed by the Group Leader, serves in a local advisory capacity with regard to any matter that concerns the nuclear safety of an operation. It functions independently of any formal AEC requirement. In addition to conducting a technical review of each Experimental Plan, this committee, on its own initiative, scrutinizes safety practices and investigates safety suggestions and complaints from any source.

II. SPECIFIC PROCEDURES

A. *SAFETY PLANS FOR OPERATIONS IN KIVAS*

The selector switch that governs the three Safety Plans for Kiva activities is actuated by the "Control Key." Only one such key shall be in use for each Kiva, and shall not be capable of actuating the selector switch for another Kiva. Any duplicate Control Key shall be in the Group Leader's custody. The meanings of the safety plans are as follows.

1. *Plan 1.* This plan is intended for periods when the Kiva is not in use or when there is no

*Operating Limits were originally intended to be the equivalent of Technical Specifications for licensed facilities safety restriction on access to the Kiva. Conditions established by setting the selector switch on "Plan 1" are:

a. A green panel light, illuminating a "1" under "Plan," is visible in the control room.

b. The red warning blinker and rotating beacon lights (located at the gate and in the Kiva area) are off.

c. The gate is open. (If closed on Plan 2 or 3, the gate will open automatically on change to Plan 1.)

d. There is no power on any machine. The security Inspectors are free to lock the Kiva doors according to their regular schedule if it is obvious that no group is working in the Kiva.

2. *Plan 2.* This plan controls access to a Kiva during preparation for remote operation, after such an operation, or during "local operation" of a machine. Conditions established by setting the selector switch on "Plan 2" are:

a. An amber panel light, illuminating a "2" under "Plan," is visible in the control room.

b. The red warning blinker lights at the gate are on. The rotating beacon lights (located at the gate and in the Kiva area) are off.

c. The gate may be closed by a manual switch near the gate entrance. It may be opened at the entrance by the Control Key.

d. No power can be applied to a machine from the control room. Power can be applied to those machines equipped with "Local Controls" by use of the Control Key in the lock switch on the "Local Controls" panel located in the Kiva; only the local controls are then operative.

3. *Plan 3.* This plan prevents access into a Kiva area during remote operation. Conditions established by setting the selector switch on "Plan 3" are:

a. The Control Key is retained in the selector switch.

b. A red panel light, illuminating a "3" under "Plan," is visible in the control room.

c. The warning horns at the Kiva are turned on for 5 to 10 seconds.

d. The red blinker lights at the gate and the rotating beacon lights at the gate and in the Kiva area are on.

e. The gate is closed; it cannot be opened at the gate entrance because the Control Key cannot be removed from the Plan Selector Switch while Plan 3 is in effect.

f. Power can be applied to the desired machine through a "Machine Selector" switch. This permits the machine to be operated remotely from the control room, but it cannot be operated from a local control board in the Kiva.

B. STORAGE OF ACTIVE MATERIALS

Usually each Kiva contains some active material which is not involved in the experiment at hand and is not installed in another machine. A lockable area is provided in each Kiva exclusively for storage of such material. Extraneous moderating materials, in particular, are excluded from this area. Shelf spacings with allowed limits of active material per cubicle are chosen to be consistent with the revised standard ANSI N16.1-1969, "Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors." For example, special metal clips conveniently limit the quantity of thin enriched uranium foil per storage cubicle. The main Pajarito Site vault is available for long-term storage of fissionable material.

C. ORGANIZATION REQUIREMENTS

1. Each new experiment involving active material shall be reviewed by the Group Leader of N-2. Unless this review establishes that the quantity of active material cannot be greater than three-fourths of a critical mass under foreseeable conditions, the experiment shall be covered by an Experimental Plan which shall be approved by the Chairman of the N-2 Nuclear Safety Committee, by the Group Leader of N-2, and by the N-Division Leader. An Experimental Plan that presents a unique, significant, safety question must also be approved by the Chairman of the RSC.

2. A copy of the appropriate Experimental Plan shall be available to the people performing the experiment, either in the control room or assembly area.

3. An Experimental Plan shall be valid for no more than two years after the date of issue unless reinstated.

4. Each operating crew that performs an experiment shall be appointed by the Group Leader, and shall consist of a crew chief, who is experienced in Pajarito Site methods of operation, and at least one other competent person. The chief shall be responsible

for all aspects of the crew's operation and shall regard personnel safety to be of paramount importance. If any crew member is dissatisfied with the safety of procedures, the operations shall be halted until all are convinced that the operations can be continued safely.

5. Entrance to a Kiva for any operation on an assembly of active material shall be made by at least two persons, one of whom is the crew chief or his designated alternate. If a person is required in the control room at the same time, there shall be a third crew member.

6. A departure from an Experimental Plan or these Operating Procedures, which presents no unique significant safety question, requires approval of the Group Leader. Other departures require approval of the Chairman of the RSC.

D. EQUIPMENT REQUIREMENTS

1. *Radiation and counting equipment* to be used with each Kiva assembly shall include:

a. At least two neutron pulse-counting systems, one with a signal audible in the Kiva. Scalers shall be available and operating in both the Kiva and the control room.

b. An ionization chamber with a linear amplifier (or an equivalent system) for automatically recording in the control room the neutron flux level in the Kiva.

c. At least two scram monitors for automatic disassembly of any remotely controlled machine at a preset neutron flux level.

d. Portable radiation survey meters shall be available:

(1) Multirange γ and α in each Kiva.

(2) Multirange γ, n, and α in the control room area.

2. *General Design of Assembly.* Each assembly shall be designed so that power failure results in a scram. Switches for assembly mechanisms and manual control shall be of the "dead-man" type. Since design specifications should depend upon the reactivity involved, it is convenient to classify assemblies into three types according to the intended scope of operation.

a. Class I—For Limited Subcritical Operation. An assembly of this class shall have:

(1) At least one major disassembly mechanism which can be triggered (scrammed) both manually and automatically by the radiation monitors. The disassembly process shall produce a monotonically decreasing reactivity at a rate which exceeds that of assembly, and shall result in a configuration with a multiplication less than 10 (see Appendix).

(2) An indicator in the control room to give the position of the major movable part that closes the assembly.

(3) An adjustable positive stop on the major assembly mechanism so that the multiplication may be measured as a function of closure distance.

b. Class II—For Normal Critical Operation. An assembly of this class shall have:

(1) At least two major disassembly devices (of which one may be a set of safety rods), both of which can be triggered automatically by the radiation monitors, and manually. The disassembly process shall produce a monotonically decreasing reactivity at a rate which exceeds that of assembly, and shall result in a configuration with a multiplication less than 10. At least one the devices shall reduce the reactivity 100 cents or more in one second.

(2) A limited rate of assembly of the major parts such that reactivity cannot be added more rapidly than 5 cents per second when the multiplication is greater than 100. In some cases, the assembly rate at lower multiplication values should be limited.

(3) An indicator in the control room to give the position of the major movable part that completes the assembly process.

(4) At least one vernier control that changes the reactivity in a continuous manner. The overall value should be 50 cents or more. The rate of travel shall be limited so that the reactivity cannot increase more than 5 cents per second. The position of control rods shall be displayed in the control room at all times during operation.

c. Class III—For Unusual Operation. This group will include assemblies intended for special purposes, such as prompt-burst devices or neutronically coupled assemblies.

3. *System of Interlocks for Reset on Plan 3.* There shall be interlocks in the scram circuit such that the following conditions must be met before the machine can be reset for operation.

a. Conditions Established at the Kiva Area.

(1) Air pressure at the machine must be adequate if air cylinders are used for operation of the safety rods or disassembly mechanism. Adjustment in the Kiva is required if the air pressure should be insufficient.

(2) A scram circuit common to all machines, with a manual actuating button located near the door of each Kiva, must be reset at the Kiva if tripped.

(3) The gate is closed.

b. Conditions Established at the Control Room.

(1) The plan selector switch must be on Plan 3 before the machine selector switch is effective.

(2) Control power is supplied to the desired control panel by means of the machine selector switch.

(3) The linear amplifier and recorder are on (an administrative requirement).

(4) Scram monitors are on and reset.

(5) The machine is disassembled to the position of minimum reactivity.

(6) Vernier control, where provided, is in the position of minimum reactivity.

4. *Sequence of Plan 3 Operations.* Upon reset, additional interlocks or automatic features shall dictate the following sequence of operations.

a. Safety "rods," where provided, are moved to the position of maximum reactivity, as indicated by appropriate lights. Control signal for assembling the machine is then available.

b. The major parts must be assembled completely, as indicated by a red panel light actuated by a limit switch, before vernier control, where provided, is operable.

c. If the major disassembly mechanism or the safety rods move so as to open a limit switch, reactivity cannot be added by means of vernier control.

d. The major parts disassemble automatically whenever a scram button is pushed, or as the result of a signal from the scram monitors, or upon power failure.

5. *Plan 2 Conditions.* On Plan 2, all control switches in the control room shall be inactive.

6. *New Machines*

a. Plans for the design of new machines shall be discussed with the N-2 Nuclear Safety Committee before construction of the machine. More general discussions within the group are also encouraged.

b. Reliability of operation of each new system, including proper behavior of interlocks and scrams, shall be established by a series of tests under conditions such that the multiplication will not exceed 10.

E. OPERATING PROCEDURES

1. *Preparation for Operation*

a. Unless specified otherwise in the Experimental Plan, there shall be a neutron source within the assembly during both local and remote operations. In certain assemblies, the normal spontaneous-fission or α-n source may be adequate. Source strength and neutron counting equipment and techniques normally should be interrelated to give multiplication values within a statistical precision of 5%. The neutron source and counters shall be located such that the counters will see the neutrons born in the assembly in preference to the neutrons coming directly from the source.

b. During operation periods (Plan 2 or 3), entrance to the Kiva area shall be controlled by the crew chief. A crew member shall be in the control room at all times during Plan 3 operation. If the control room area is to be unattended on Plan 2, the Control Key shall remain in the possession of a crew member or a Pajarito Health Physics Surveyor, or shall be locked in the control-room safe. During nonoperating periods, the Control Key shall be locked in the safe.

c. The Kiva area shall be cleared of personnel prior to operation on Plan 2 or Plan 3. Tests shall verify proper performance of the safety monitor systems (at least two independent monitors shall function properly, although three are normally used) and of the manually actuated scrams. Since each monitor may be set on one of several trip levels, the crew chief is responsible for setting it to respond to the lowest level consistent with the intended operation.

2. *Local Operation (see Appendix)*

a. No assembly step shall be performed in the presence of personnel unless there is clear evidence that the resulting multiplication will not exceed 10.

b. Any hand assembly of an unmeasured configuration shall be monitored by means of an audible counter system responding to neutrons from the assembly. Each increase of reactivity shall be limited such that the reciprocal multiplication is not reduced by more than a factor of two.

c. Occasionally it may be necessary for personnel to be in the Kiva while on Plan 3 in order to observe or to adjust the motion of a part such as a control rod. Such an operation should be performed only by personnel thoroughly familiar with the particular assembly. There shall be definite precautions to ensure that the multiplication cannot exceed 10, for example, the removal of active material or the insertion of a mechanical stop between major components.

3. *Remote Operation (see Appendix)*

a. General

(1) All assembly procedures shall be monitored by two or more counters which are responsive to the reactivity of the system.

(2) A plot of reciprocal multiplication (or reciprocal counting rate) vs the parameter controling reactivity (such as the amount of active material) shall serve as a guide to the incremental increases of reactivity. Each increment of reactivity increase shall be limited such that reciprocal multiplication is reduced by no more than a factor of two, until vernier control (if any) can be used to attain delayed criticality.

(3) During the initial closure of an assembly, or after any change in stacking which cannot be clearly demonstrated to be less than +50 cents net, a stepwise procedure shall be used. At each step of closure there shall be a wait of at least 30 seconds to permit observation of the buildup of delayed neutrons as indicated by the counters. The size of each step shall not exceed one-half the increment to delayed criticality. In any questionable case, the reciprocal counting rate should be plotted against position.

b. Class I Assemblies. The multiplication shall not exceed 200, but the nominal multiplication limit should be ~100.

c. Class II Assemblies. The reactivity limit should correspond normally to a positive period of ~10 seconds. If reliability has been demonstrated at longer periods, the positive period limit may be decreased to no less than 5 seconds by consent of the Group Leader. For a system progressing above delayed criticality, the Keepin-Wimett relationship between measured positive period and reactivity in cents is our best guide toward approaching shorter periods, see, for example, Phys. Rev. *107* 1044 (1957).

d. Class III Assemblies. Special operations (such as the production of prompt bursts) and their limits shall be detailed in the Experimental Plan.

F. RADIOLOGICAL HEALTH PROCEDURES

Persons working with radioactive material shall follow the radiation safety policies in Chapter 1 of LA-4400, "Los Alamos Handbook of Radiation Monitoring," 1970. These policies are implemented for Pajarito Site by the "STANDARD OPERATING PROCEDURES, General and Emergency, Pajarito Site, TA-18." This document is in possession of Health Physics Surveyors assigned to Pajarito Site.

Following are rules of particular significance to N-2 operations.

1. Health Physics Surveyors, stationed at Pajarito Site, are available to give advice regarding radiation levels and tolerance doses. Their presence with an operating crew should be requested whenever there is significant risk of exposure. They should be notified of any change in crew schedule or of any unscheduled Kiva entry when fissile material may be handled.

2. All personnel entering the Kiva areas or handling sources or any sizable amounts of active material shall wear standard film badges.

3. Neutron sources shall be swipe tested for leakage immediately before removal from or return to the source storage room. A Health Physics Surveyor shall be asked to investigate any evidence of leakage.

4. Before each day's operation with Pu or ^{233}U, enclosing surfaces shall be swipe tested, and any evidence of leakage shall immediately be brought to the attention of a Health Physics Surveyor.

5. In the event of a radiation accident, the "Pajarito Plan for Radiation Emergency" shall be followed.