Attachment 2 to
AECM-85/0354

NUCLEAR QUALIFICATION TEST PLAN
For The

GENERIC EQUIPMENT QUALIFICATION
FOR
GRAND GULF I and CLINTON I
NUCLEAR POWER STATIONS

50-416
463

Prepared for:

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TEST PLAN

1.0 GENERAL

This test plan describes the procedures and tests which will be performed on three (3) Class 1E safety-related components to demonstrate that they would remain functional for their respective service lives under the worst expected conditions in nuclear service. The intent of this test plan is to define tests which would qualify these three Class 1E safety-related components for application in the Grand Gulf 1 and Clinton 1 nuclear power stations.

This test plan is written on the basis that the components will be considered Class 1E safety-related components. The general requirements for testing Class 1E components are defined in IEEE Std. 323-1974 (Reference 2.1 below). Additional requirements, especially post-seismic environmental testing is suggested by NUREG 0588 (Reference 2.2 below). These documents have been widely circulated and accepted as defining the conditions, projecting for nuclear components. This test plan is written to meet the requirements of these documents. In addition, the requirements for Class 1E component testing are defined in greater detail with regard to seismic testing in NRC Regulatory Guide 1.100 and IEEE Std. 344-1975 (Reference 2.3 and 2.4). The seismic tests described in this test plan conform to the requirements of these documents.

This test plan describes a sequence of tests which when performed will demonstrate that the test items qualify for Class 1E safety-related nuclear use according to the method of qualification by type testing, Section 5.1, Reference 2.1. This is described as being the "preferred method". It will be demonstrated before and after aging of the test items and before, during, and after seismic and environmental testing that the Class 1E function of the test items is not impaired.

2.0 REFERENCES

2.1 IEEE 323-1974, "Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations," Nuclear Power Engineering Committee of the IEEE Power Engineering Society, 1974.

2.2 NUREG 0588, "Interim Staff Position on Environmental Qualification of Safety-Related Electrical Equipment," A.J. Szukiewica, 1980.

2.3 U.S. Nuclear Regulatory Commission, Regulatory Gudie 1.100, "Seismic Qualification of Electrical Equipment for Nuclear Power Plants," Revision 1, August 1977.

2.4 IEEE 344-1975, "Recommended Practices for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations," Nuclear Power Engineering Committee of the IEEE Power Engineering Society, 1975.

2.5 NUTECH Generic Equipment Qualification Test Specification for Grand Gulf 1 and Clinton 1 Nuclear Power Stations, Report Nos. MPL-04-200 and IPC-01-200, June 1, 1982, Revision 2.

2.6 SwRI Nuclear Quality Assurance Program Manual, Revision 2, November 1980.

2.7 SwRI Division 02 Nuclear Projects Operating Procedure XII-EE-101-3, "Calibration of Mechanical Sciences Dynamic Test Equipment," November 1981.

2.8 SwRI Division 02 Nuclear Projects Operating Procedure XI-EE-101-2, "Seismic Tests of Electrical and Mechanical Components," November 1981.

2.9 EPRI NP-1588, "A Review of Equipment Aging Theory and Technology," Franklin Research Center, Carfagno, Gibson, Sept., 1980.

2.10 IEEE 101-1972, "IEEE Guide for the Statistical Analysis of Thermal Life Test Data," IEEE Standards Coordinating Committee on Thermal Rating, 1972.

2.11 SwRI Division 02 Nuclear Projects Operating Procedure XI-MS-105-1, "Environmental Testing of Electrical and Mechanical Components," October 1981.

3.0 DEFINITIONS

Term definitions are as given in Section 3.0 of Reference 2.1, Section 2.0 of Reference 2.4, and as they appear in Reference 2.9.

4.0 TEST ITEM IDENTIFICATION

The test items to actually be type tested will be as defined below.

4.1 Main Steam Isolation Valve, Leakage Control System (MSIV-LCS) Limit Switch (Namco, Model EA-740, Rev. K).

4.2 Safety Relief Valve Solenoid (Seitz AG, Model 0-105-562e).

4.3 Temperature Element (Pyco, Model N145C3224).

Specifications for the test items are identical to those given in Section 2.2, Performance Specification, and Section 2.3, Physical Specification in Reference 2.5.

5.0 TEST PROCEDURE

5.1 General

This test procedure will require multiple units of each type of component to undergo the aging tests. The object of the test procedure will be to successfully age at least one of each type to an aged condition equivalent to their respective end of service life. This will be covered in greater detail later in the plan. Subsequent to aging, one of each type of component of Section 4.0 will undergo seismic testing and finally undergo an MSLB/LOCA simulation. The units which successfully pass all of the tests will be qualified.

5.2 Test Sequence

The qualification test sequence is delineated in Table 5.1. This test sequence is in accordance with Section 6.3.2 of Reference 2.1, and Section 2.3 of Reference 2.2. This sequence will also be in accordance with Section 4.0 of Reference 2.5. The test sequence will include an investigation of known synergistic effects in accordance with Section 4 of Reference 2.2. At this time it does not appear that there are any known synergistic effects which would be relevant to these tests. Items 1 and 11 of Table 5.1, Test Sequence, are identical. They are identical complete functional procedures. Intermediate functional checks may be partial checks that are less time consuming used only to detect failures that may have occurred in the preceding test.

5.3 Margin

In accordance with Section 6.3.1.5 of Reference 2.1, and Section 3.0 of Reference 2.2, appropriate margins have been added to the test parameters described below. In general, margins include the addition of 10% to the value of the independent variable or the dependent variable. For example, 10% is added to the time of thermal aging as margin, or 10% can be added to the temperature at which the test item is aged. Margin is not added to both, however. Certain parameters have a natural maximum, for example, humidity can have no greater than 100% RH, consequently margin cannot be added to these parameters. In accordance with Section 4.2 of Reference 2.5, the following margins shall be added to the test parameters.

5.3.1 Temperature

Positive 15°F (8°C) when qualification testing is conducted under saturated steam conditions, the temperature margins shall be such that the

TABLE 5.1 TEST SEQUENCE

1. Visual Inspection
   Baseline Performance Test
2. Radiation Aging Test (Normal and Accident)
3. Performance Test
4. Thermal Aging Test
5. Performance Test
6. Operational Aging Test
7. Performance Test
8. Seismic Test (Performance Test during)
9. Performance Test
10. MSLB/LOCA Test (Performance Test during)
11. Post-Test Inspection
    Post-Test Performance Test (Same as Baseline Performance Test)

test pressure will not exceed saturaged steam pressure corresponding to peak surface temperature by more than 10 lb per square inch.

5.3.2 Pressure

Plus 10% of gage but not more than 10 lb psi.

5.3.3 Radiation

Plus 10% of accident dose.

5.3.4 Voltage

Plus or minus 10% of rated value unless otherwise specified.

5.3.5 Time

Plus 10% of the period of time the equipment is required to be operational following a design basis accident event.

5.3.6 Frequency

Plus 5% of rate value unless otherwise specified.

5.3.7 Vibration

Plus 10% added to the acceleration of the response spectrum at the mounting point of the equipment unless otherwise specified.

5.3.8 Environmental Transient

The initial transient and the dwell at peak temperature shall be applied at least twice.

5.4 Test Item Preparation and Inspection

In accordance with Section 4.2 of Reference 2.11, the test items shall be visually inspected for any signs of damage as a result of shipment to SwRI upon receipt of the test items. Each test item shall be clearly marked with an SwRI inventory number in a manner which will optimize the permanence of the number without impairing the function of the test item.

All test components, upon receipt, shall be electrically interfaced in accordance with Section 3.2 of Reference 2.5 to an integral junction box. Prior to seismic testing a flexible conduit shall be affixed to the integral junction box. The open end of the flexible conduit shall be attached to the side of their respective mounting brackets. A 1/4 inch weep hole shall be drilled at the lowest point of the flexible conduit arc prior to MSLB/LOCA testing to prevent the accumulation of liquids in the conduit.

5.5 Performance Test

Prior to testing a baseline performance test will be performed on the test items. This baseline performance test shall demonstrate that the requirement complies with the operability requirement described in Tables 2.2-1 to 2.2-3. These tables are contained in Appendix B of this test plan. Performance tests will be performed during seismic testing and also during MSLB/LOCA tests demonstrating that the units continue to function while exposed to these environments. These performance tests are also included in Appendix B of this test plan. Performance tests will be used after each test in order to detect failures that may have occurred in that test. Performance tests will also be performed on the test items periodically during the thermal aging. After all testing, a post-performance test will be run. This post-test is the same as the baseline performance test and will establish the pass/fail for the test items. Performance test procedures for all test items are contained in Appendix B of this test plan.

5.6 Radiation Aging

The objective of radiation aging is to subject each component to an exposure equivalent to those anticipated during their design lifetime and the design basis accident event. Each of the test items will be exposed to radiation aging. The test items will be exposed to gamma radiation from Cobalt 60 sources to a total minimum dose as specified in Table 5.2. These doses are in accordance with Table 6.4-1 of Reference 2.5. Radiation aging will be performed in our High Level Radiation Effects Facility. A description of this facility appears in Appendix C. Our Cobalt 60 sources are a number of point sources which will be arranged to give homogeneous dosage rate per unit volume. Irradiation rate shall be a maximum of 1.0 megarads per hour. The chamber temperature and pressure shall be maintained at a standard temperature and pressure condition. The dose rates shall be checked and verified by optical dosimeters. A performance test will be performed on the test items before and after aging. This will include a visual examination for evidence of damage or permanent deformation as a result of the aging.

5.7 Thermal Aging

The purpose of thermal aging will be to as nearly as technically feasible precondition each test item to its expected end of service life condition. Accelerated thermal aging will be performed in the laboratory by exposing the test items to elevated temperatures for a period of time which is projected by the best applicable aging model as equivalent to the service life conditions. There is currently no deterministic way of extrapolating the

TABLE 5.2 RADIATION AGING REQUIREMENTS

[redacted]

TABLE 5.3 THERMAL AGING REQUIREMENTS

[redacted]

effects of thermal aging at short periods in the laboratory to those which would have occurred in a component over a service life. All existing models for predicting the appropriate time temperature relationships have inherent defects when applied for this purpose. Use of the Arrhenius methodology is considered acceptable (Section 4.4, Reference 2.2) and this is the methodology which will be used. The Arrhenius equation and its application is described in References 2.5, 2.8 and 2.9. The relevant parameters to the Arrhenius model are the service life temperature of the test item, the service life of the test item, the aging temperature for the test item, the aging time for the test item, and the minimum activation energy constant applicable to the test item. The thermal aging tests proposed are based on the service life conditions listed in Table 3.3-1 of Reference 2.5. The time of thermal aging is predicted on the basis of the Arrhenius equation for a choice of the minimum expected applicable activation energy constant. These activation energy constants are given in Tables 2.3.1, 2.3.2, and 2.3.3 in Section 2.3 of Reference 2.5. They are also given in Table 5.3 of this test plan. Activation energy constants are associated with the speed of reaction in organic materials in the test item. Using the appropriate minimum activation energy constants in the assumed service lives of the test items, the thermal aging time temperature relationships given in Table 6.4-1 of Reference 2.5, and Table 5.3 of this test plan, were obtained.

The test items will be aged in thermally controlled ovens to the requirements stated in Table 5.3. Temperature will be monitored on low frequency strip chart recorders. The test items will be in a non-operating state while aged. During aging the test items may be removed periodically to check their function. In accordance with the Arrhenius equation, the aging processes are cumulative so that periodic removal of the test items to check function does not invalidate aging. At the same time it makes it possible to catch thermally related failures before long periods of time are wasted. After aging a performance test will be performed on the test items in accordance with the procedure (see Section 5.5).

5.8 Operational Aging

Analysis of the test items indicates that items 4.1 and 4.2 may expect significant operational aging as a result of operating the test items over their service life. Thus operational aging will only be performed to produce the equivalent wear on these items that would occur in the expected service life. The following operational aging will performed.

[redacted]

[redacted]

5.9 Seismic Testing

5.9.1 Test Item Mounting

The following test items which have successfully passed the aging test previously described, will be seismically tested after mounting them to our biaxial hydraulically actuated seismic facility. A description of this facility is given in Appendix D. The following test items will be seismically tested.

1. A Namco limit switch with a simulated 10-year qualified life.
2. A Pyco temperature element with a simulated 40-year qualified life.
3. A Seitz solenoid valve with a simulated 40-year qualified life.

Mounting will simulate as closely as possible in-service mounting. Appendix F shows required mounting details in a suggested arrangement on the fixture which will be mounted to the vibration table. The test item mount may be slightly altered to accommodate the simultaneous testing of more than one test item. Electrical hookups and pressure hookups to the test items pose no special problems with regard to mechanical support, or mechanical force input to the test items. Therefore no special precautions need be taken with regard to mechanical hookup or lead wire routing or support.

5.9.2 Exploratory Testing (Resonance Search)

A resonant frequency search will be performed on each test item to determine the characteristic resonances of the design, if any. The resonant search will be performed by inputting uniaxial sinusoidal excitation in the frequency range of 1 to 100 Hz at a level of 0.1 g peak. The excitation will be swept from 1 to 100 Hz at a sweep rate of 1 octave/minute. The test items will be mounted to our biaxial hydraulically actuated seismic facility as described above. A uniaxial response accelerometer will be used to monitor response accelerations in the direction of excitation for each axis on each test item. Placement of response accelerometers is shown in the figures of Appendix F. Plots of transmissibility as a function of frequency will be made for each response acceleration position. Resonant frequencies will be determined from these plots at points where the transmissibility peaks are higher than a factor of 2.0 greater than the input. During excitation the test components will be visually monitored for any evidence of structural failure. The failure or loosening of a part that does not affect the operation of the test components will not be considered a malfunction but shall be noted in the test report.

5.9.3 Fatigue Test

Three tests shall be performed, one in each orthogonal axis. Simulated SRV fatigue tests and SRV + LOCA fatigue test will be conducted with the test items oriented in the simultaneous X-Z orientation and in the simultaneous Y-Z orientation. The essential equipment arrangement for the table drive signals is shown in Figure 5.1. For the SRV tests, initially two independent random signals (horizontal and vertical) will be taped on the drive tape recorder. Each respective signal will be obtained by taking an 800 second sample from a random noise generator and passing it through adjustable bandpass filters such that the energy content approximates that indicated for the amplified regions of the RRS (see Figure 5.2 for the respective horizontal and vertical axes). Each of these signals will then be passed through a multiplier which will produce amplitude modulation which is a half-sine of 2 sec. duration and 0 for 2 sec. duration with repetition of this sequence for 800 seconds, thus each resulting drive signal representing a sequence of 2 second half-sine modulated random pulses followed by 2 seconds of zero. The modulation will be time-synchronized on both the horizontal and vertical axes, although the detailed random signals will be completely independent. A total of 200 pulses will be applied for each of the two orientations while data from the table accelerometers will be recorded on analog tape. Verification that the TRS envelopes the RRS (see Figure 5.3) will be provided by the SD321 shock spectrum analyzer. This will be done by selecting a single 4-second sample near the start of the 800 second sequence in order to produce a TRS for both the horizontal and vertical table motion as recorded on the analog tape. Power spectral densities (PSD) of these signals will also be processed on the FFT analyzer.

A similar arrangement will be used for the SRV + LOCA fatigue tests, also as shown in Figure 5.1. In this case only 100 pulses of 2-second random excitation will be applied for each test item orientation. SRV + LOCA RRS will be as shown in Figure 5.4. During fatigue testing the test components shall be visually monitored for any evidence of structural failure. The failure or loosening of a part that does not affect the operation of the test component will not be considered a malfunction but shall be noted in the test report.

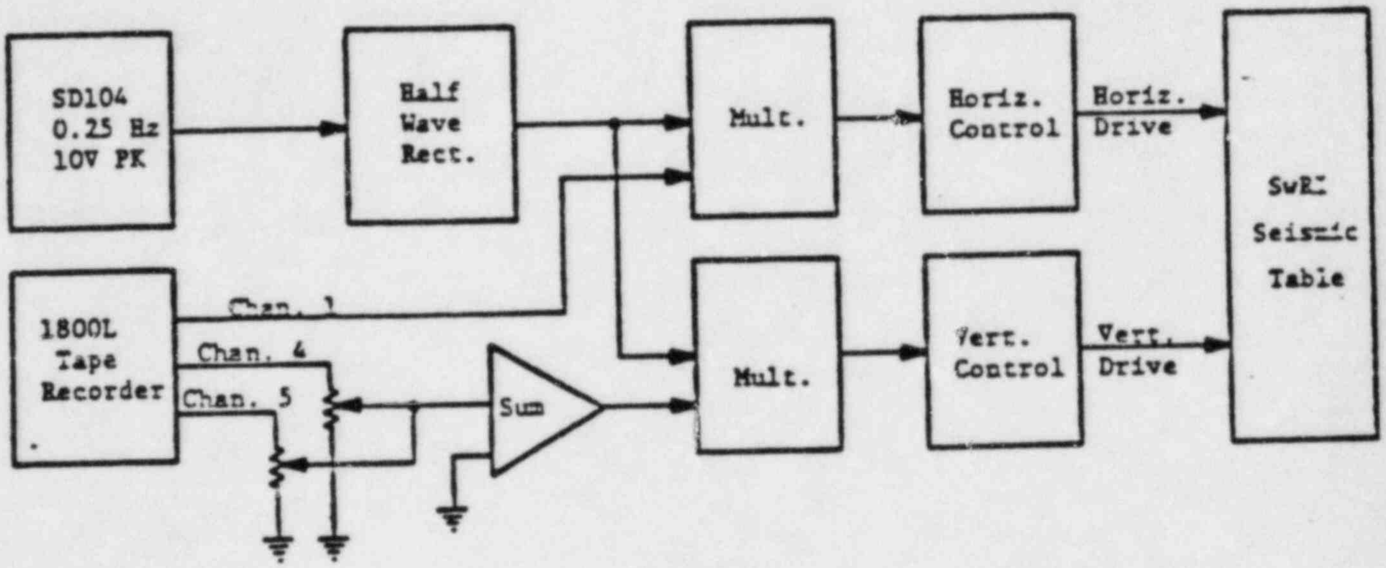


Figure 5.1 SRV and SRV + LOCA Test Table Drive

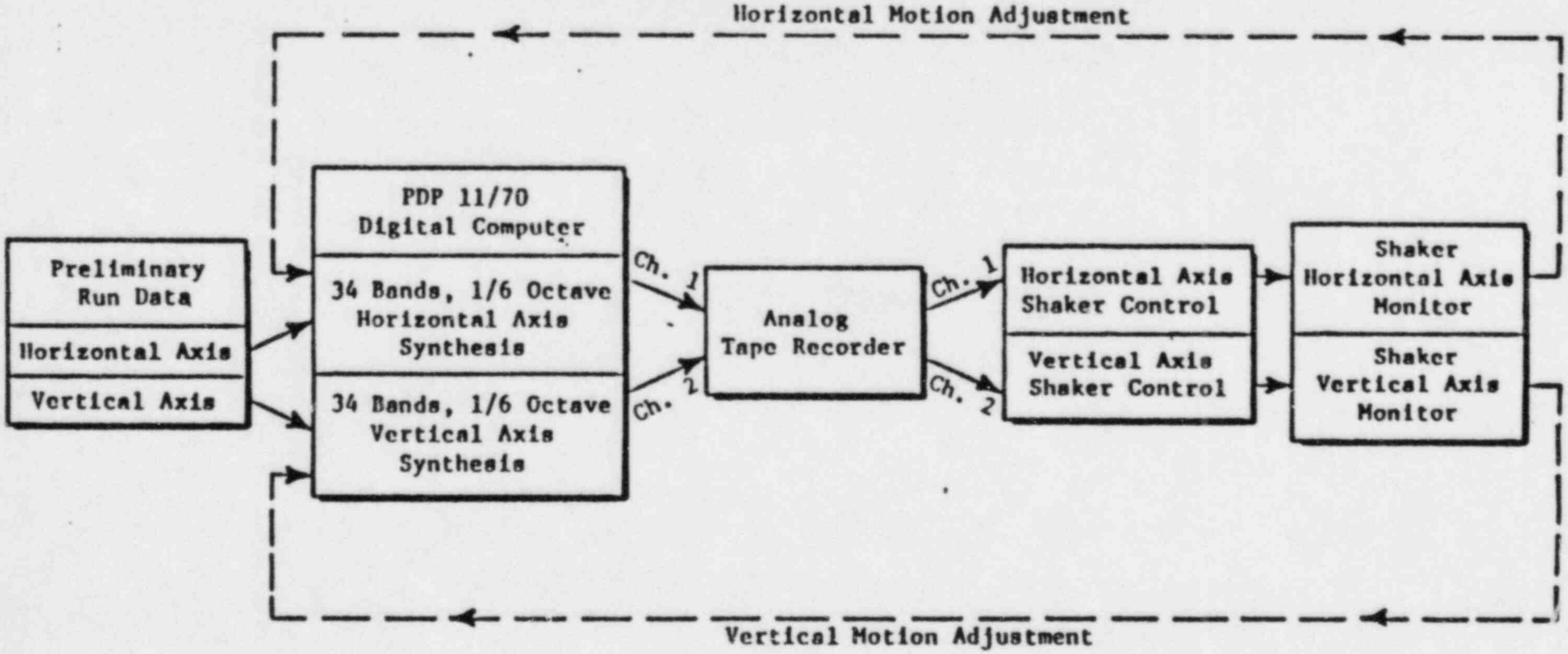


Figure 5.2 OBE and DBE Shaker Table Drive

Figure 5.3 SRV Fatigue Test RRS

(TO BE INCLUDED LATER)

Figure 5.4 SRV + LOCA Fatigue Test RRS

(TO BE INCLUDED LATER)

5.9.4 Proof Testing (Random Motion Tests)

Random motion tests will be performed on the test items by inputting random excitation simultaneously in the vertical and horizontal axes for the mounted test items. Random tests will be performed such that the motion of the axes will be uncorrelated. Drive signals for each run will be formed by digital computer synthesis process which is described by the diagram in Figure 5.2. This synthesis process is accomplished within the computer by operating on 34 bands of narrow band random data, each of 1/6 octave bandwidth. The amplitude of each band is modified according to the RRS and the table transfer function in that band. The final result is summed together and a proportional analog time history is formed for each axis independently on respective channels of an analog tape recorder. These signals are then used to drive the seismic simulator. The corresponding table accelerations are monitored and fed back to the computer to produce a second iteration as necessary. The RRS will be as shown in Figures 5.5 through 5.8. A typical test sequence for a test item will consist of the following:

A. Five consecutive tests at the OBE (Upset) level each 30-seconds in length will be performed.

B. One test will be performed at the SSE (Emergency) level 30 seconds in length.

C. The test item will be rotated 90° about its vertical axis and A and B above will be repeated.

D. Performance test will be made before, during and after each OBE and SSE in accordance with the procedure given in Appendix B of this test plan. Also the test items shall be visually examined for evidence of damages or permanent deformation and results shall be recorded. Test results which deviate from the acceptance criteria as specified in the performance specification, shall be reported.

E. Verification of table motions enveloping the TRS over the RRS will be performed by digital computation to 50 Hz and by computation with the SD321 shock spectrum analyzer to 100 Hz. During all runs all acceleration data will be recorded on analog tape. TRS will be plotted for a damping value of 2.5%. The TRS will exceed the RRS for all frequencies subject to a table displacement limit in the low frequency range.

F. Power spectra density (PSD) plots shall be developed for the first test in each orientation.

Figure 5.5 OBE (Upset), Required Response Spectra for Both Horizontal and Vertical Loads for Temp. Element and Limit Switch

(TO BE INCLUDED LATER)

Figure 5.6 SSE (EMS), Required Response Spectra for Both Horizontal and Vertical Loads for Temp. Element and Limit Switch

(TO BE INCLUDED LATER)

Figure 5.7 OBE(Upset), Required Response Spectra for Both Horizontal and Vertical Loads for Solenoid Valve

(TO BE INCLUDED LATER)

Figure 5.8 SSE (EMS), Required Response Spectra for Both Horizontal and Vertical Loads for Solenoid Valve

(TO BE INCLUDED LATER)

5.10 Main Steamline Break (MSLB)/Loss of Coolant Accident (LOCA) Simulation

Subsequent to seismic testing, the items listed in Section 5.9.1 will be subjected to an MSLB/LOCA simulation test. The objective of MSLB/LOCA simulation is to verify the capacity of the components to operate during postulated loss of coolant design basis accident consisting of demineralized water spray, pressure, temperature, and steam exposures. The MSLB/LOCA simulation tests shall be performed in accordance with Appendix A of this test plan. Performance tests will be performed before, during and after the MSLB/LOCA test in accordance with the procedure provided in Appendix B of this test plan.

6.0 TEST FACILITY

All tests described in this test plan excluding the MSLB/LOCA test will be performed at:

Southwest Research Institute
Department of Engineering Mechanics
6220 Culebra Road
San Antonio, Texas 78284

The MSLB/LOCA test will be performed at:

Conax Corporation
2300 Walden Avenue
Buffalo, N.Y. 14225

7.0 TEST EQUIPMENT

Appendix E gives a partial list of the test equipment available to perform these tests. All test equipment will be calibrated in accordance with Reference 2.7. Prior to tests, all instrumentation used for obtaining data will be checked to show that it is either within calibration, cycle, or has been specially calibrated for the test. Calibration records will be maintained in accordance with the requirements of Reference 2.7.

8.0 QUALITY ASSURANCE

8.1 Quality Assurance Section

The QA Section has been established as an organization element which is responsible to executive management independent of the project. It has the responsibility to identify and evaluate quality-related problems and to initiate, recommend, or develop solutions. It has the direct access to executive management that may be required to ensure corrective action, and it has stop-work authority if such action becomes necessary for proper execution of the test plan. Figure 8.1 demonstrates the separation of lines of command between the QA Section of the Quality Assurance Systems and Engineering Division and a typical project organization.

8.2 Quality Assurance Program

The SwRI Nuclear QA Program is described in the SwRI NQAPM, Reference 2.6.

8.2.1 Quality Assurance Procedures

SwRI Nuclear Quality Assurance Procedures are contained in the SwRI NQAPM. The proper implementation of these procedures assures that the critical service supplied to NUTECH by SwRI meet the requirements of the applicable sections of 10CFR50, Appendix B.

8.3 Project Quality Assurance

Some of the significant activities of QA personnel for the duration of the project are described in the following sections.

8.3.1 Test Personnel Certification

SwRI QA will review the certification records of the test personnel.

8.3.2 Control of Measuring and Test Equipment

SwRI QA will review critical test equipment calibration records to verify that the requirements of NQAP 10-1, Test and Inspection Equipment Control, have been fulfilled.

8.3.3 Test Surveillance

SwRI QA will perform periodic test surveillance to ensure adherence to approved test procedures.

8.3.4 Deviation and Nonconformance Control

Deviation and nonconformances shall be controlled in accordance with NQAP 13-1.

8.3.5 Corrective Action

SwRI QA will participate in all corrective actions required by deviations or nonconformances in accordance with NQAP 14-1, Corrective Action Control.

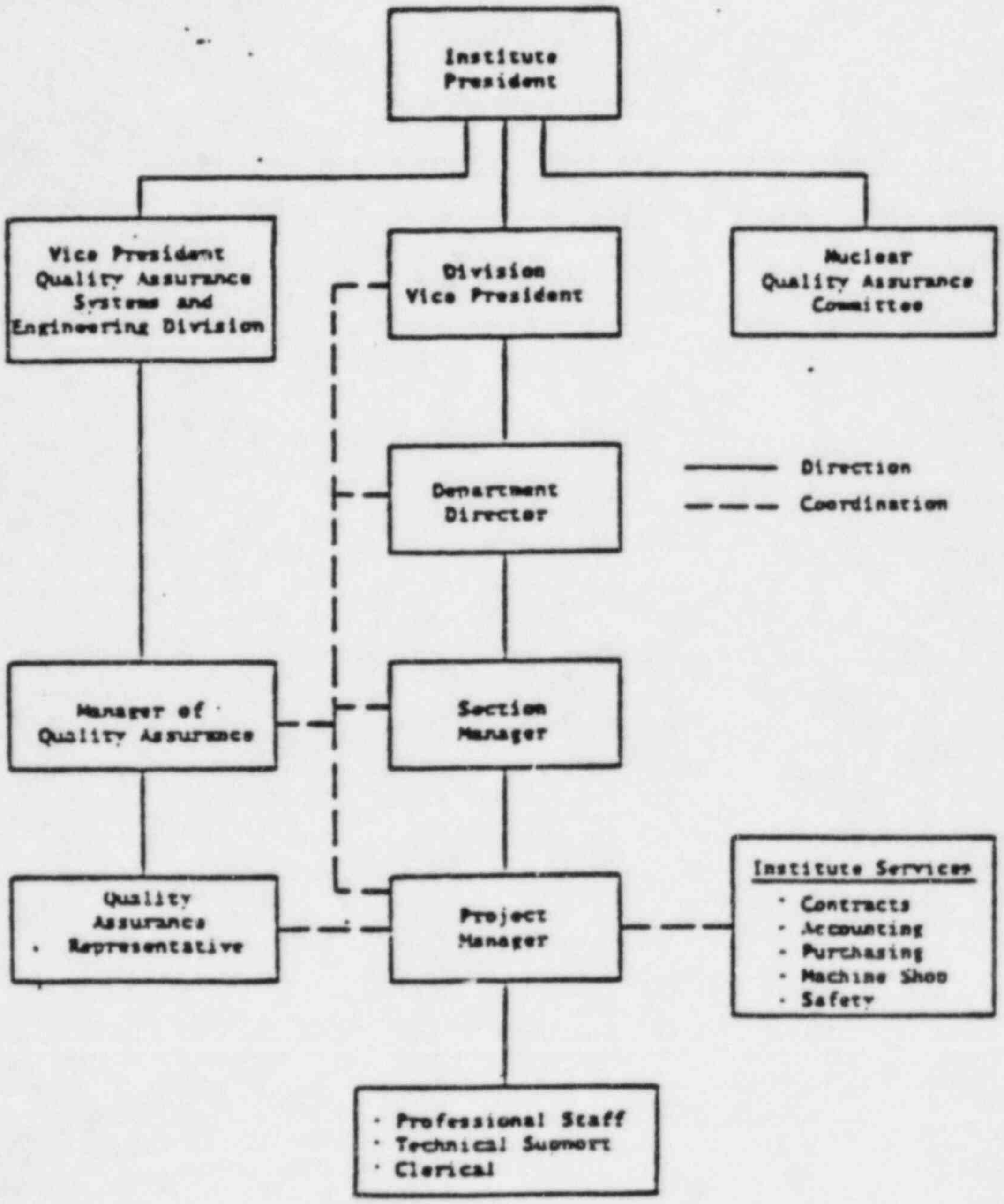


Figure 8.1 Typical Project Organization

8.3.6 Procurement of Critical Items and Services

Critical items and services shall be purchased in accordance with NQAPs 7-1 and 7-2.

8.3.7 Quality Assurance Documents

Procedures and other appropriate QA documents shall be developed and controlled according to NQAP 9-1, Document Control.

9.0 TEST REPORT

At the conclusion of the qualification tests a complete test report will be submitted. The test report will contain the following information as a minimum: A description of the test items, a description of the tests performed, photos and line diagrams describing the test setup, results of the tests, conclusions with regard to passing or failing of the test items, data such as transmissibility plots and TRS's obtained during the tests, a review of the report by independent reviewers and by a Professional Engineer and an affixed engineering seal. The test report will also contain the requirements of Section 12.0 of Reference 2.5.

APPENDIX A

MSLB/LOCA TEST

TO BE INCLUDED LATER

APPENDIX B

PERFORMANCE TEST

TABLE 2.2-1

Performance Specification

Pyco Temperature Element, Model N145C3224

(References 13.1 and 13.2)

[redacted]

TABLE 2.2-2

Performance Specification

Namco Limit Switch, Model EA740, Rev. K

(References 13.3 and 13.4)

[redacted]

TABLE 2.2-3

Performance Specification

Seitz Solenoid Valve, Model 0-105-562e

(References 13.10 and 13.11)

[redacted]

Performance Tests During Seismic and MSLB/LOCA Testing

1) Pyco Temp. Element -

Visually monitor output voltage of element on Digital Voltmeter. Compare output voltage to specified temperature/voltage relationship of Table 2.2-1 of Reference 2.5.

2) Namco Limit Switch -

Apply 1.5 volts DC through contacts. Monitor contact opening or closing during seismic testing. During MSLB/LOCA test, the limit switch will periodically be cycled with the aid of a pneumatic cylinder (2 cycles). Contact opening or closing will be monitored visually with an oscilloscope.

3) Seitz Solenoid Valve -

a) MSLB/LOCA

200 psig air/nitrogen will be supplied to the valve. 106 volts will be applied to solenoid to open or close valve periodically. Exhaust will be piped out of the chamber so that it can be determined whether or not the valve is open.

b) Seismic

In each orientation the following tests will be performed:

1) OBE (UPS)

One run with valve open (106 VDC) pressure supply off.
One run with valve closed (106 VDC) pressure supply off.
One run with valve open 15 sec., closed 15 seconds, pressure supply off.
Two runs with valve closed (106 VDC), 200 psig air/nitrogen supply to valve.

2) SSE (EMS)

Valve closed (106 VDC), 200 psig air/nitrogen supply to valve. Measure valve leakage by displacing water.

APPENDIX C

HIGH LEVEL RADIATION EFFECTS FACILITY


STOP

General

Southwest Research Institute's High-Level Radiation Effects Facility is available to assist government and industry in research and development programs requiring high-intensity cobalt-60 irradiation or studies of post-irradiation effects. The cells within the laboratory are designed to handle 100,000 curies of cobalt-60; our current source strength is approximately 13,000 curies. The laboratory may also be set up to accommodate gaseous or liquid radioisotopes.

For the past 12 years the Facility has been set up to test the change in physical properties of metals exposed directly to neutron bombardment. Radioactive test specimens are placed in the cells and subjected to charpy impact tests, tensile tests, and fracture mechanics tests by a variety of remotely controlled equipment specifically designed for these purposes. A remotely operated charpy impact machine is shown in Figure 99.

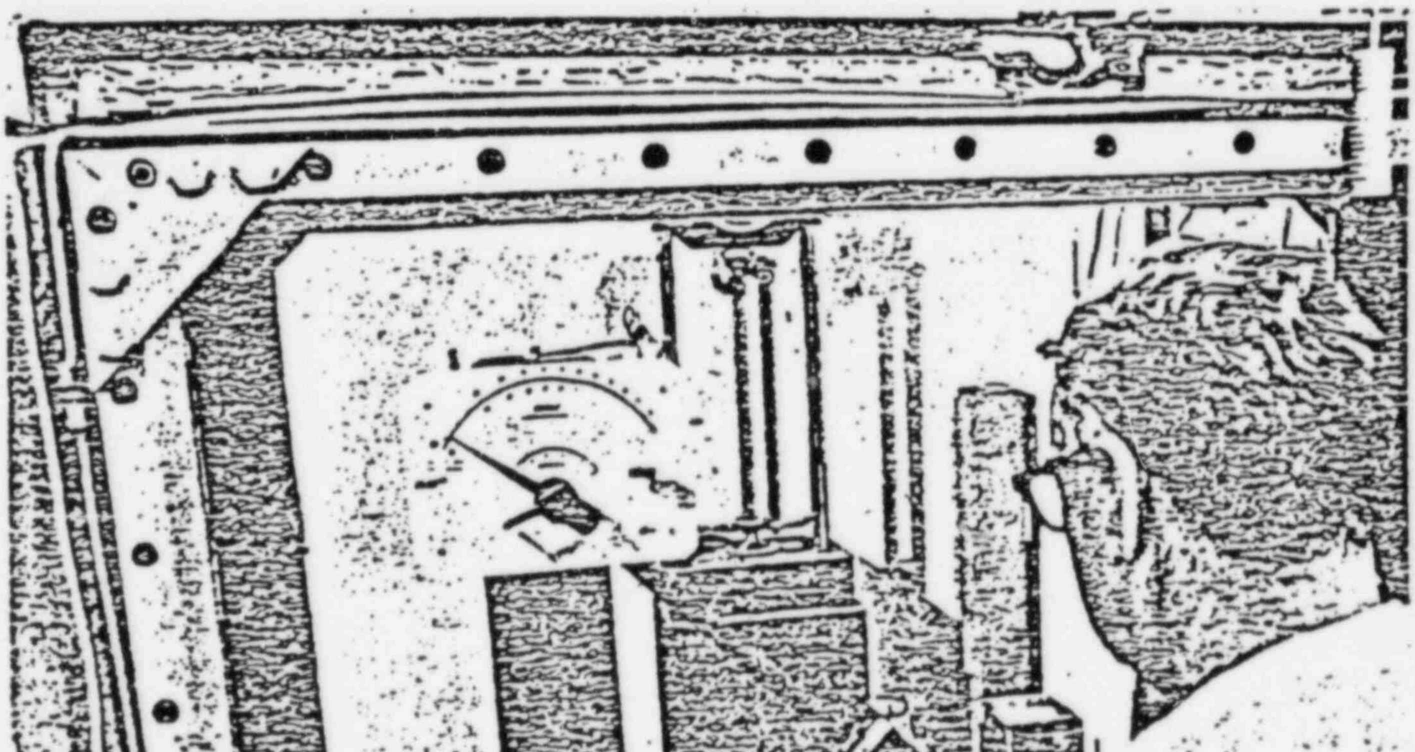


Figure 99. Remotely Operated Charpy Impact Machine

The High-Level Radiation Effects Facility has twin radiation cells (hot cells), each with a 9 X 15-foot floor plan and a 13-foot ceiling (see Figure 100). Entrance to each cell is through a hydraulically operated 8-ton magnetic concrete access door 3 feet wide by 6 feet 4 inches high. (The doors are lowered into a floor well to eliminate the psychological hazard of walking beneath such a large suspended weight.) One of the cells is equipped with a motorized chain hoist for lifting heavy objects or opening shipping casks. In front of the hot cells is a working area of 1000 square feet for the preparation of specimens and for test equipment to be used in conjunction with work in the hot cells.

Cobalt-60 and other highly radioactive materials are stored in a room (approximately 64 cubic feet) located between the cells and can be transported into either or both cells for irradiation of test materials or for tests to be run on the material itself. The doors for closing off the storage room are constructed of the same material as the access doors. They are also hydraulically moved, but rise when opened instead of dropping into the floor. The sources are transported on two steel dollies guided by tracks in the floor. Movements of the dollies and the doors are remotely controlled and electrically interlocked for safety.

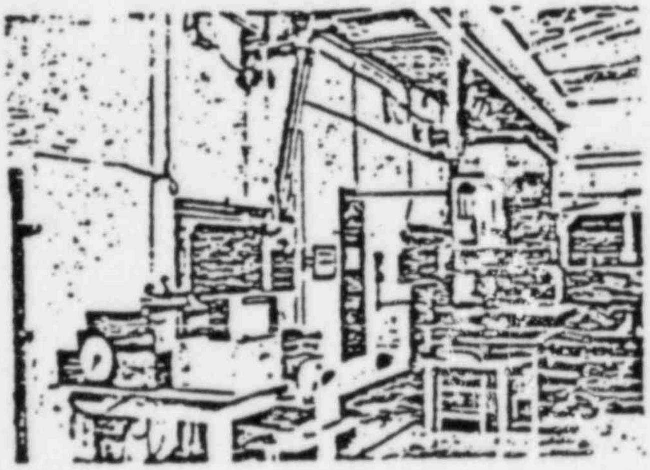


Figure 100. Front View of Hot Cells

The operator's wall consists of 42 inches of magnetite concrete (244 pounds/cubic foot), and provides operational shielding with a million-curie source. The viewing windows, one to each cell, are conventional zinc bromide construction with 3 inches of nonbrowning glass on the source side, 37 inches of optical-grade zinc bromide, and 2 inches of laminated plate glass on the viewer's side. The window on the source side is 48 inches wide by 42 inches high, and on the operator's side is 48 inches wide by 22 inches high. These windows offer a superb view of the entire cell area (see Figures 101 and 102).

A pair of Central Research Laboratory Model 8 manipulators are available for operation

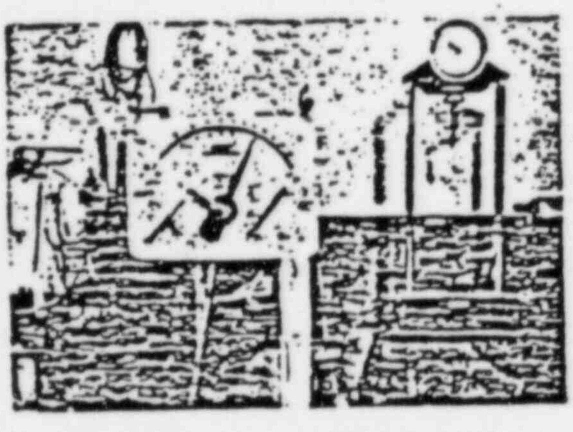


Figure 101. Interior of Left-Hand Cell

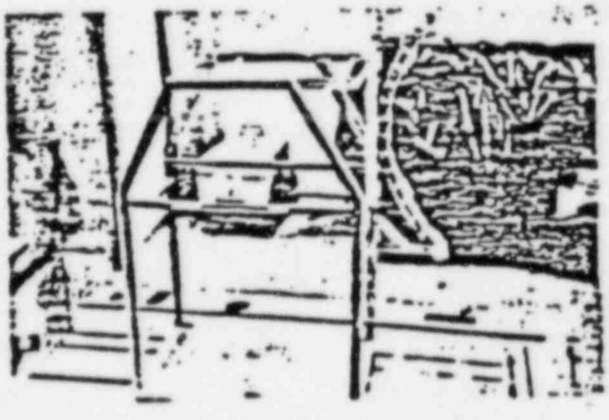


Figure 102. Interior of Right-Hand Cell

in either cell (see Figure 103). These manipulators have a 45-inch "Z" travel and a longer arm in the hot cell than on the operator's side. Motorized side and forward separation is built into the manipulators to facilitate operations in front of the viewing window.

In addition to the manipulator holes above the viewing window, the wall to the side of and above the viewing window has two holes to allow relocation of the manipulators, using an "A" frame. Relocation takes about 10 minutes and allows the movement of the manipulators to cover the entire cell area. Adequate access holes for utilities, pressure connections, instrumentation, and electrical leads are provided near the floor line and just below the ceiling line. The utility and instrumentation leads pass through corkscrew-shaped conduits encased in plugs of high-density material. This eliminates line-of-sight radiation through the utility connections.

Figure 103. Testing With Use of Model 8 Manipulators

Each cell is ventilated with a complete change of air every minute. A high-quality commercial air filter is used on the inlet side, and on the outlet side an identical air filter is used ahead of a Cambridge absolute air filter. The blower is located on the suction side to keep the cell itself at a negative pressure. This ensures that, in the event of some catastrophic accident in the cell, contaminating or contaminated particles could not spread to the personnel area.

Each cell is equipped with a high-level radiation monitor. The radiation monitors are interlocked with the access doors for protection of the personnel operating the cells. In addition, there are two radiation monitors in the preparation room to warn personnel in case of an accidental loss of shielding.

Description of Gamma Flux Source

The cobalt used to provide the gamma flux field is doubly encapsulated in stainless steel right circular cylinders approximately 1 inch in diameter. The capsules have only 40 mils of stainless steel shielding the cobalt on the end that faces the specimen to be irradiated. This reduces the attenuation of the gamma flux by the encapsulating material. The 16 high-activity capsules, with an average activity of 625 curies per capsule, can be arranged in an infinite variety of arrays to tailor the flux to the requirements of the specimen being irradiated. Other source capsules have activities from as low as 3 curies up to a maximum of 800 curies per capsule. Dose rates may be varied from several hundred millirem per hour to over one megarad per hour.

Flexibility

The present facilities allow research with any solid radioisotope. Additional facilities and changes in the existing facilities may be added when required for future research programs. The concrete floor can be covered with a temporary vinyl plastic floor to accommodate investigations with liquids or dusts. Waste traps can be added for work with high-activity liquids. An exhaust stack

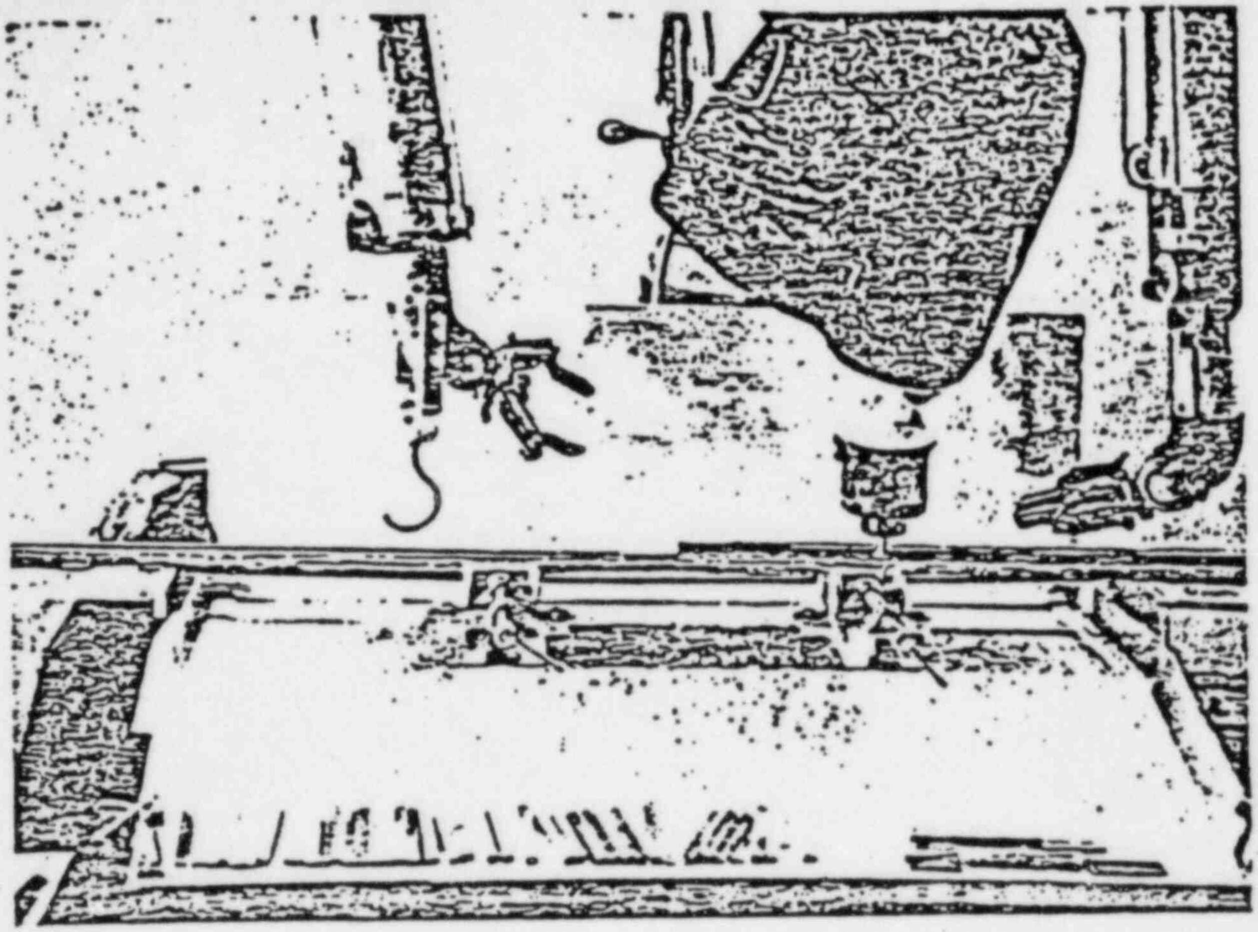
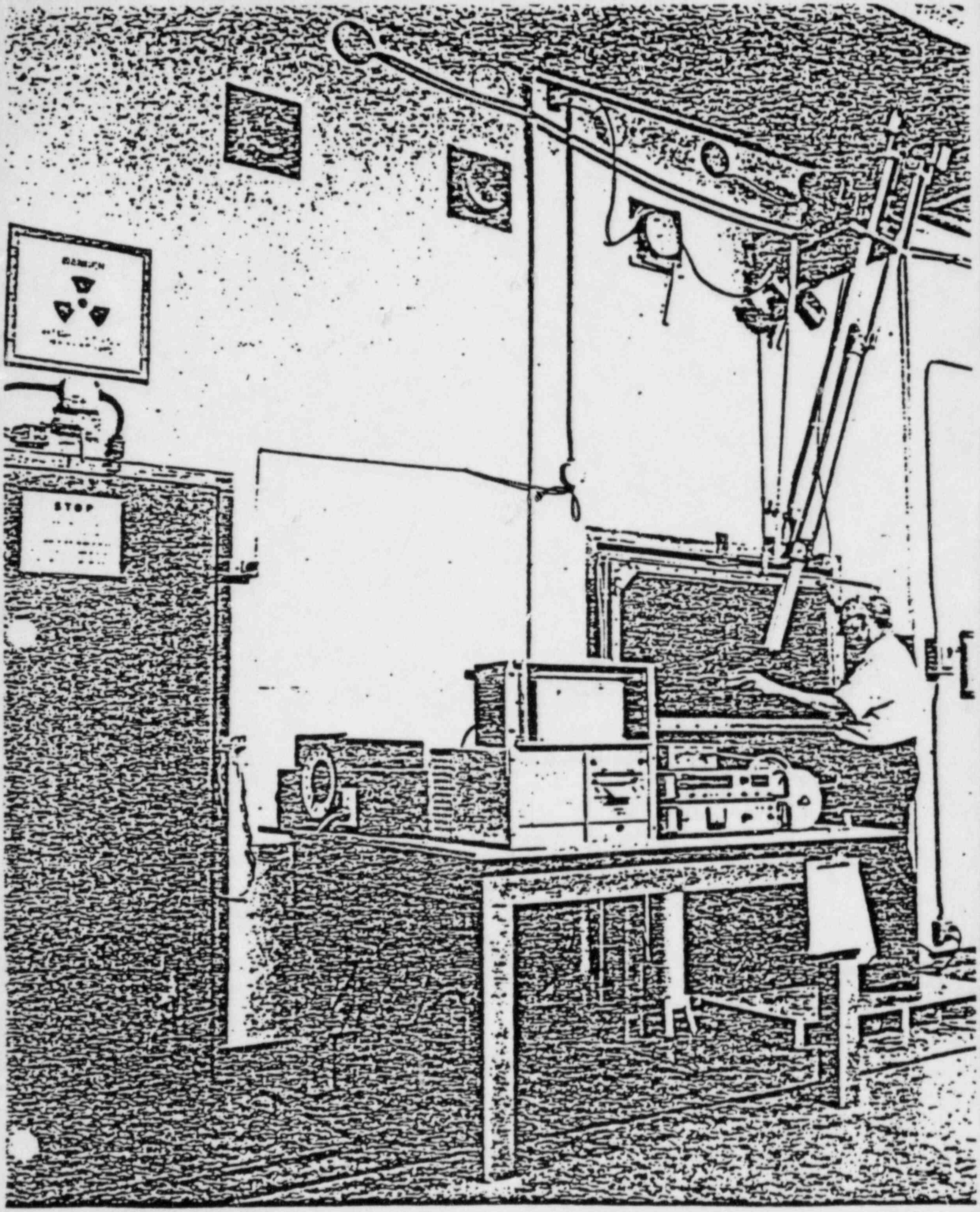
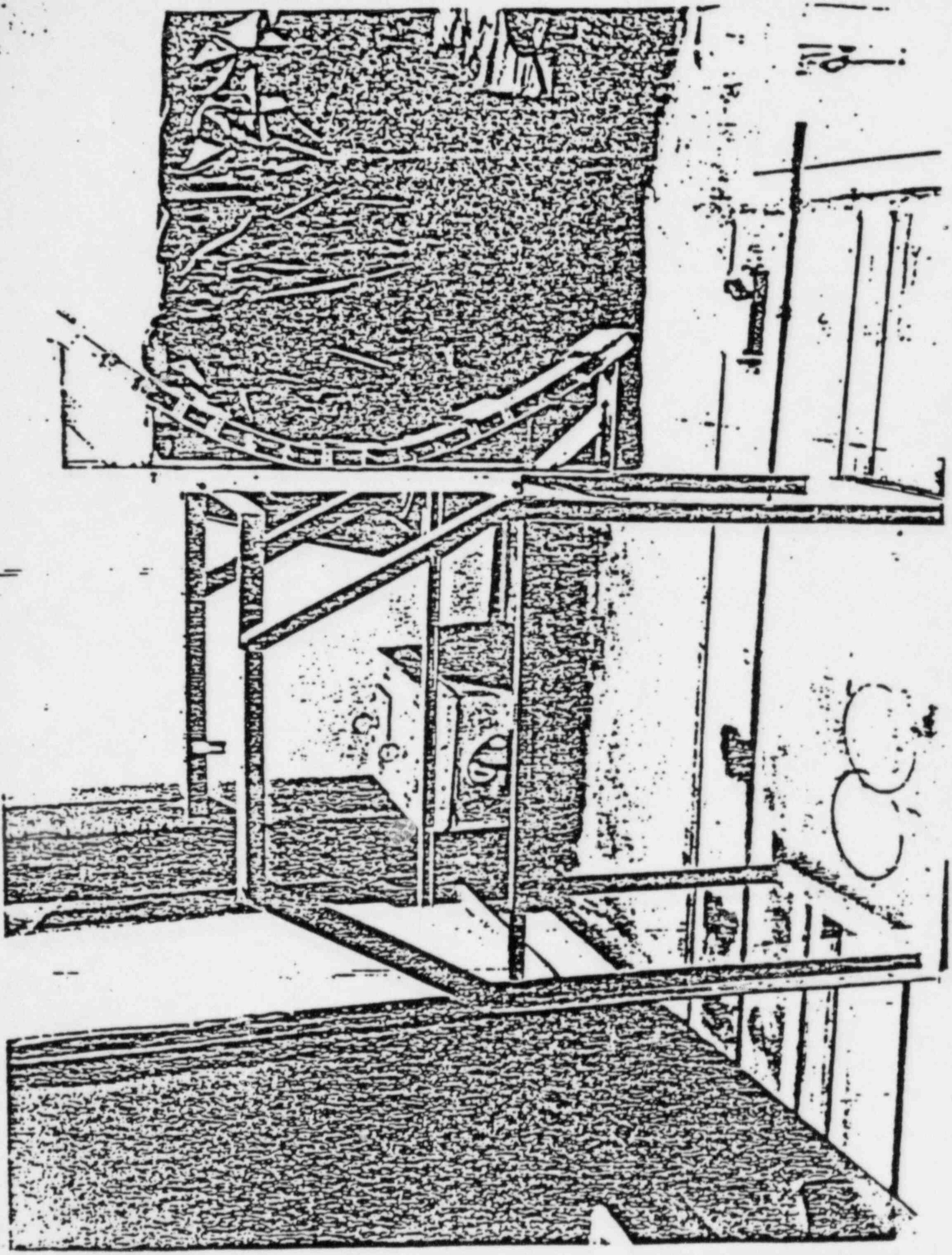


Figure 104. Opening Surveillance Capsule With Milling Machine in SwRI Hot Cell

and a more elaborate filtering system can be added for research and using high-activity gases, dusts, or volatile liquids. Figure 104 shows one of the cells set up to machine radioactive specimens remotely.

Southwest Research Institute recognizes that waste disposal, isotope shipping, dosimetry, radiation monitoring, and health physics are constant problems in radioisotope work, and is prepared to provide equipment and technical assistance in these areas. The Institute also has the capability to design and construct any accessory which might be needed to perform an investigation utilizing radioisotopes.

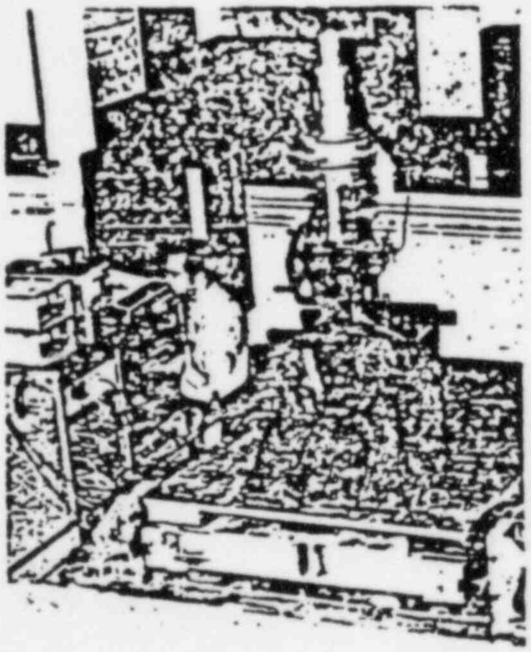

STOP



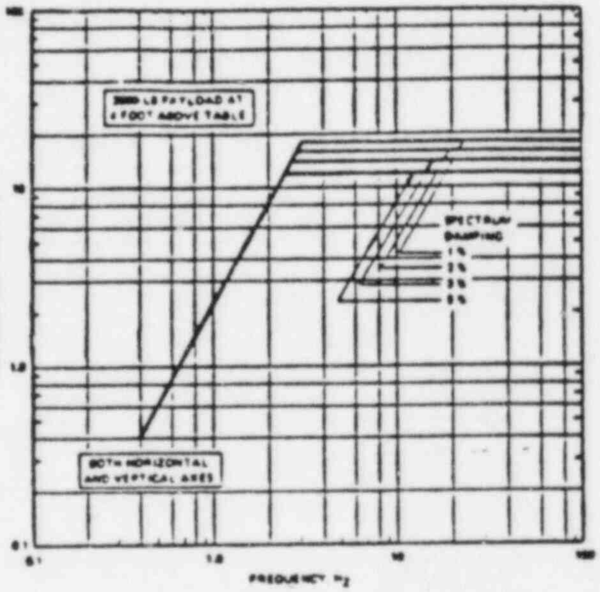
APPENDIX D

SEISMIC FACILITY

SPECIFICATIONS FOR SwRI SEISMIC TEST FACILITY



Overall View of Simulator and Instrumentation System



Earthquake Response Spectrum Capacity Under Typical Load

System Description

This facility has the capability of realistic simulation of earthquake motions as well as many other low frequency dynamic environments. It is a true biaxial vibration table having the capability of delivering simultaneous independent excitation along both horizontal and vertical axes. Drive mechanisms are servo-controlled, electrohydraulic systems with independent control for each axis. It is capable of producing all current types of nuclear plant seismic qualification tests prescribed under USNRC Reg. Guide 1.100 and IEEE 344 (1975), and many other types of tests as well. Detailed capabilities include:

Max. Payload Weight	— 6000 lb
Payload Mounting Area	— 6 ft × 6 ft
Payload Max. Envelope	— 10 ft wide × 10 ft deep × 14 ft high
Max. Payload CG Height Above Table Top	— 2 ft for 5000 lb 4 ft for 3000 lb 6 ft for 1000 lb

Table Limits	Horizontal	Vertical
Frequency Range	0-200 Hz	0-100 Hz
Force Capacity	10,000 lb	20,000 lb
Max. Stroke	8 in.	7 in.
Max. Velocity	90 in./sec	22 in./sec
Max. Acceleration	10 g	10 g

Associated Instrumentation

Excitation signals are provided typically by random or deterministic function generators, or actual field-measured signals recorded on analog tape. Table displacement is accurately controlled at low to medium frequencies by automatic feedback. Table motions are monitored by accelerometers whose outputs can be analyzed according to several standard parameters. Acceleration or velocity response spectrum can be computed and plotted within seconds. Power spectral density, probability density, and other associated statistical parameters can be computed with Real Time Analyzers. All time histories can be recorded on analog or digital tape, on oscillographs, or monitored on oscilloscopes.

For More Information, Contact

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Engineering Sciences Division
Southwest Research Institute
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San Antonio, Texas 78284
(512) 684-5111 (Ext. 2345 or 2333)

APPENDIX E

EQUIPMENT LIST

1	CAMERA	TEKTRONIX	C-30A	B023377	FC	SCOPE CAMER
2	NOISE GENERATOR	ELGENCO	311A	015-1056	FC	RANDOM NOIS
3	TONE GENRATOR	MICRODOT	F220A	3058	FC	FUNCTION GE
4	SWEEP OSCILLATOR	SPECTRAL DYNAM	SD104A-5	1119	FC	3 DECADE SW
5	SWEEP OSCILLATOR	SPECTRAL DYNAM	SD104A-5	1856	FC	3 DECADE SW
6	SERVO MONITOR	SPECTRAL DYNAM	SD105A	557	FC	5-10K HZ
7	SERVO MONITOR	SPECTRAL DYNAM	SD105C-1	935	FC	1-5K HZ
8	FILTER	SKL	308A	407	FC	VARIABLE FR
9	FILTER	SKL	308A	368	FC	VARIABLE FR
10	POWER AMPLIFIER	TEAM	152B	102	FC	PILOT VALVE
11	ACCELEROMETER	ENDEVCO	2221D	JC 15	BU	1-5000 HZ
12	ACCELEROMETER	ENDEVCO	2221D	JC 16	BU	1-5000 HZ
13	ACCELEROMETER	ENDEVCO	2221D	JC 17	BU	1-5000 HZ
14	ACCELEROMETER	ENDEVCO	2221D	JC 18	BU	1-5000 HZ
15	ACCELEROMETER	ENDEVCO	2221D	JE 66	BU	1-5000 HZ
16	ACCELEROMETER	ENDEVCO	2221D	XB-75	BU	1-5000 HZ
17	ACCELEROMETER	ENDEVCO	2221D	XB-76	BU	1-5000 HZ
18	ACCELEROMETER	ENDEVCO	2220	MD-75	BU	1-5000 HZ
19	ACCELEROMETER	ENDEVCO	2220	MD-76	BU	1-5000 HZ
20	ACCELEROMETER	ENDEVCO	2220	JD-49	BU	1-5000 HZ
21	ACCELEROMETER	ENDEVCO	2220	KC-53	BU	1-5000 HZ
22	ACCELEROMETER	ENDEVCO	2220	KC-56	BU	1-5000 HZ
23	ACCELEROMETER	ENTRAN	EGC-500DS-20	27C7D-M1-1	BU	20G
24	ACCELEROMETER	ENTRAN	EGC-500DS-20	27C7D-M2-2	BU	20G
25	ACCELEROMETER	ENTRAN	EGC-500DS-20	27C7D-M3-3	BU	20G
26	ACCELEROMETER	ENTRAN	EGC-500DS-20	30H8I-R8-8	BU	20G
27	ACCELEROMETER	ENTRAN	EGC-500DS-20	30H8IR1010	BU	20G
28	ACCELEROMETER	ENTRAN	EGC-500DS-20	30H8IR1212	BU	20G
29	ACCELEROMETER	ENTRAN	EGC-500DS-20	20H8IR1313	BU	20G
30	ACCELEROMETER	ENTRAN	EGAL2-125-20D	30C7-1	BU	20G
31	ACCELEROMETER	ENTRAN	EGAL2-125-20D	25C7-2	BU	20G
32	ACCELEROMETER	BELL & HOWELL	4-202-0001	21311	BU	25G
33	ACCELEROMETER	BELL & HOWELL	4-202-0001	21312	BU	25G
34	ACCELEROMETER	BELL & HOWELL	4-202-0001	24292	BU	25G
35	PRESSURE CELL	BELL & HOWELL	4-312-0002	38387	BU	25 PSIA
36	PRESSURE CELL	BELL & HOWELL	4-312-0002	38389	BU	25 PSIA
37	PRESSURE CELL	BELL & HOWELL	4-312-0002	38394	BU	25 PSIA
38	PRESSURE CELL	BELL & HOWELL	4-312-0002	38396	BU	25 PSIA
39	AMPLIFIER	SWRI		1	BU	BRIDGE 18 (
40	AMPLIFIER	SWRI		2	BU	BRIDGE 10 (
41	AMPLIFIER	KISTLER	504	864	BU	CHARGE
42	AMPLIFIER	KISTLER	504A	645	BU	CHARGE
43	AMPLIFIER	KISTLER	504D	1545	BU	CHARGE
44	AMPLIFIER	ENDEVCO	2721A	AT35	BU	CHARGE
45	AMPLIFIER	ENDEVCO	2721A	AT36	BU	CHARGE
46	AMPLIFIER	ENDEVCO	2721A	AT46	BU	CHARGE
47	AMPLIFIER	ENDEVCO	2721A	AT54	BU	CHARGE
48	OSCILLOGRAPH	BELL & HOWELL	5-134-18	5042	BU	18 CHANNEL
49	DISPLAY UNIT	TEKTRONIX	602	B078100	BU	CRT
50	FILTER	SPECTRAL DYNAM	SD121	178	BU	TRACKING
51	FILTER	SPECTRAL DYNAM	SD131L	444	BU	TRACKING
52	DYNAMIC ANALYZER	SPECTRAL DYNAM	SD120/122L	86/259	BU	2 CHANNEL
53	CO/QUAD ANALYZER	SPECTRAL DYNAM	SD 109	27	BU	ANALOG
54	X-Y RECORDER	HEWLETT-PACKAR	7005B	1429	BU	ANALOG
55	X-Y RECORDER	HEWLETT-PACKAR	7045A	1734A01580	BU	ANALOG
56	CONTROLLER	SWRI		1	BU	HYDRAULIC
57	OP. AMP. MANIFOL	ANALOG DEVICES	194	136	BU	ANALOG OPN
58	OP. AMP. MANIFOL	ANALOG DEVICES	194	12128	BU	ANALOG OPN
59	OP. AMP. MANIFOL	ANALOG DEVICES	194	12167	BU	ANALOG OPN
60	OP. AMP. MANIFOL	ANALOG DIVICES	194	12171	BU	ANALOG OPN
61	MULTIPLIER	SWRI		2	BU	ANALOG

62	POT MANIFOLD	SWRI		1	BU	7 EA.
63	POT MANIFOLD	SWRI		2	BU	7 EA.
64	POT MANIFOLD	SWRI		3	BU	7 EA.
65	ACCELEROMETER	BELL & HOWELL	4-202-0001	19742	6M	HORIZ. TABL
66	ACCELEROMETER	BELL & HOWELL	4-202-0001	22529	6M	VERT. TABLE
67	CONTROLLER	TEAM	1522		6M	HORIZ. TABL
68	CONTROLLER	SWRI		2	6M	VERT. TABLE
69	RESPONSE SPECTRU	SPECTRAL DYNAM	SD321	12	6M	SHOCK SPECT
70	OSCILLOSCOPE	TEKTRONIX	212	B041498	6M	BATT PWR
71	OSCILLOSCOPE	TEKTRONIX	R-561B	B071522	6M	RACK MOUNT
72	SCOPE PLUG-IN	TEKTRONIX	3A74	5662	6M	4-CHANNEL
73	SCOPE PLUG-IN	TEKTRONIX	2B67	23215	6M	TIME BASE
74	OSCILLOSCOPE	TEKTRONIX	564B	B112148	6M	STORAGE
75	SCOPE PLUG-IN	TEKTRONIX	3A74	8175	6M	4-CHANNEL
76	SCOPE PLUG-IN	TEKTRONIX	2B67	31456	6M	TIME BASE
77	OSCILLOSCOPE	TEKTRONIX	5111	B118209	6M	STORAGE
78	SCOPE PLUG-IN	TEKTRONIX	5A14N	B053025	6M	4-CHANNEL
79	SCOPE PLUG-IN	TEKTRONIX	5A14N	B053045	6M	4-CHANNEL
80	SCOPE PLUG-IN	TEKTRONIX	5B12N	B065791	6M	DUAL TIME
81	COUNTER	HEWLETT-PACKAR	5512A	450-01511	6M	PERIOD/FRE
82	COUNTER	HEWLETT-PACKAR	5300B/5308A	6451/3227	6M	TIMER/COUNT
83	TAPE RECORDER	AMPEX	FR 1800 L	7040122	6M	14-CHANNEL
84	TAPE RECORDER	AMPEX	PR 2230	9170879	6M	14-CHANNEL
85	DIGITAL MULTIMET	WESTON	4442	1294	6M	BATT PWR
86	DIGITAL MULTIMET	HEWLETT-PACKAR	3466A	1716A01910	6M	4 1/2 DIGI
87	DIGITAL SERVO DI	TEAM	1564	102	6M	W/ TEAM 15
88	ACCELEROMETER/CA	KISTLER	808K/561T	769/416	1Y	NBS TRACEA
89	ACCELEROMETER	ENDEVCO	2224C	EW50	BU	10000 HZ
90	ACCELEROMETER	ENDEVCO	2224C	EW68	BU	10000 HZ
91	ACCELEROMETER	ENDEVCO	2224C	EW69	BU	10000 HZ
92	ACCELEROMETER	ENDEVCO	2225	FP49	BU	20000 G
93	ACCELEROMETER	ENTRAN	EGC-500DS-20	2TITR20-20	BU	20 G
94	ACCELEROMETER	ENTRAN	EGC-500DS-20	2TIT-E14-1	BU	20 G
95	ACCELEROMETER	ENTRAN	EGC-500DS-20	2TITR15-15	BU	20 G
96	ACCELEROMETER	ENTRAN	EGC-500DS-20	21VOT1R7-1	BU	20 G
97	ACCELEROMETER	ENTRAN	EGC-500DS-20	20LBT1R9-2	BU	20 G
98	PRESSURE CELL	BELL & HOWELL	4-312-0002	39040	BU	25 PSIA
99	PRESSURE CELL	BELL & HOWELL	4-312-0002	25249	BU	25 PSIA
100	PRESSURE CELL	BELL & HOWELL	4-312-0002	38844	BU	25 PSIA
101	AMPLIFIER	ENDEVCO	2721A	BJ98	BU	CHARGE
102	AMPLIFIER	ENDEVCO	2721A	BJ94	BU	CHARGE
103	AMPLIFIER	ENDEVCO	2721A	BJ91	BU	CHARGE
104	OSCILLOSCOPE	TEKTRONIX	5111	B131937	6M	STORAGE
105	SCOPE PLUG-IN	TRKTRONIX	5A14N	B074473	6M	4-CHAN
106	SCOPE PLUG-IN	TEKTRONIX	5A14N	B074477	6M	4-CHAN
107	SCOPE PLUG-IN	TEKTRONIX	5B12N	B077663	6M	DUAL TIME
108	CAMERA	TEKTRONIX	C-5B	B011395	FC	SCOPE CAME
109	MEGGER	ASSOC. RES.	2001	5217	6M	500 VDC
110	CURRENT METER	DAYTON	4X221	-	6M	AC
111	HYPOT	ASSOC. RES.	422	1240	6M	10 KVAC
112	HYPOT	ASSOC. RES.	4013	983	6M	2.5 KVAC
113	FILTER	ITHACO	4302	59971	FC	HP/LP
114	FILTER	ITHACO	4302	59972	FC	HP/LP
115	TAPE RECORDER	HEWLETT-PACK	3964A	1925A01016	BU	4-CHAN
116	POWER SUPPLY	KEPCO	ATE 150-7M	F32789	FC	150V-7A
117	DIGITAL TEMP	OMEGA	2166A	8000174	1Y	TYPE K
118	DIGITAL TEMP	OMEGA	2166A	2000547755	1Y	TYPE K
119	ENVIRON CHAMBER	TENNEY	TR-40	10255	6M	TEMP/HUMID
120	OVEN	DESPATCH	LDB 1-69	108313	FC	400 DEGREE
121	OVEN	BLUE M	OV-18A	RP-1943	FC	400 DEGREE
122	ANALYZER	NICOLET	444A	8948425	1Y	FFT 1-CHAN
123	X-Y PLOTTER	TEKTRONIX	4662	B043979	FC	DIGITAL
124	COMPUTER	TEKTRONIX	4052	B022760	FC	DESK TOP

125	ANALYZER	ZONIC	6080	221	1Y 4-CHAN FFT
126	ADC SYSTEM	KINETIC SYSTEM			BU 14-CHAN
127	COMPUTER	DEC	11/70		FC DIV-02 SYST
128	CAMAC	STANDARD ENGR.	PS3742	2318	1Y HI-BAY SYST
129	COMPUTER	DEC	11/23	WF17625	FC HI-BAY SYST
130	TERMINAL/PRINTER	DEC	LA 120-DA	PND6533	FC 1200 BAUD
131	TERMINAL	TEKTRONIX	4006-1	B036557	FC GRAPHICS
132	HARD COPY	TEKTRONIX	4631	B184635	FC THERMAL
133	COUNTER	HEWLETT-PACKAR	5300B/5304A	3075/2990	6M FREQ/PERIOD
134	DIGITAL MULTIMET	HEWLETT PACKAR	3465A	1546A04548	6M 4&1/2 DIGIT
135	OSCILLOSCOPE	TEKTRONIX	RM561A	8347	6M RACK MOUNT
136	SCOPE PLUG-IN	TEKTRONIX	3A74	5832	6M 2-CHAN
137	SCOPE PLUG-IN	TEKTRONIX	2B67	9473	6M TIME BASE
138	SCALE	OHAUS	20KG45LB	5485	6M 45 LBS
139	T/H RECORDER	SERDEX	E 1275	227042	6M 7-DAY
140	TEMP RECORDER	AMPROBE	LT 8100	1	6M STRIP CHART
141	TEMP RECORDER	AMPROBE	LT 8100	2	6M STRIP CHART
142	TEMP RECORDER	AMPROBE	LT 8100	3	6M STRIP CHART
143	ACCELEROMETER	ENDEVCO	2262-1000	AM 96	6M 1000G
144	DIGITAL MULTIMET	WESTON	4442	849	6M BATT POWER
145	OVEN	DESPATCH	LDB 1-69	108318	FC 400 DEGREES
146	COLD CHAMBER	WARD	FFT803400A	478-02822	FC 0 DEGREES
147	T/H RECORDER	WILH. LAMBRECHT	252 UA	482010	6M -30+130F, 0-
148	HUMIDITY METER	BECKMAN	HUMI-CHEK2		6M 20-90 PER C
149	DIGITAL TEMP	OMEGA	199KC-A-DS	26951	1Y PORTABLE
150	RECORDER	OMEGA	141	B002774	6M 1-CHAN
151	DIGITAL TEMP	OMEGA	199KC-A	25692	1Y HEL LAB OVE
152	DIGITAL TEMP	OMEGA	199KC-A	25694	1Y HI-BAY OVEN
153	RECORDER	OMEGA	141	B002601	6M 1-CHAN
154	IMPLUSE HAMMER	PCB	208A03	2922	BU KIT

C

APPENDIX F

TEST FIXTURE AND COMPONENT MOUNTING

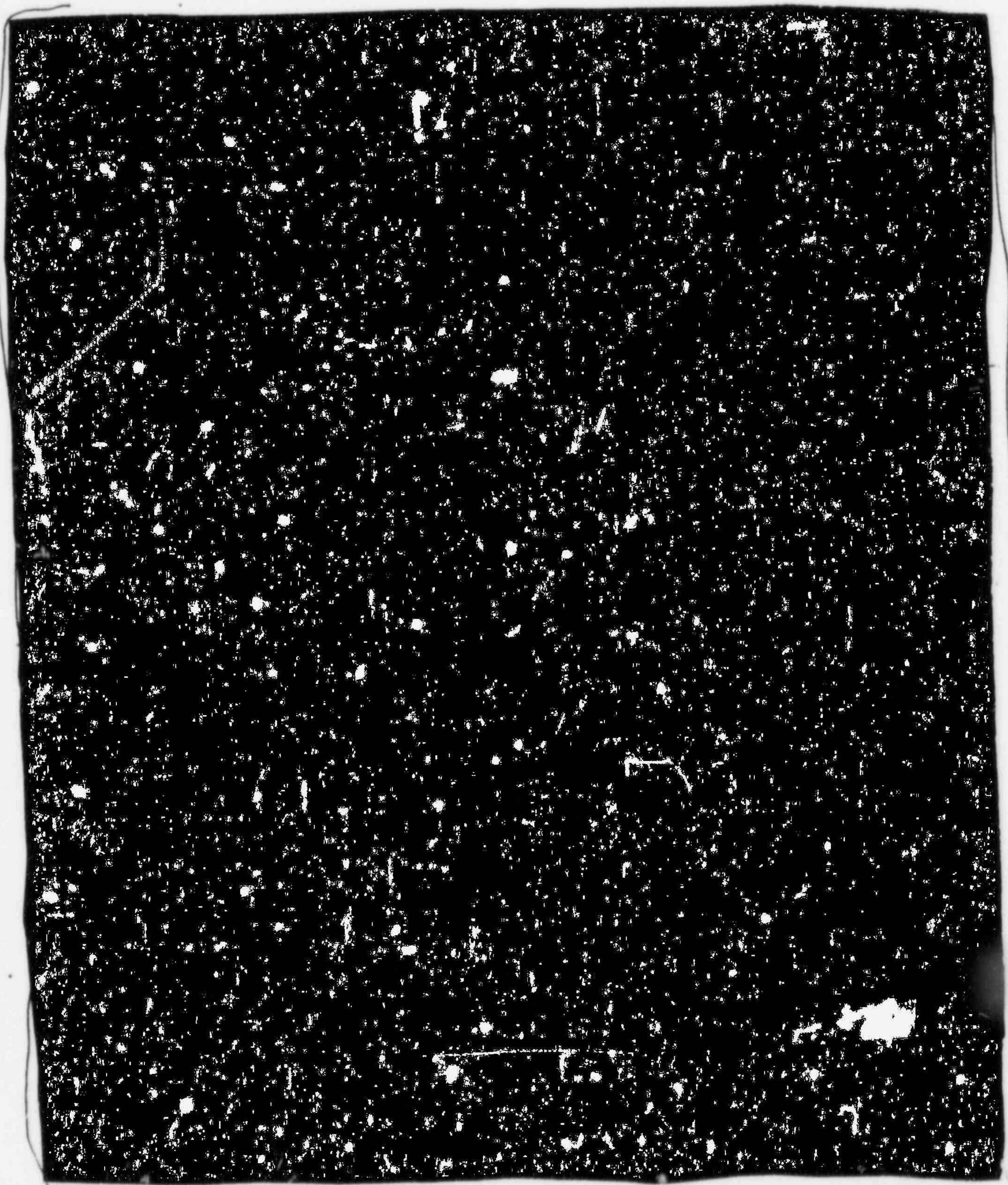
nutech

San Jose, California

Project Grand Gulf Nuclear Station and Clinton Nuclear Station

Owner Mississippi Power and Light Co. and Illinois Power Co.

Client Mississippi Power and Light Co. and Illinois Power Co.



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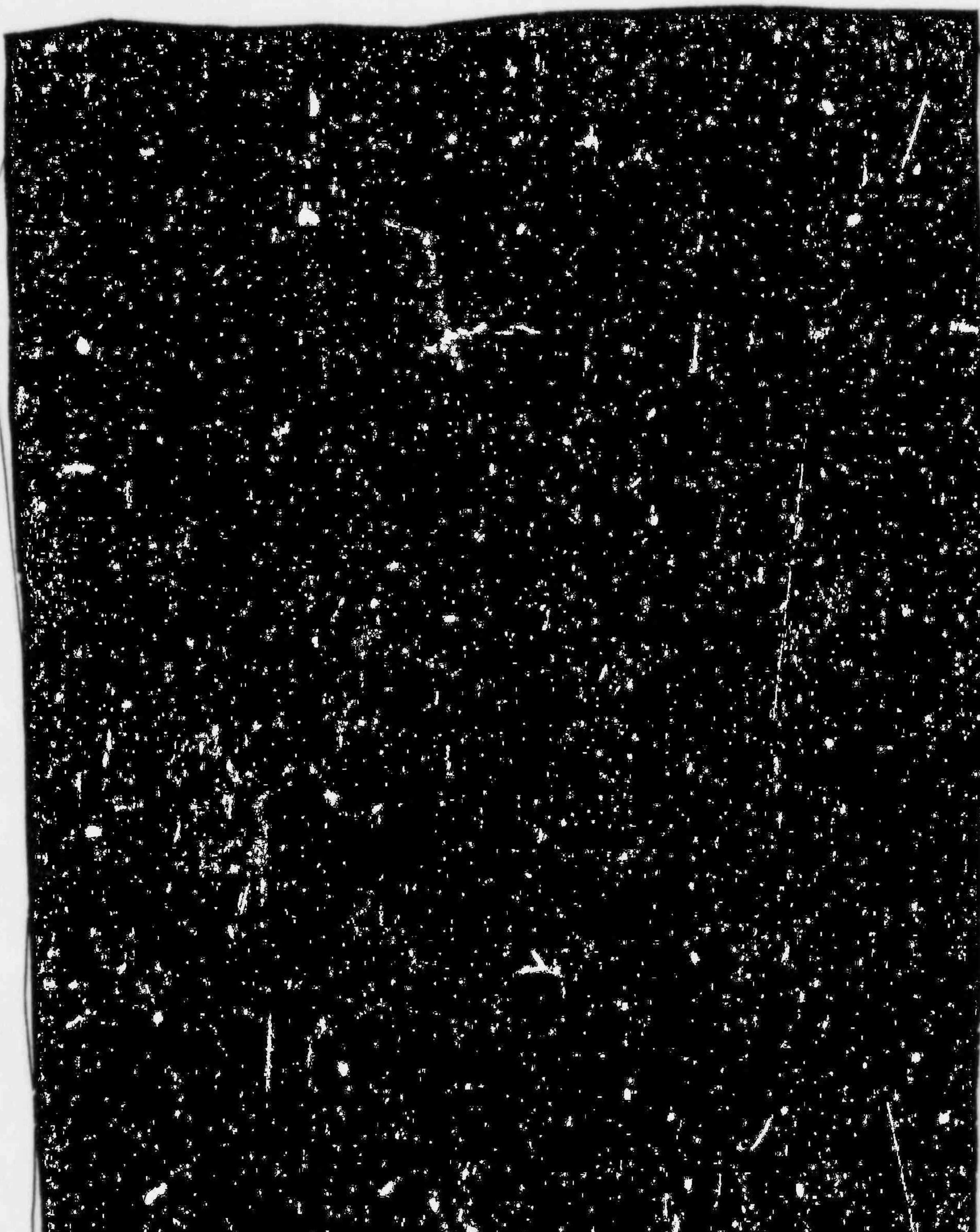

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San Jose, California

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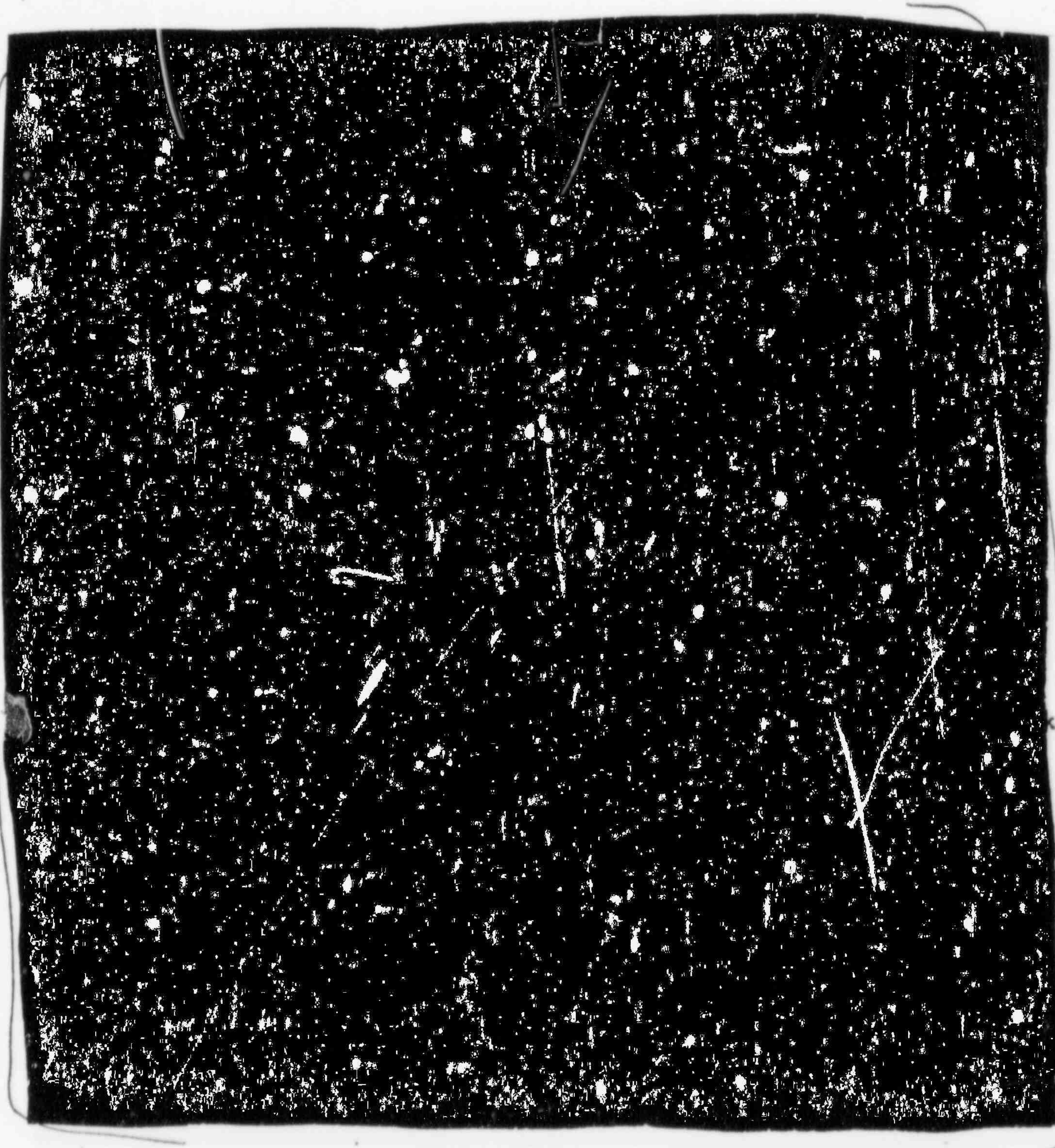

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