*Bell, Frank.
Please read. This
is mostly nonsense.
See me Jim D.*

WANL-TME-244

From: Ground Support Engineering

Date: January 10, 1963

Subject: Aerojet-General Corporation
Report No. 2325

ASTRONUCLEAR LABORATORY

To: Mr. A. M. Poindexter

Reference: (I) Aerojet-General Corporation Report No. 2325, "NERVA
Post-Operative Requirement and Support System Utilization,
Second Rough Draft, dated October 23, 1963

I. Introduction

Sections of reference (I) were submitted to WANL for review and the
following comments are noted.

The information submitted does not reflect any changes necessitated due
to modification of the E-MAD facility, phase II design from the original criteria.

II. Sections Submitted to WANL

The sections submitted to WANL for review were the following:

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Section IV, pages 3 through 15

Section IV, pages 24 through 27

Section V, page 1

Section V, pages 6 through 9

Section VI, pages 1 through 3

Section VI, page 7

Section VI, pages 10 through 40

Section VI, pages 47 through 53

Section VI, pages 57 through 68

III. Suggested Changes

WANL suggested changes which are consistent with previous communications have been indicated by underlining in or noted deletions in the following pages which are attached:

Section IV, pages 3 through 6

Section IV, pages 8 and 9

Section IV, pages 12 through 15

Section V, page 1

Section V, page 6

Section V, pages 8 through 11

Section VI, pages 1 through 3

Section VI, page 26

Section VI, page 34

Section VI, page 48

Section VI, page 53

Section VI, page 60

Section VI, pages 62 and 63

IV. Drawings

A copy of a suggested modified version of preliminary sketch V-B-1 is enclosed.

A. J. Svasek
Ground Support Engineering

AJS/kes

Enclosure

B. REQUIREMENTS FOR POST-OPERATIVE ANALYSIS OF NERVA REACTOR COMPONENTS

An intensive examination and test effort, after completion of static tests at NRDS, is required in order to develop a reliable, light weight, and high-performance NERVA reactor in a time consistent with the current NERVA Program Schedule.

The Los Alamos Scientific Laboratory (LASL) KIWI Post-Mortem Program has been used as the basis for determining the required NERVA Reactor (Fuel elements) Post-Operative Examinations and Tests. A brief description of the currently planned NERVA Post-Operative Analysis, referenced to a B-4 type core, follows (other core configurations will require an appropriate analysis):

1. Visual Inspection

Each individual fuel element will be cross-checked for its serial number and core location and then its exterior surfaces inspected for imperfections. In addition, all large components, i. e., control drums, graphite barrel, reflector segments, etc., will undergo a visual inspection and a sampling of small reactor components, i. e., graphite tiles, springs, etc., will be visually inspected. If any reactor component indicates any particular effects of interest, it will be set aside for later detailed inspection.

In its simplest form, visual inspection involves thorough examination, perhaps with the aid of binoculars, a magnifying glass or other visual techniques.

2. Periscopic Examination

This examination will be used as a supplement to the visual inspection phase of the post-operative studies in order to investigate more fully the

surface imperfections of the core components and to evaluate more accurately the effect of the test. The cell assigned in this function must be equipped with periscope sleeves just above the cell windows and a periscope provided. Periscopes are usually equipped with objectives that permit viewing at two diameters and ten diameters.

It is expected that all defective reactor components uncovered during the visual inspection will be examined using the periscope.

3. Borescopic Examination

The flow holes of various core components will be borescopically examined to detect any changes that may have taken place during firing. The borescope will need an integral light source and, if possible, a camera attachment. A sleeve through the cell wall (scheduled for this function) will be required for the borescope installation. It is planned that the flow holes of all defective reactor components will be examined and photographed by this method. Defective reactor components may be determined by periscopic examinations, visual inspection, flow testing or gross gamma scanning.

4. Stereomicroscopic Photography

Stereomicroscopes are capable of indicating the relative depth of shallow holes, cracks and other flaws and as such are considered as required tests. The stereomicroscope, in addition to being equipped with magnification capabilities, will be equipped with a camera attachment. This unit will permit photography in order to retain, for off-site inspection, a picture of the surface defect. It is expected that all defective components uncovered during the visual inspection and verified as defective by periscopic examination would be photographed by this technique for later analysis.

5. Ultrasonic Inspection — *about 7 min*

In fuel element examination, ultrasonic inspections are especially useful and required where the gamma emission may cloud the film in the radiography. It is expected that all fuel elements will be ultrasonically inspected to detect any subsurface imperfections caused by the firing. In addition, all suspect reactor components will be checked ultrasonically.

Ultrasonic test instruments utilize high frequency sound waves produced by applying an alternating current voltage of suitable frequency to a quartz crystal. Quartz is a piezoelectrical substance, therefore, a change in dimensions of the crystal, as produced by an applied force, will result in generation of a voltage. In the reflecting type instrument, the sound input is converted to a visual signal on a cathode-ray oscilloscope. A reflection from the far surface of the part being examined also shows up on the oscilloscope, but at the far end of the sweep. A defect between the surface where the sound beam enters and where it is reflected shows up as a pip between the input signal and the reflected signal. Since the velocity of the sound is constant in a given metal and since it travels in a straight line through the metal, the distance from the input signal to the pip and from the pip to reflected signal locates the discontinuity. The size and character of the pip indicates the size and character of the defect. Reflection type ultrasonic testing instruments are flexible and portable, therefore, this method provides a thorough means of internal examination.

6. Dimensional Checks

This examination will determine any dimensional changes due to the firing. This will be accomplished by comparison of the pre-test and post-operative dimensions. The post-operative cell will be equipped whereby dial indicator

readings of the dimensions may be obtained for all reactor components. It is proposed that all of the fuel elements be checked to determine the length and the distance across the flats.

7. Flow Testing

It is expected that all of the fuel elements will be tested in order to determine the roughness and friction factors of the flow holes, using an instrumented air flow loop. SECTION DELETED

There may be a need to air flow test the orifices after high power operation to determine if any changes or distortions occurred due to radiation or the thermal gradients. This test will follow an inspection in order to determine the breakage rate of the fuel element orifices. All fuel elements will be tested and all other reactor components having passages.

8. Weighing

This examination is necessary to determine any change in the weight of the component due to oxidation, hydrogenation, irradiation, corrosion, etc., that has occurred since the pre-test evaluation. A sensitive balance will be used and the weight will be indicated on a digital read-out.

It is proposed that all of the fuel elements be weighed and cross-checked with pre-test weights. All other components will be sampled selectively to evaluate any changes in weight.

9. Gamma Scanning

There are basically two types of gamma scanning presently in use for analyzing the KIWI cores and they are gross and incremental. Both types are required for evaluation of NERVA cores.

a. Gross Gamma Scanning

Gross Gamma Scanning utilizes an ionization chamber in which

by the scattering of x-rays and by the lack of parallelism in the radiation emitted from the source. Therefore, the radiography to detect successfully the presence of a void, the void should represent at least three percent of the thickness of the metal, measured in the direction of the radiation. The x-ray equipment usually lacks portability.

The variations of the x-ray exposure of the film will be interpreted concerning subsurface imperfections and by comparison to the pre-test x-ray; thus, it is currently planned that all fuel elements will be examined by this technique and selected sample of the other reactor components.

11. Autoradiography

Autoradiography provides a photographic record of the power distribution, hot spot location, etc., within the fuel element.

Testing using autoradiography is presently being performed on the KIWI cores at LASL. The test utilizes the fact that the gamma activity of the fuel element can be used to expose a gamma-radiation sensitive photographic film, the greater the exposure, the greater the activity of that section of the fuel element. The exposure can be read and automatically recorded and interpreted outside of the hot cell area. It is expected that the fuel elements of the entire core will be tested using autoradiography.

12. Machining

The machining of specimens such as tensile bars, impact bars, etc., from the various reactor components for further post-operative examination and tests is required. The necessary equipment includes a cut-off machine, a lathe, and a milling machine, all of which will be operated remotely from outside the cell. The lathe and milling machine may be used in conjunction with templates to provide for ease of operation as well as accuracy of results.

13. Sectioning

Metallography and Microhardness Testing require preparation of test specimens. This is accomplished by sectioning, polishing grinding, mounting, etc.

14. Hardness

a. Microhardness

It is proposed that all of the metallograph specimens by microhardness tested to determine the hardness of various grain boundaries.

The principal uses of microhardness testers are measuring the hardness of constituent particels in alloys, thin surface-hardened layers, fiols, single grains, interfaces and diffusion zones, etc. Both the Knoop and Diamond Pyramid tests are excellent for accuracy. A commercial remoted Tukon microhardness tester is available.

b. Hardness Testing

The testing of the hardness of the material will be accomplished in order to compare the pre-test and post-operative readings for an indication of any change in the component characteristics. Indentation hardness or resistance to localized penetration is widely used industrially as a measure of hardness, and indirectly as an indicator of other desired properties in a manufactured product. The indentation tests, through imperical relationships of hardness to such properties as tensile strength, fatigue strength and impact strength, will assist in detecting defects due to these properties.

It is proposed that one-twelfth of the reactor components will be examined to determine the tensile strength of the material.

16. Impact Testing

Impact Testing is primarily required on core materials to detect material changes which may have occurred during the test. Information such as radiation and hydrogen embrittlement are determined.

Most impact machines are designed so that they can be used for both Charpy and Izod impact tests. A typical machine consists essentially of a free-swinging pendulum, a rigid frame, and a vise or anvil for holding the specimen. Specimens for the Izod test are held in a vise at one end and loaded at the other, making this type of test a cantilever beam test. In the Charpy test, the specimen is supported at its ends of an anvil and is loaded as a simple center loaded beam. It is planned to test one-twelfth of reactor components.

17. Fatigue and Duration Testing

Fatigue testing will be accomplished on reactor components that undergo a constant stress cycle during the test.

Fatigue refers to the failure of materials under the action of repeated stresses. It is responsible for a large porportion of the failures occurring in machine parts. In fatigue testing, a specimen is subjected to periodically varying stresses by means of mechanical magnetic devices.

It is expected that about 100 specimens will be examined using this test. The possible reasons for failure are 1) Possible transmutation of an impurity, 2) the hardening effect of the radiation, and 3) the embrittling effect of radiation.

18. Stress Rupture Testing

The stress rupture test measures the creep of a material.

The test is conducted by applying a dead weight to one end of a level system, the other end being attached to the specimen surrounded by a furnace and thereby held at constant temperature.

The difference in the modes of fracture between the pre-firing and the post-operative testing are compared for determining embrittlement or weakening of the material. It is expected that specimens will be machined from the fuel elements, barrel, outer reflector, inner reflector, etc.

19. Thermal Expansion Testing

The thermal expansion of the irradiated core materials may be determined by this test. It is possible that the coefficient may change due to irradiation. The use of a commercial dilatometer limited to 1000C and recording the coefficient directly on paper is planned. Approximately one-twelfth of fuel elements will be tested.

20. Thermal Conductivity Test

The difference of the thermal conductivity between the pre-test and the post-operative results are compared.

The fuel elements require high thermal conductivity, whereas the pyrolytic tiles, in one direction, require very low thermal conductivity.

It is expected that 3 to 6 samples from each reactor component, where thermal conductivity is an important factor in the design, will be tested.

21. Coefficient of Friction Determination

It will be desirable to compare the pre-test and post-operative results since changes are suspected in the surface conditions of some materials.

It is expected that 3 to 6 samples, from each component where rubbing action is expected in the B-4 core, will be examined.

22. Radiochemistry

The purpose of this test is to determine the fission distribution in selected fuel elements from the core following the power transients. The test will provide an absolute calibration for the subsequent power mapping of the reactor core.

The most critical unknown in power mapping a reactor core is the proportionality constant between radiation intensity and number of fissions. Radiochemical analysis offers an excellent means of determining the absolute number of fissions.

Approximately 30 fuel elements will be selected for radiochemical analysis and these will be pulverized. Certain fission products are retained in the fuel elements. Quantitative analysis will determine the amounts of these retained fission products present in the pulverized elements. Then, knowing the fission yield of these fission products, one can determine the total fissions which occurred in the fuel element during operation. The proportionality constant between radiation intensity and number of fissions can be determined from this data and previous radiation level measurements. Since ranges of fission products are extremely short, analyzing the individual element segments will determine the axial fission distribution as well as the radial. In addition, detailed radiochemistry will be performed on at least one sample from each material in the core to determine any nuclides formed

during the test. This is necessary due to the fact that the formation of the nuclides may adversely affect the physical characteristics of the material.

23. Metallography

Metallography is the science dealing with the constitution and structure of metals and alloys as revealed by the unaided eye or by such tools as low-powered magnification, optical microscope, electron microscope, or x-ray diffraction techniques.

After sectioning, the sample is mounted in a plastic resin to provide ease of handling. Then the sample is ground to a 600 grit finish and later polished to obtain a scratch-free surface. The polished sample is viewed using a metallograph and any pores, cracks, or flaws are photographed at a suitable magnification. The sample is then etched to reveal the structure and again examined using a metallograph. Photomicrographs may again be obtained at this time.

At the present time, it is expected that representative portions of one-sixth of the reactor components plus defective parts will be examined utilizing a remote operated metallograph.

24. Corrosion Hydrographic Studies

The effects of various conditions to which the components might be exposed will be determined using corrosion hydrographic studies, i. e., exposure of the materials under controlled pressure, temperature, time and various gaseous atmospheres and measurements of moisture content. This test may be more properly called environment testing.

V. POST OPERATIVE OPERATIONAL FUNCTIONAL CONCEPT

A. INTELLIGENCE MOVEMENT AND SCHEDULES

1. NERVA Reactor Components

In order for the information obtained from the post-operative analysis of the B-4 NERVA Reactor Components to be useful to the design effort and to prevent time wasting backlog of unanalyzed reactor components, the duration of time for the examination of reactor components must be the same of less than the time interval between tests. In addition, the validity and usefulness of some tests and measurements are dependent upon rapid performance after a firing, e. g., decay information obtained from foil materials, ~~SECTION DELETED~~ must be determined within a few days after a firing. Initially the tests are four weeks apart, however, during the full-scale NERVA Program Test Operations at NRDS, tests are scheduled every two weeks. This test schedule permits the initial core analysis work to extend over a four week period during which techniques, procedures and equipment are being refined and proven and the capability for handling a core analysis in two weeks is being developed. The magnitude of the work and the required schedule, precludes the use of a normal scientific test techniques and procedures to evaluate the NERVA B-4 reactor components. The solution and transfer system must then be capable of speed and efficiency. Proficient personnel and well defined techniques must be utilized to the fullest extent to achieve the defined program schedule.

B. SEQUENCE OF POST-OPERATIVE ANALYSIS

1. NERVA Reactor Components

The sequence of reactor component post-operative analysis is graphically depicted in Preliminary Sketch V-B-1 "Preliminary Post-Operative Procedure for NERVA Reactor Components (B-4 Core)." This sequence is referenced to the post-operative analysis B-4 core. The deviations imposed on this plan by other core designs cannot be determined from the currently available information.

Upon receipt of the B-4 Reactor Components from the Core Disassembly Cell (127), ~~SECTION DELETED~~ the post-operative examination begins with a gross visual inspection. Finer visual inspection takes place at the periscope examination work station where possible defects are sorted out and transferred to the borescope and stereomicroscope stations for detailed surface examinations. Components determined acceptable by the periscopic examination are sequentially fed to the ultrasonic, flow testing, weighing, gross and incremental gamma scanning, X-ray and auto-radiography stations. For the remaining post-operative analysis, portions, rather than the entire reactor components, are examined and tested. Therefore, the reactor components are machined and/or sectioned into the appropriate specimens. Machining prepares the specimens for destructive tests to include; hardness, tensile, impact, fatigue, stress rupture, thermal expansion, thermal conductivity and coefficient of friction. ~~SECTION DELETED~~ Sectioning prepares the specimen for metallography and microhardness testing.

SECTION 10 (1014035)
to a predetermined level, the NERVA engine parts move into the post-operative area. ...Additional breakdown of the parts is required during post-operative analysis and will normally take place in the post-operative work area. As an example, in the referenced plan valves will be removed from the engine in the main bay and large bay cell and disassembled in the post-operative cells.

1. NERVA Reactor Components - The radiation level of the reactor components after a normal test, as seen in the radiation data in Section IV, is of sufficient magnitude to dictate remote handling. The shielding must be sufficient to attenuate the total radiation to the operators to levels below AEC and Industrial requirements.

After core disassembly, the reactor components are sequentially fed through non-destructive testing. Conveyors are utilized when practical for sequential feeding to examination fixtures and machines. Post-Operative examination and tests are grouped or clustered about the shielded leaded glass viewing windows which offer the premium remote operating area. This is because there are distinct advantages of direct vision through the shielded window as compared to indirect vision by television, periscope, etc. In addition, transfers and movements of reactor components are best facilitated by direct viewing; therefore the area about the window

must be efficiently used. For this reason areas away from the cell windows are used for sequential feeders and larger instruments and examinations not requiring refined operation. Removable shielding partitions are required between work areas. In order to provide a low radioactive background level for various operations, such as radiography and gamma scanning, and to facilitate changes in test fixtures, personnel entry into the various work stations under Rad-Safe control for various functions, such as maintenance of equipment, must be accomplished without interference to the adjacent work stations and operations.

Intercell movement of reactor components is effected by conveyors direct to the examination or test fixture or via an intercell railroad. The latter also is capable of travel into the core disassembly cell and is capable of feeding all work stations and maintaining parallel flow of reactor components. Series flow is also necessary to provide for defects, reexamination, calibration and other reactor component movement counter to parallel flow. Series flow also provides the flexibilities required to alleviate congestion at high load centers. In addition, series flow facilitates equipment changes without interference to the remaining operations. This feature permits multiple use of work stations for a number of post-operativd evaluations.

After completion of non-destructive testing, specimens prepared for destructive testing are transferred to destructive testing areas utilizing the parallel movement capabilities. Series flow is required for removal of the radioactive waste from the specimen preparation and destructive test work stations. Protective shielded containers are required for removal of the radioactive waste in order to prevent spread of contamination outside the cells.

VI SUPPORT SYSTEMS IMPLEMENTATIONA. POST-OPERATIVE ANALYSIS LOAD DISTRIBUTION1. NERVA Reactor Components

Post-operative load distribution has been established for each cell 160 to 165 and 174 to 179 by estimating the time for each B-4 core reactor component operation and multiplying by the number of components to be examined. The time estimates for the actual testing whenever possible, have been based on existing similar nuclear inspection operations, especially the LASL, KIWI post-mortem inspection. The production line techniques have been assumed; therefore, set-up time, transfer time, hold-up and other type delays not normally occurring in an efficient production-type flow have not been estimated. This assumption makes the estimate extremely optimistic, especially for the initial operation at NRDS.

Non-production time would include calibration, re-test due to inconsistent data and time lost by the operator. A summary of the NERVA post-operative fuel cells 160 to 165 is shown in the attached tables . ^{SECTION DELETED} Based on the requirement of completion of testing in 2 weeks during full scale operation (established in Section V-A) all cells are overloaded. Fortunately, an average of 7 weeks is permitted initially for intelligence feedback to design. This initial loose schedule will permit refinement of production line techniques. There are several methods of operating within the schedule. In the case of the larger discrepancies in the time estimates shown in the attached tables , incremental gamma, x-ray, machining and sectioning, is to either increase the productivity of the equipment or to add parallel equipment. The latter is the more acceptable since the equipment utilized in these tests are, for the most part, standard and/or can be patterned after existing proven prototypes such as the LASL incremental gamma scanning instrument currently in use on the KIWI program.

PRELIMINARY

Another method is to increase the work day from two 8-hour shifts to two 10-hour shifts. The latter has been found, for somewhat similar operation, to represent an operating - maximum effort. A third method includes general efficiency equipment improvements, etc. which cannot be realistically estimated with current information.

The work load of NERVA reactor component post-operative cells 160 to 165 appears compatible with the required schedule only under optimum and maximum conditions during peak work load. It should be remembered that the portion of the B-4 core that will be examined is not expected to change significantly during the program. The purpose or reason for examination varies as the program progresses.

In the destruction test cells, number 174 to 179, high-production techniques, for the most part are not practical. The reasons are many, however, special items, such as equipment and inspection technique, are not comparative and the test procedure often varies considerably from test to test; for this reason, it is impractical to assume a full production line concept and the estimating technique used above for cells 166 are not applicable. The time estimates are presented in the attached tables _____.

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PRELIMINARY

SECTION DELETED

Utilizing this data and assuming a nominal setup time, which would include all pre-test and post-test operation, cleanup, recalibration, etc., of 1 to 2 hours, the full loading of cell 174 to 179 is immediately evident.

The load distribution denotes the need for 13 post-operative cells; seven of which are required for physical examination and specimen preparation and six for destructive test.

B. SUPPORT EQUIPMENT

The fundamental support equipment necessary to perform the required post-operative analysis, based on the reference plan described in Section IV, is tabulated and briefly described in this section.

The equipment list presented below is as detailed and complete as present experience permits. The planning has been organized to allow sufficient flexibility to accommodate any required changes generated as a result of additional experience gained in the NRX and E-engine programs. The fundamental support equipment has been arranged into functional work areas to facilitate spatial planning (Preliminary Sketches VI-C-1, 2, 3, & 4). In addition, the equipment descriptions are supplemented by envelope dimensions provided in Preliminary Sketches VI-1 & 2 and in Preliminary Tables VI-B-1.

(Excluded from this draft, reference REON Letter L741_0027, dated 31 July 1962, these data will be updated and included in final draft.) For clarification, cell numbers 160 through 166 and 167 through 171 are the same numbers employed by Vitro in the preliminary design Sketches 1425-R-18 for the reactor component and metal parts cells. Cell numbers chosen within this text 174 - 179, 172, 173, and warm area 180 - 186 define requirements for reactor component, metal parts and warm area heretofore not delineated.

The physical features and functions described in the following have been arranged according to post-operative work area and/or cells. The reactor component work areas are first; then the NERVA metal parts post-operative areas are described.

1. Cell 160 Equipment - The equipment to be installed in Cell 160, based on the Reference B-4 Core Plan, is as follows:

a. Work Table - This unit may be attached to the inside front wall of the cell or be parts of the equipment car. It will be utilized in loading and unloading reactor components from the transfer car and for component location. It will be in front of the cell windows for the width of the cell and be $2\frac{1}{2}$ feet deep. A section of the table, approximately 24 inches by 54 inches and mirrored on the underside so that transfer operations can be viewed, will be hinged. When this section is opened, the reactor component to be examined will be unloaded from the transfer car and lifted up through the hole and placed in the cell on stands or fixtures.

b. Equipment Car - Two of the basic units will have all of the examination equipment of this post-operative cell mounted upon them. This will allow the equipment to be removed or inserted into the cell with a minimum of down time required to replace or change cell equipment.

(1) Function and Alternates - During normal operation it is expected that equipment must be relocated, removed, or inserted due to the change in emphasis on various examinations conducted in the hot cells. Due to the need for production line examination procedures, it is necessary to perform these changes efficiently in the shortest period of time and with minimum personnel radiation exposure.

The system uses an equipment car with a built-up bed section especially designed for the equipment needed in that specific cell. All of the equipment is securely fastened to the bed of the equipment.

5. Cell No. 16⁴ Equipment - The equipment to be installed in Cell No. 16⁴, based on the References B-4 Core Plan, is as follows:

- a. Work Table - This is described in detail in section II.A.5.a.
- b. Equipment Car - One unit is required and it is described in subparagraph 1.
- c. Electrically Operated Transfer Car - As many as four of these units will operate on the transfer system and the unit is described in subparagraph 1.
- d. X-ray - There will be one x-ray unit in the cell.

Radiography or x-ray is a non-destructive method of internal examination in which materials are exposed to a beam of x-rays.

The reactor components are positioned on thin wires over a plastic case. The film is then passed through the front cell face and positioned under the component. The x-ray unit is positioned above the reactor component, and is mounted so that it can move from the front to the rear of the cell. After it is exposed, the film is removed and forwarded for developing and interpretation.

The air-tight plastic case for the film and the unit for supporting the component will weigh 60 pounds. The entire unit will be remotely operated. The in-cell dimensions will be 20 inches wide by 80 inches long by 20 inches high.

- e. Autoradiography - There will be one of these units in the cell. This test utilizes that fact that the gamma activity of the fuel

and also an indexing mechanism of 90 degrees in either direction of the vertical position. The vise and all clamping devices for the specimens will be capable of being operated by the master/slave manipulators.

All controls for the unit are to be located in a mobile console which will be located in the operating gallery. The space envelope for the in-cell unit is 60 inches long by 60 inches wide by 84 inches high, however, in order to move the milling machine into a cell from the cell service area, the vertical spindle or head can be positioned so that it will pass through the rear door.

The maximum time expected for machining a specimen from a reactor component is about one hour.

10. Cell No. 176 Equipment - The equipment to be installed in Cell No. 176, based on the Referenced B-4 Core Plan, is as follows:

- a. Work Table - This unit is described in detail in subparagraph 1.
- b. Equipment Car - One unit is required and it is described in subparagraph 1.
- c. Electrically Operated Transfer Car - As many as four of these units will operate on the transfer system and the unit is described in subparagraph 1.
- d. Pulverizer - There will be one unit of this type positioned in the cell. It will be utilized to crush and grind one complete fuel element at a time. The powder will be removed under air pressure using the cyclone transfer after passing through a sieve to insure the particle

Cell Number Remote Operation	Functional Floor Area Envelope Dimension
176	8' x 11' 3"
177	8' x 11' 3"
178	8' x 11' 3"
179	8' x 11' 3"
180	16' x 15'
181	16' x 15'
182	16' x 15'
183	16' x 15'
184	12' x 15'
185	42' x 35'
186	12' x 35'

The rectangular dimensions above represent modules rather than fixed room sizes. A modular concept is essential in order to permit flexibility of a work area to encompass one or several work stations as the loading of the program changes. Spatial flexibility can be achieved by removable partitions between work areas. The shielding requirements of work area envelopes, including the partition, is given in Section VI-D.

In addition, flexibility is obtained by similarity of reactor component and metal parts cells. Therefore, over loads in one area can be partially or totally absorbed by other areas. Cell functional opening sizes and clearances can be readily obtained from preliminary sketches VI-C-1, 2 and 3.

The height of the cell openings are determined by the movement of equipment and materials. From the sketches, the need for an 8-foot clearance is evident due to the x-ray unit, stress rupture, and tensile tester sizes. The movement of material also indicates a need for an eight foot high clearance,

- e. The cost of modifying the existing facilities at locations other than the E-MAD facility may be significant, for example, large holes in the cell walls may be necessary to accommodate various equipment such as periscopes, borescopes, etc.
- f. The disposal of scrap material, such as turnings from fuel elements, may be a problem at certain locations, whereas, at the E-MAD facility a waste disposal area will be provided.

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Within the complex, the non-destructive analysis cells 160 to 171, should be located together with a common service area. This permits interchangeability of equipment to accommodate the change work loads.

Further, cells 160 to 171 should be adjacent to E-MAD disassembly cell 127 and 130 because the main flow of post-operative materials are from these cells.

The cells accommodating the post-operative destruction testing (number 172 to 179) are desirable to have adjacent to cells 160 to 171, however, this is not essential because specimens are, for the most part, the only flow and handling procedures and package techniques for radioactive specimens are normal operative procedures at radiation facilities throughout the country.

Similarly, the warm area need not be physically attached to the hot cells; however, there is a larger volume of flow and the materials (engine components) are more difficult to package. Therefore, from a logistics consideration, the warm area should be near hot cells 160 to 171 and a rapid means of transportation provided for heavy engine components.

air flow test. The control should be a manual valve located on the gallery side of the wall. The outlet side within the cell should be equipped with a quick disconnect coupling and a pressure of 100 psi through a 3/4 of an inch line should be satisfactory.

e. Gas Line (Nitrogen, Helium, Steam, Etc.) - These lines are necessary to supply various gases, air and hydraulic fluid to the cells. Their primary uses are the post-operative flow, leakproof, and some pneumatic tests. The lines will be installed through the walls, however, they will not be connected but will be capped on both sides of the wall.

f. Amphenol Connectors - This requirement is to provide the wiring connection between the gallery and the inside of the cell. This wiring will be used to transmit signals for test equipment and it is not for electrical power or already provided electrical controls. It is suggested that provisions be made for 20 pin connectors and 10 connectors per cell.

g. Intercommunications - Intercommunications systems service, an extension of main area, is required for coordination of post-operative operations.

h. Manipulator Sleeve - Sleeves must be provided at each window station for a pair of Model 8, extended reach, heavy duty, master/slave manipulators.

i. Periscope Sleeve - Sleeves must be provided for the insertion of periscopes. The periscope will probably be Kollmorgen Model 301 or equivalent. The opening required is a 9 inch thru-hole with a 10 inch step on the gallery side. A height of 7 feet is recommended, placed about two to three feet from the viewing windows.

p. Steam Line - This utility should be provided in the gallery in front of the post-operative cells with capped tees pointed upward provided in front of each cell. This will facilitate easy piping at a later date when it is needed in a specific hot cell.

q. Railroad Tracks - The tracks are necessary in order that they may be utilized in moving the cell equipment using the equipment car. The rails shall be standard 4' 8" apart, and of the girder type which has been standardized throughout the remainder of the E-MAD facility. The centerline of the tracks should be the same as the centerline of the rear door of the post-operative cell. It is not necessary that the cell window centerline and the railroad track centerline be the same. Railroad linkage to cells 172 to 179 if remote from cell 160 to 171 should be provided as well as rail extensions to the warm area and decontamination areas.

r. Stereomicroscopes - The provisions for stereomicroscopes are 10 inch thru-holes with a 12 inch step on the gallery side. SECTION DELETED

s. Pass-Thru Drawers - Pass-thru drawers are required to accommodate package of tools, instruments and other gear about six (6) inches in diameter and two to three feet long into the cell from the operating gallery. The location in the post-operative complex requiring the discussed above are as follows:

<u>Area</u>	<u>Services</u>
operating window of cell 160 to 179	a to i, k, o to q
rooms 180 to 186	
cell service area	a, d to g, k, n to o
cells 163, 164, 167, 168	l
<u>windows W-101, W-102, W-103, W-104,</u> <u>W-105, W-106, E-102, and E-104</u>	j

<u>Area</u>	<u>Services</u>
cells 161, 165, 168, 170, 172, 175, 177	s
cells 160, 165, <u>166</u> , 168, 170, 173	r

3. Control

a. Control Plug for Transfer Car - A transfer car system for transferring the core and metal parts components from cell to cell is planned. In order to operate this unit from any post-operative cell window, it will be necessary to control the transfer system from a movable console, therefore, the control panel at each window should have a plug for this unit.

b. Cell Receptacle Control - 110 VAC - A 110 VAC receptacle located in the cell should be separately controlled from a console in the gallery. This allows each piece of equipment to be remotely shut off independently of the other units in the cell.

c. Cell Receptacle Control - 220 VAC - A 220 VAC receptacle located in the cell should be separately controlled from a console in the gallery. This allows each piece of equipment to be remotely shut off independently of the other units in the cell.

d. Cell Receptacle Control - 440 VAC - A 440 VAC receptacle located in the cell should be separately controlled from a console in the gallery. This allows each piece of equipment to be remotely shut off independently of the other units in the cell.

e. Receptacle - 110 VAC - Receptacles located in the gallery are necessary to use certain equipment outside the cell.

f. Receptacle - 220 VAC - Receptacles located in the gallery are necessary to use certain equipment outside the cell.