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GENERAL STANDARDS GUIDE FOR EXPERIMENTS IN ORNL RESEARCH REACTORS

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ORNL-TM-281

Contract No. W-7405-eng-26

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Paper presented at Conference on
Light-Water-Moderated Research Reactors
June 11-14, 1962
Gatlinburg, Tennessee

Date Issued

AUG 20 1962

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GENERAL STANDARDS GUIDE FOR EXPERIMENTS IN ORNL RESEARCH REACTORS

Compiled by C. D. Cagle
from Existing ORNL Procedures,
Practices, and Regulations

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GENERAL STANDARDS GUIDE FOR EXPERIMENTS IN ORNL RESEARCH REACTORS

ABSTRACT

The Oak Ridge National Laboratory has three general-purpose research reactors which accommodate testing loops, target irradiations, and beam-type experiments. Since the experiments must share common or similar facilities and utilities, be designed and fabricated by the same groups, and meet the safe safety criteria, certain standards for these have been developed. These standards deal only with those properties from which safety and economy of time and money can be maximized and do not relate to the intent of the experiment or quality of the data obtained.

The necessity for, and the limitations of, the standards are discussed; and a compilation of general standards is included.

GENERAL STANDARDS GUIDE FOR EXPERIMENTS IN ORNL RESEARCH REACTORS

INTRODUCTION

This report represents a first attempt to collect into one document the general standards required in the preparation, operation, and disposal of equipment for reactor experiments at ORNL. The need for some of these standards was self-evident and have been requirements since the research program began; the need for others, although seemingly self-evident, has become apparent as a result of experience.

When only the Graphite Reactor and the Low-Intensity Test Reactor were in operation, the number and the degree of complexity of reactor experiments were both relatively low; therefore, only one person in the Operations Division was required to assist experimenters both in developing designs that were acceptable to the Reactor Experiment Review Committee and in handling operational problems after installation of the equipment. This arrangement generally guaranteed a standard approach to design and operating problems. Since the Oak Ridge Research Reactor was started up, however, the problem of liaison between Operations and the experimenters has become so complex that several people are required to handle the detailed portion of the work. In order to maintain a standard approach to design and operating problems, the Operations Division technical personnel assisting the Operations-Research Coordinator had to consult with him about even minor details. This necessarily introduced undesirable delays. In order to minimize the need for such close liaison, written standards have been developed.

The use of nuclear reactors as research tools has introduced some new practices in the performing of scientific experiments and engineering tests. Perhaps the greatest novelty has been the grouping of a large number of independent endeavors into one work location where they must use common facilities with as little interference as possible with one another. Such common facilities generally consist of the reactor, electrical power sources, radioactive and nonradioactive waste-disposal systems, compressed air, steam, water, working space, service personnel, radiation control

personnel, etc. Without certain standards, such an arrangement would necessarily be chaotic; and the hazards associated with research work in reactors would be very much amplified.

The general economy of performing tests and experiments is also enhanced by having established standards. This is reflected in the speed of maintenance, improved reactor operating time, smaller parts inventories, reduction of the frequency and severity of contamination incidents, savings in time spent in trouble-shooting and scheduled checking of safeguard systems, and other similar efficiencies. When much of the work associated with preparing and performing of the tests and experiments can be reduced to a routine--more time, money, and effort can be expended on just those parts which are unique to the particular work so that efficiency is further improved.

Most reactor experiment or test facilities and irradiation targets must, at least in part, be installed remotely and, therefore, require exceptionally careful planning, design, fabrication, and installation. The need for great care in design and fabrication is further amplified by the close tolerances required in the fitting of experiment adapters into the LITR- and ORR-type lattices so that the action of shim-safety rods is not hampered and fuel elements are not difficult to remove or to insert. In contrast with most other types of equipment where repairs may be made in the event of breakdown, if the in-reactor portion of any apparatus fails before completion of the test or experiment, it usually has to be discarded, causing great losses of money and time; therefore, quality standards must be high. Although rigid standards may seem to make initial costs somewhat high, the actual long-term economies are vastly enhanced.

In another light, standards represent the collective known experiences of personnel who have been associated with the type of work for which they are written and, therefore, lessen the impact of loss of experience as a result of personnel changes. It has been found that personnel, although experienced in related fields, tend to repeat the same mistakes made by others when planning, designing, fabricating, installing, and operating experiments in reactors. Written standards, carefully studied and used, should minimize such repetitions.

Some of the more common faults which the use of standard criteria are intended to prevent are:

1. Lack of sufficient information in the proper hands to allow coping with emergencies such as power failure, equipment breakdown, and unexpected variations of operating parameters;
2. Use of materials not compatible with the reactor environment or with the operating conditions of the experiment or test facility itself;
3. Use of unreliable mechanical, electrical, and electronic equipment and components;
4. Poor fabrication techniques, mistakes in the usage of materials such as welding rods, and poor inspection and testing practices;
5. Inadequate provisions for heat removal and for temperature and pressure control;
6. Inadequate or unreliable containment provisions caused by the use of containment shells, structures, or gaskets which will not withstand the pressure due to failure of a loop or other test facility and/or the lack of safe ventilation and off-gas cleanup arrangements;
7. Insufficient radiation shielding;
8. Use of wrong water supplies and drains;
9. Lack of adequate handling tools and portable radiation shields;
10. Failure to anticipate credible hazards and possible component failures;
11. Lack of consistent, safe operating and servicing procedures;
12. Setting of safeguard-instrument trip points beyond the bounds of safe operation;
13. Altering of approved safeguard instrument trip-point settings without proper justification or approval;
14. Lack of preplanning for the disposal of equipment after completion of an experiment or test.

Limitations of Standards

The safety and maintenance criteria for experiments and tests performed in, and with, reactors are necessarily subject to progressive changes due to the continuing development of improved systems and components, discoveries of formerly unsuspected hazards, and tightening of restrictions on the exposure of personnel to radiation. For these reasons, the experimenters and testing engineers are being more and more confined to doing work in prescribed ways and to revising existing facilities to conform to new criteria. Since the generating of standard criteria can lead to very detailed regulations, restrictive listings of acceptable components, and time-consuming inspections and reviews, a great deal of care must be exercised to be certain that they actually accomplish their intended purposes. These purposes are only safety of personnel, safety of the reactor and other expensive equipment, and economy of time and money.

Standards should contain positive and negative criteria which are sufficiently flexible to permit the introduction of new materials, new systems, and new concepts not specifically covered by the original standards. A procedure for systematic review and updating of standards must also be established to insure their continued usefulness.

Items Subject to Standardization

For the various types of experiments, those items which are generally subject to standardization are:

1. Planning, design, and review procedures;
2. Construction materials;
3. Methods of access (both to the reactor facility and to the experiment or test facility);
4. Fabrication and installation techniques and procedures;
5. Containment (requirements and methods);
6. Shielding (stationary);
7. Instrumentation and controls (drawings, types of components, and methods of use);
8. Utilities (including emergency electrical power);
9. Handling (tools, portable shields, techniques, etc.);
10. Operating procedures;

11. Waste disposal;
12. Procedures for revising equipment or operating procedures.

Types of Experiments and Tests

The fact that the experiments and tests conducted in and/or with reactors can be grouped into fairly well defined categories with respect to types also makes possible the use of certain basic standard design criteria which are desirable both for safety and for economy. These categories are:

1. Noninstrumented capsules or nonreactive solids;
2. Instrumented capsules or nonreactive solids;
3. Noninstrumented loops and access tubes;
4. Instrumented loops and access tubes;
5. Beam-type;
6. Special.

Most experiments and tests are of types 1 - 5 or a combination of these. In addition to being subject to placement in "type" categories, certain other common properties exist such as type of reactor facility used and the use of common utilities and waste-disposal systems.

In the included standards, no attempt is made to fully justify each one; however, such justification can be supplied in the event that the reason for any requirement is not evident. Further, it is realized that this compilation is not complete and will have to be updated from time to time.

General Standards Guide for Reactor Experiments at ORNL

1. General Requirements

1.1 Planning, Design, Fabrication, Review, and Installation

1.1.1 Information Requirements

1.1.1.1 All experiments to be operated in ORNL research reactors must be reviewed for safety and operability by the Operations Division technical staff and, in most cases, by the Reactor Experiment Review Committee. In order to furnish complete information for these reviews, a standard Experiment Review Questionnaire (Form No. TX-3300) must be filled out by the experimenter. An indexed, descriptive report for the experiment may be substituted for the questionnaire if all the information required by the questionnaire is provided in the report in such a manner that it can be readily found.

1.1.1.2 The design of an experiment must be in the form of sketches or blueprints of such detail that engineers and craftsmen can build all necessary parts and procure all components and install them with a minimum of technical assistance. The following blueprints or sketches are required:

1.1.1.2.1 General physical layout of the installation.

1.1.1.2.2 Dimensioned assembly and subassembly drawings for all components fabricated at ORNL and for any other component when this knowledge is required for installation.

1.1.1.2.3 Dimensioned details of all parts of assemblies and subassemblies including materials and parts lists, description of fabrication techniques, types of welding materials, cleanliness requirements, and such other items of information that are required for correct fabrication and installation.

1.1.1.2.4 Piping and wiring layouts for all utilities and instrumentation requirements. Three-dimensional (isometric) prints (or sketches) are frequently necessary for insuring correct installations.

1.1.1.2.5 Flow diagrams and control-circuit elementary diagrams, where applicable, to show locations of all instrumentation and controls components, including the types and ranges of all components. The standard ORNL instrumentation and controls nomenclature must be used. (References: CF-57-2-1, Rev. 1, Instrumentation Flow Plan Symbols and Recommended Drawings and CF-60-10-62, Electrical Design Standards.)

1.1.2 All prints and/or sketches required for fabrication and/or installation are subject to approval by the Operations Division. All prints and/or sketches required for installation must be approved and signed by the appropriate Operations Division representative. (See Section 1.1.4.) All instrumentation and controls prints and sketches must be approved and signed by the Instrumentation and Controls staff engineer assigned to the Reactor Operations Department locality. Other approvals may be requested by the Operations Division for certain installations.

1.1.3 The design should be such that installation can be done during the regular shutdowns of the reactor; i.e., the installation schedule should be compatible with the reactor operating schedule.

1.1.4 Planning, Design, Review, Fabrication, and Installation Procedure

The planning of each experiment, testing facility, and irradiation target of any kind requires the participation of the experimenter, the Operations Division representative, design and fabrication engineers, and, in the case of unusual hazards or problems, Health Physics and Radiation Safety and Control. The general procedure for planning, design, review, fabrication and installation, and final inspection is as follows:

1.1.4.1 When the need for any test or experiment is determined by any experimenter and the necessary management approvals for its performance have been obtained, contact is made with the Operations-Research Coordinator, a member of the Operations Division.

1.1.4.2 The Operations-Research Coordinator will examine the operational requirements for performing the experiment or test and will arrange such other discussions that may be required with other technical personnel of the Operations Division. If such an experiment or test is feasible and can meet requirements of safety and operability, approval for design is recommended. (If the Operations Division technical staff considers the experiment or test to be too hazardous or objectionable for other reasons such as excessive reactor down-time or inconvenience to other research work, approval will be withheld. In such an instance, the experimenter may appeal to the Reactor Experiment Review Committee.) Assignment of space in a reactor will be done at this stage if space is available, or the experimenter will be informed as to when space will be available. Space assignments in the LITR and OGR require only the approval of the Operations Division Superintendent unless there is a conflict of interest. Space assignments in the ORR are made by the Operations Division Superintendent and are subject to approval by the Laboratory Deputy Director. The Laboratory Deputy Director also resolves any dispute concerning space assignments in the LITR and OGR.

1.1.4.3 After it has been established that the experiment or test will be done, an Operations Division technical representative is assigned to follow the design and to generally assist the experimenter in meeting standard safety and operability criteria. Responsibility for developing an acceptable design, however, rests with the experimenter who normally secures assistance from the Engineering and Maintenance and the Instrumentation and Controls Divisions and acts in the capacity of coordinator for their activities.

1.1.4.4 Although it is not always advisable to begin fabrication and installation of out-of-core parts of an experiment or test facility before the design is completed and the necessary approvals for the design have been obtained, installation may begin if the partial design has been approved by the Operations Division. Such approval must be indicated on each blueprint by the signature of the Operations Division technical representative assigned to follow the project. Operations Division approval in these instances only indicates that the installation of the equipment is approved as not hazardous to personnel and the reactor and is compatible with continuity of operation. There is always the risk that revisions may be required as a result of final review by the Operations Division technical staff and the Reactor Experiment Review Committee.

For complex systems which require an extensive time for design, fabrication, and installation, the Reactor Experiment Review Committee may be requested to review various stages of design to permit simultaneous design and installation. This does not preclude the possibility that revisions of installed parts may be required when the design has been completed and the final review conducted.

1.1.4.5 When the design of an experiment or test has been completed and the operating parameters have been established, an Experiment Review Questionnaire Form (Section 1.1.1) must be completed by the experimenter and submitted to the Operations-Research Coordinator. At this time a review of the instrumentation and controls by the area I & C staff engineer will be requested by the Operations Division. If the design is not acceptable, revisions to the design will be requested. If the design is acceptable, the Operations-Research Coordinator will arrange for a review by the Reactor Experiment Review Committee if this is required.

1.1.4.6 Notification of acceptance or rejection of a design by the Operations Division, together with conditions required for approval, will be issued in the form of a memorandum by the Operations Division technical staff. This memorandum will also state whether or not a review by the Reactor Experiment Review Committee is required and will serve as notification that the experiment or test is ready for such review. (Experiments or tests which are being repeated, or those sufficiently similar to others already approved, may not require review by the Reactor Experiment Review Committee.) The chairman of the Committee is notified of either decision by the Operations Division so that a review may be requested by the Committee if they do not concur with the Operations Division's decision.

The completed questionnaire should be given to the Operations-Research Coordinator at least four weeks before the review meeting for the experiment is to be held by the Reactor Experiment Review Committee. This is necessary in order to allow two weeks for final evaluation by the Operations Division technical staff and two weeks for study by members of the Committee before the meeting. Although some experiment or test designs may be studied and reviewed in less time, such scheduling cannot be routinely expected.

1.1.4.7 Following approval by the Reactor Experiment Review Committee, the experiment or test facility may be fabricated, installed, and placed in operation. During this phase the Reactor Supervisor and the Operations technical representative assigned to the project should see that good workmanship practices are being followed. Responsibility for good workmanship, however, belongs to the E & M and I & C field engineers. Installation scheduling should not require prolonging normal reactor shutdowns nor require special shutdowns.

1.1.4.8 After complete installation of an experiment or test facility, a thorough checkout of the performance of all components is required before reactor startup. This checkout must be satisfactory to the Reactor Supervisor and to other personnel that he may designate.

1.1.4.9 After installation and initial operation of an experiment or test facility, liaison between the Operations Division and the experimenter becomes the responsibility of the Reactor Supervisor who may seek technical guidance, as required, from the Operations Division technical staff.

1.1.4.10 Approval of an experiment or test by the Operations Division and by the Reactor Experiment Review Committee is for a period of not more than one year, after which it is subject to a new review at the discretion of the Operations Division and/or the Reactor Experiment Review Committee. In the event of undesirable behavior of the experiment or test, a new review may be required at any time by the Operations Division.

1.1.4.11 If any experiment or test develops or is found to have a condition which may be hazardous to personnel or to the reactor or which causes excessive down-time of the reactor and if the condition cannot be readily corrected, its removal from the reactor will be required by the Reactor Supervisor.

1.1.4.12 Each specimen to be inserted into a test facility is subject to inspection by the Reactor Supervisor and such other personnel that he deems advisable. If the specimen is of a type not specifically approved for the facility, review by the Operations Division technical staff and, generally, by the Reactor Experiment Review Committee will be required.

1.1.4.13 Revising Equipment, Operating Parameters, and Procedures

1.1.4.13.1 Revisions of equipment which may affect the safety or continuity of operation of an experiment or loop must be approved by the Reactor Supervisor and are subject to approval by the Operations Division technical staff and the Reactor Experiment Review Committee.

1.1.4.13.2 Revisions of operating parameters need only be approved by the Reactor Supervisor unless the new values are beyond the limits approved by the Operations Division technical staff and the Reactor Experiment Review Committee. If the new values are outside these bounds, formal approval by the above groups is necessary.

1.1.4.13.3 Any revisions which involve changes from an approved flow sheet, alterations of piping or types of components, re-arrangement of wiring, installation of additional components, removal of components, etc., may not be made until updated blue-prints or sketches are supplied to and approved by the Reactor Supervisor and such other personnel as he deems advisable.

1.1.4.13.4 Revisions of operating procedures associated with conducting an experiment or test may be requested either by the experimenter or by the Operations Division. Such revisions of procedure must not jeopardize safety regardless of convenience or scheduling considerations. Procedure changes which affect safety must be approved by the Reactor Supervisor, the Operations Division technical staff, and, generally, the Reactor Experiment Review Committee.

1.2 Construction Materials

In general, construction materials for the various components of test loops and other types of experiments to be operated in reactors must be of types which are structurally suitable and are compatible with the environment. Certain unique and specific regulations, however, govern the selection of these materials for some components:

1.2.1 Any component installed in, and exposed to, a reactor system must be compatible with the reactor materials which include the structural materials, reflector, fuel elements, and coolant. Some materials to be avoided in the ORR and LITR are:

1.2.1.1 Copper and its alloys;

1.2.1.2 Carbon (This includes organics which might be charred by intense radiation.);

1.2.1.3 Iron or carbon steel;

1.2.1.4 Silver or gold brazes;

1.2.1.5 Rhenium metal or compounds;

1.2.1.6 Aluminum alloys with high Mg, Cu, or Si content;

Most structural materials, other than organics, may be used in the OGR for indefinite times as far as compatibility is concerned. Some are to be avoided where removal shields may have to be excessively large and/or expensive. Excessive neutron absorption (reactivity loss) must also be avoided. Any material not routinely used in the reactor must be shown to be compatible with the reactor system and operating conditions before it is used.

1.2.2 Items made of plastics, rubber, or wood may be installed in some portions of the reactor systems. In general, these may be used where the radiation which may be encountered is of low intensity. Under certain controlled conditions these materials may be inserted into the reactor cores. Each use, however, must be specially investigated and approved; this includes the use of plastics or rubber for gaskets.

1.2.3 All piping, pumps, etc., must be compatible with any circulating liquid or gas which they might contain, including materials formed as a result of radiation acting on the pipe contents.

1.2.4 All components must be made of materials capable of passing accepted codes for pressurized vessels where these codes are applicable. Such acceptance must be decided by ORNL Inspection Engineering.

1.3 Methods of Access to the Reactors and to Facilities

Methods of access to the reactors' interiors are, for most purposes, prescribed by the built-in access openings; however, where the type of experiment or loop is sufficiently unique and important, new openings may be made in the reactor vessel or through the biological shields. Decisions for providing new access routes will be made as the need arises and must be approved by the ORNL structural engineers to be certain that the reactor and/or the building structural strength is not jeopardized.

Access into a reactor tank or similar facilities must be such that reactor coolant leakages are avoided by flanges or welds having the same, or greater, strength and integrity as that prescribed by the reactor construction specifications. Any access tube installed in a reactor tank must be so constructed that the reactor coolant pressure, even in the event of accidental downstream blocking of flow, will not either expell it from the reactor tank or collapse it. This must be demonstrated either in a test stand or by standard calculational techniques.

1.4 Fabrication and Installation Techniques and Procedures

1.4.1 Fabrication of components must be done under carefully controlled conditions to insure good workmanship and strict adherence to prescribed methods approved by the designers and review groups. Containment components, in particular, must meet the requirements of established codes prescribed or approved by ORNL Inspection Engineering.

1.4.2 Materials used in fabrication must be exactly those specified by the designers and review groups. Substitutions may be made only with the approval of these groups.

1.4.3 Fabrication techniques must be such that the following conditions are met:

1.4.3.1 Articles fabricated of aluminum must not have inclusions of carbon (graphite), copper, or other materials which might accelerate corrosion if the articles are to be wetted by water or aqueous solutions during the experiment, or loop, operation. Since some aluminum alloys are soft enough to have these materials pressed into them, work areas, tools, vises, pliers, etc., must be cleaned of any filings or chips of prohibited materials before fabrication of the aluminum is begun. Also, lead-pencil marks (graphite) must not be used on these aluminum articles during fabrication.

1.4.3.2 Stainless steel must be kept free of chloride contamination.

1.4.3.3 Any surface of any article which will be exposed to the LITR reactor system or to the ORR reactor or pool system must be kept free of mercury or mercury compounds.

1.4.4 Access tubes to the ORR core and any simulated core pieces must be checked for proper fit in the ORR tank-dimension mock-up in Building 3001 before being installed into the ORR. Core pieces must conform to the dimensions on ORNL Drawing No. D-24078 and must not bind adjacent core pieces. Access tube pathways must be checked to be certain that they only occupy assigned space and do not hinder the lifting of hold-down arms or reactor refueling operations. The tubes must have sufficient strength to withstand the reactor coolant flow forces and must not vibrate enough to cause damage to the reactor, to themselves, or to other experiments.

At the time of insertion into the core, adjacent fuel and reflector pieces are to be checked by lifting to insure that side pressure is not being exerted by the access tube. This check is to be made both before and after bolting the access tube flange into place.

1.4.5 Access tubes and core pieces for the LITR may be fitted into the core itself during shutdowns. Adjacent core pieces must be checked to insure that there is no binding caused by the new core piece. Access tubes must clear existing tubes, the shim rods, and the shim-rod magnets. Tubes which are not routinely removed during core servicing must be routed to prevent interference with core-piece removals and insertions and must not hinder the removal, storage, and replacing of the upper grid assembly.

1.4.6 Access tubes to the interior of the OGR, for most purposes, are unnecessary because the tunnels are access tubes themselves. When the installation of an access tube or equipment shell is required, adherence to standard dimensions will insure that the tube or shell will fit the access tunnel. Such dimensions will be furnished by the Operations Division as required.

1.5 Containment

All radioactivities generated during the operation of tests and experiments must be contained and/or directed to appropriate radioactive waste-disposal systems. To accomplish this, a variety of types of systems may be used; however, experience has shown that certain requirements must be met and that some types of systems and components are not reliable. The more important guide rules to be followed in designing an adequately contained experiment or test facility are:

1.5.1 The reactor building is not to be considered as emergency containment for any radioactivity release from an experiment or test except as a third "line of defense".

1.5.2 Any system which operates under a positive pressure or may develop a positive pressure due to accident and contains, or is expected to contain, amounts of releasable radioactivities which would, if released, jeopardize personnel safety and/or expensive equipment must have a second line of defense with the space between the two barriers exhausted or capable of being exhausted to an adequate radioactive-waste-disposal system.

If the space between the two barriers is not monitored to indicate when either the primary or secondary barrier has failed, the system is not acceptable without further protection. Under certain circumstances, certain portions of pressurized containment may be acceptable without a secondary barrier. Such portions must not normally contain dangerous amounts of releasable radioactivities and must be free of components subject to developing leakages which would not be immediately detected. Decisions concerning the acceptability of such systems will be made by the Operations Division technical staff and/or the Reactor Experiment Review Committee.

1.5.3 Check valves usually may not be considered as constituting a secondary barrier against the leakage of radioactive gases or liquids, regardless of the number used in series, since their integrity cannot be routinely and individually checked.

1.5.4 Any pressurized system must be protected from overpressurization. If the volume is small and secondary containment is adequate to contain the pressure which would result from failure of the primary containment, further pressure protection on the primary containment is not mandatory unless probable monetary and operating time losses make such protection advisable. If the secondary containment is not adequate to withstand the full release of normal pressure from the primary containment, it is not acceptable. If, due to misoperation or failure of pressure-regulating devices, the primary or secondary containments may be subjected to pressure higher than the design strength, they must be equipped with rupture discs or pop-off valves vented to an appropriate waste-disposal system. Some pressure sources to be considered are:

1.5.4.1 Failure of pressure regulators on gas supply cylinders;

1.5.4.2 Misoperation of pressure regulators which are manually set (Such misoperation must be considered possible if the range of the regulator is greater than the allowable system pressure.);

1.5.4.3 Leakage of water into a high-temperature region;

1.5.4.4 Production of radiolytic gases and radiation damage of organics;

1.5.4.5 Gas expansion or vapor production due to overheating;

1.5.4.6 Downstream stoppage of coolant flows.

1.5.5 Containment shells or pipes inside reactor tanks (ORR and LITR) must be designed to protect the reactor tanks from over-pressurization. Systems which may be capable of pressurizing the ORR tank to more than 40 psid or the LITR tank to more than 60 psid must have a secondary-containment shell capable of withstanding the rupture of the primary system unless the same protection can be reliably provided by pressure-relieving devices and/or flow-limiting devices.

1.5.6 Equipment cells for primary-containment components must meet secondary-containment requirements. Sampling hoods or glove boxes must also meet these standards if the primary system is directly piped to the hood or glove box during the sampling operation.

1.5.7 Any system which requires instrument-initiated activation of a closure or exhausting system as the only method for providing secondary containment is not acceptable unless it can be shown that containment cannot be impaired by any single failure or credible combination of failures.

1.5.8 Any pressure-regulating device connected to either primary- or secondary-containment volumes must be of a type which does not relieve overpressure directly to the environment and which will not produce an unsafe condition in the event of loss of electric, pneumatic, or other motivating power.

1.5.9 Both primary and secondary systems must be designed structurally strong enough, or protected by physical barriers, to withstand external abuse from the environment such as:

1.5.9.1 Pipes or shells being stepped on or climbed on by personnel if these are in frequented areas;

1.5.9.2 Bumping by handling tools, portable shields, etc., if in close proximity to other systems;

1.5.9.3 Backup of pressure from waste-disposal systems;

1.5.9.4 Forces due to water flow and pressure in the reactor tanks;

1.5.9.5 Breakage of thermocouple or heater lead penetrations.

1.5.10 Gas-filled containment shells must be of sufficient strength to withstand inadvertent filling with water if they contain water lines or if they are immersed in water which may leak inward. Such containment shells which exhaust to the off-gas systems must be designed to automatically dispose of water without impairing the off-gas systems.

1.6 Stationary Shielding

All components of any experiment or test which normally contain radioactivities or which may, in the event of a failure of the primary containment, contain radioactivities must be shielded to protect personnel. In general, the following regulations apply:

1.6.1 Components which normally contain radioactivities and are located in areas frequented by personnel must be shielded to maintain the radiation level below 2.5 mrem/hr. Where the radiation level is greater than 0.25 mrem/hr, warning signs should be provided.

1.6.2 Components which normally do not contain radioactivities but may under abnormal conditions contain radioactivities must generally be shielded to limit the exposure of personnel to less than 5 rem/hr if they are located in areas frequented by personnel. Areas which contain such components must be furnished with radiation monitors with audible alarms which will automatically warn personnel of a radiation increase.

1.6.3 Special conditions to allow radiation levels to exceed 1 rem/hr through shielding or from unshielded components are as follows:

1.6.3.1 The area must be established as a radiation zone for the duration of the test or experiment in compliance with the standard ORNL radiation protection procedures. This includes erecting barriers to prevent inadvertent entry by personnel and posting of entry requirements. (See ORNL Health Physics Manual.)

1.6.3.2 Routine or continuous radiation intensity readings must be made at the personnel barrier to be certain that the expected level is not exceeded.

1.6.3.3 Approvals must be obtained from the Radiation Control Officers of the divisions involved and from the Reactor Supervisor.

1.6.4 Shields may be constructed of any suitable materials as long as they are structurally sound and are compatible with their environment. The following regulations apply:

1.6.4.1 Except for temporary emergency shields, concrete blocks must be mortared, and lead bricks must be tack-welded together.

1.6.4.2 Ample supporting structures must be provided, and floor load limits must be checked before the erection of shields is begun.

1.6.4.3 Tanks of water used for shielding must have safeguards to maintain the required water level and to provide emergency protective action if the water is lost. Such emergency action must include reducing the radiation level, if possible, and warning personnel by an audible alarm.

1.6.4.4 The adequacy of shields must be established by computation or by tests if they are to be used for long terms or are so complex in structure that the thickness cannot readily be increased after installation. Such adequacy includes withstanding the physical conditions of the maximum credible accident associated with the experiment or test and providing protection for personnel during and following the accident.

1.6.5 Equipment shields may constitute secondary containment provided they meet the structural strength, leak-tightness, and venting requirements for such containment.

1.7 Instrumentation and Controls

Instrumentation required for data taking by the experimenter are not subject to limitations other than that their presence and usage must not constitute a hazard. Instrumentation and controls required as safeguards are subject to strict regulations in order to insure reliability. Unless justified otherwise and approved by Operations Division and the Reactor Experiment Review Committee, all safeguard, or protective, instrumentation and controls must comply with recommendations in ORNL-TM-77, Guide for the Design of Safeguard Instrumentation for Experiments in the LITR and ORR. Safeguard instrumentation for experiments in the OGR must also comply with the same recommendations except for the method of connecting to the reactor control circuits. The general regulations as applicable to all three reactors are as follows:

1.7.1 All properties of an experiment which may generate an unsafe condition with respect to personnel, the reactor, or expensive equipment must be monitored and, if possible, automatically controlled. If such control action fails, a reactor power reduction is required if this will alleviate the condition or reduce the hazard.

1.7.2 All safeguard conditions which must be maintained and are subject to change by malfunction of equipment must be monitored so that corrective action is taken immediately if the required conditions are altered. This includes such items as negative pressure and/or ventilation of equipment cubicles and secondary containment volumes, electrical power supply, coolant supplies, etc.

1.7.3 All effluents to radioactive-waste-disposal systems must be continuously monitored if there is a likelihood of a radioactivity increase which will require special precautions or handling.

1.7.4 Adequate instrumentation must be provided to indicate when a system failure has occurred, what the failure is or might be, and, if the consequences of the failure may be hazardous, initiate appropriate emergency action.

1.7.5 Protective instrumentation tie-ins to the reactor controls must comply with the recommendations of ORNL-TM-77.

1.7.6 After the operation of an experiment or test has begun, changes of safeguard trip settings, revisions of protective circuits, and substitution of sensors must be reviewed and approved by the Operations Division technical staff with the assistance of the I & C staff engineer except as described in Section 1.1.4.13.2. Any revisions which extend beyond the limits of the conditions imposed by the Reactor Experiment Review Committee must be approved by the Committee; such approvals will be obtained by the Operations Division. Such changes, if predictable, may be approved as alternates of the initial operating conditions during the original review and approval procedure.

1.7.7 When the need for any safeguard is questionable (due to such situations as the inability to predict certain operating conditions accurately), the safeguard must be incorporated into the design but may be disarmed if actual operating conditions prove that it is not needed. The disarming of such safeguards must be approved by the review groups that originally approved or required them; these approvals will be obtained by the Operations Division.

1.7.8 In designing safeguard, or protective, instrumentation and controls for an experiment or testing facility, it is desirable to have a reasonable definition of what have become known as "credible incidents". These are incidents which, without special safeguards, are sufficiently likely to occur that the safeguards must be provided if an incident will or may result in an intolerable hazard to personnel, the reactor, continuity of reactor operation, or expensive equipment. In order to evaluate the degree of reliability required for the safeguards, it is also desirable to establish the "maximum credible accident (or incident)" which may result if the safeguards should fail. Some of the considerations which must be included in postulating the maximum credible accident and in providing adequate safeguards are:

1.7.8.1 Any single component such as an electrical relay, electronic tube, thermocouple, pump, single containment wall, etc., is likely to fail. It is, however, assumed that simultaneous failure of two or more independent components is not likely.

1.7.8.2 If a component can fail in such a manner that failure cannot be detected, it must be assumed to be in "failed" status at all times. (An example would be "double containment" of a specimen in two concentric tubes when the annular volume is not adequately monitored to detect failure of either of the two containment shells. In this case, one of the shells must be assumed to be leaking at all times. See 1.5.2.)

1.7.8.3 If detection of a failed component is dependent upon conducting special tests, such as a maintenance checkout, the component must be considered as having low reliability. Providing two or more independent components of this type for the same purpose increases the likelihood that at least one will function when needed.

1.7.8.4 Protective instrumentation trip switches are components of the type described in 1.7.8.3; therefore, redundancy of such instrumentation is required if the consequences of the maximum credible accident being safeguarded against would be serious. If the consequences of the maximum credible accident would be intolerable, further protection must be provided in the form of adequate reliable containment or similar type of defense. Otherwise, the degree of hazard must be lessened by reducing the source of hazard itself by such means as using smaller specimens, lower pressures and/or temperatures, lower neutron flux, etc.

1.8 Heat Removal and Temperature Control

1.8.1 Any surface of any test or experiment facility in the ORR or LITR must be sufficiently cooled to prevent boiling within the core and reflector regions of the reactor. In the OGR, the surface temperature in contact with the moderator graphite must be kept below 350°C.

Unless it can be demonstrated that surface boiling will not occur in the LITR and ORR and that surface temperatures will not exceed 350°C in the OGR, temperature monitors must be provided to insure that these temperatures are not exceeded during operation.

1.8.2 Adequate cooling must be provided to protect all parts of any experiment or loop from damage due to excessive temperatures. If excessive temperature can produce hazards to personnel, the reactor, or expensive equipment, reasonable safeguards must be provided to guarantee that coolant supply is not lost or that the heat source is removed or reduced.

1.8.3 Emergency measures for temperature control should have the following sequence if response time allows:

1.8.3.1 Reduction of electrical heater power (or equivalent);

1.8.3.2 Supply of emergency cooling;

1.8.3.3 Reduction of reactor power.

If feasible, experiments in the ORR should be designed to be automatically withdrawn from the reactor core to reduce temperatures rather than to use action 1.8.3.3.

1.8.4 Temperature monitors must meet the minimum instrumentation standards contained in Section 1.7 when these are part of the safeguard system. Adequate spare sensors should be provided to insure meeting these standards after at least one sensor failure. However, approval for the use of a spare sensor in the safety system may not be permissible unless operating data is available from this spare for comparison with indications from the original sensor.

1.9 <u>Reactivity Effects</u>

1.9.1 The maximum reactivity change which any experiment or test facility in the ORR or LITR may produce due to failure or malfunction is normally limited to 0.5% $\Delta k/k$ if such a change may occur in less than one second. A "ramp" change normally must not exceed 1.0% $\Delta k/k$ per minute nor a total of 1.4% $\Delta k/k$. The types of failures and malfunctions to be considered are:

1.9.1.1 Replacing of any gas-filled volume with water due to collapse of container walls, water leak, or expulsion of a container from the reactor core or reflector region;

1.9.1.2 Replacing of any solid with water if the solid may reasonably be expected to be expelled from the core due to a pressure surge in the reactor (A lattice access tube could be expelled if not properly anchored at the access flange.);

1.9.1.3 Expulsion of a test specimen or other material from an irradiation facility due to: inadvertent automatic specimen withdrawal, breaking of a specimen support, steam formation resulting from a water leak or coolant flow loss, and similar occurrences.

1.9.2 Automatic or manual withdrawal of any experiment or test from the LITR or ORR core or reflector while the reactor is critical normally must not exceed the ramp reactivity limitations of 1.0% $\Delta k/k$ per minute nor a total of 1.4% $\Delta k/k$. Under special conditions these limits may be increased. Such conditions must be approved by the Reactor Experiment Review Committee.

1.9.3 In the OGR, step reactivity changes are normally limited to a maximum of 0.10% $\Delta k/k$. Ramp changes are normally limited to 1.0% $\Delta k/k$ per minute and a maximum of 1.0% $\Delta k/k$. These limits may be raised if approved by the Reactor Experiment Review Committee.

1.9.4 In determining the maximum reactivity effects which any experiment or test facility may produce in a reactor, the effects which may be produced by all the experiments in the reactor must be considered. If a single event can produce simultaneous reactivity changes by several experiments or test facilities, then the sum of these effects must normally not exceed the limits for step and ramp changes. Some of the events to be considered are:

1.9.4.1 A reactor excursion which elevates the temperature of experiments or test specimens and causes automatic withdrawal which, in turn, worsens the reactor excursion by increasing the reactivity;

1.9.4.2 A pressure surge in the reactor which may expel access tubes from the reactor core or reflector or may collapse gas-filled containers.

1.9.5 Minor reactivity fluctuations caused by an experiment or test facility must not be great enough to prevent the reactor servo from maintaining a constant power level. Objectionable fluctuations may be caused by:

1.9.5.1 Boiling in the reactor core or reflector regions;

1.9.5.2 Gas bubbles in a liquid coolant;

1.9.5.3 Too rapid insertion and withdrawal of an experiment or test assembly for temperature control purposes;

1.9.5.4 Vibration of an access tube;

1.9.5.5 Oscillation of a test specimen or other component by a coolant stream.

1.9.6 The maximum reactivity effects which an experiment may produce must be measured at the time it is inserted into a reactor. If the measured effect exceeds that normally allowed, approval from the Reactor Experiment Review Committee must have been or be obtained to allow the experiment or test equipment to remain in the reactor.

1.10 Utilities (Electricity; hot and cold potable and process water; steam; compressed air and bottled gases; and hot-waste, process, storm, and sewage drains)

Utilities supply lines are routed through the reactor buildings with convenience outlets near each experiment facility. Frequently, however, additional supply lines may have to be installed by the experimenter. The need for these must be determined by the experimenter and the design engineers. Routing paths for new supply or effluent lines must be approved by the Reactor Supervisor. All such supply lines must be clearly labeled as listed under requirements for each utility.

1.10.1 Electricity

1.10.1.1 All electrical power system installations must meet existing ORNL standards and must, therefore, be designed and approved by E & M electrical design engineers and be installed by E & M craftsmen or by subcontractors secured by standard E & M procedures.

1.10.1.2 All exposed electrical conduits must be labeled at about 20-foot intervals and at points of entrance to and exit from a room to indicate voltage and phase. Special electrical supplies whose use is limited to certain applications must be so labeled both on the conduit and on outlets.

1.10.1.3 All electrical wiring which forms a part of any safeguard system must be enclosed in conduit or otherwise protected. Extension cords which pass through or across personnel thoroughfares (except those for temporary lights, service tools, etc.) must be protected from inadvertent damage by personnel and must not constitute a hazard to personnel from tripping, etc.

1.10.1.4 Servicing of electrical power systems, such as replacing fuses, must be done by E & M craftsmen.

1.10.1.5 All electrically operated systems which are required to function for after-heat removal, containment, or other critical functions to prevent a hazardous condition not immediately remedied by a reactor scram must be supplied with a reliable emergency electrical power source which will function in the event of loss of regular electrical power.

1.10.2 Water, Hot and Cold Potable and Process

1.10.2.1 Neither hot nor cold potable water is to be connected to any experiment or test apparatus in any manner. Usage of potable water is limited to drinking fountains, lavatories, or safety showers which might be considered necessary for the convenience of research personnel stationed at a control center for an experiment.

1.10.2.2 The usage of process hot and cold water is limited only by the available supply and the waste-disposal system. If the already furnished supplies are inadequate for any installation, new supply lines must be installed from the main. Before any new connection is made to any supply, there must be a careful check by the E & M design or field engineers to determine that the new connection will not rob existing usages and thereby endanger other experiment equipment or introduce hazards. The written justification for tying into any particular water supply system should contain a listing of the existing flow usages, the intended added flow, and the total flow and pressure available.

1.10.2.3 Usage of demineralized water from the Building 3004 demineralizer system must be specifically approved by the Operations Division due to the very limited supply.

1.10.2.4 All water pipes must be insulated to prevent dripping of condensate from cold-water lines and to prevent personnel from being burned by hot-water lines.

1.10.2.5 All water lines connected to an experiment must be equipped with back-flow preventer if back flow would contaminate the water system.

1.10.2.6 All water pipes must be labeled at about 20-foot intervals, at place of entrance to and exit from rooms, and 2 feet on both sides of turns or branches to describe the type of water (hot potable, cold potable, hot process, cold process, or demineralized) and the pressure. Special-usage lines which must not be tapped for new uses must be so labeled; a distinctive color for the pipe is preferable.

1.10.2.7 All valves must be labeled as to purpose, whether they must be kept open or closed, and who must authorize changing the valve setting.

1.10.2.8 All initial pipe installations and subsequent revisions must be approved by the Reactor Supervisor.

1.10.3 Compressed Air and Bottled Gases

1.10.3.1 All compressed-air and gas-supply lines must meet existing ORNL standards for materials, pressure, flow, and pressure-reducing systems and must, therefore, be approved by E & M engineers.

1.10.3.2 All pressure-reducing stations must have a pressure gauge on the downstream side with appropriate valves for isolating the pressure reducer. There must be no bypasses around pressure reducers. The use of a pressure gauge upstream of the pressure reducer is optional.

1.10.3.3 All high-pressure pipes ($>$ 15 psig) must be of rigid construction and capable of withstanding reasonable abuse from inadvertent bumping when not confined to limited-access areas. Copper and plastic tubing used for high-pressure gases must be sheathed with protective conduit or otherwise protected except in limited-access areas or at gas-cylinder stations (pigtails).

1.10.3.4 All compressed-air and gas-supply pipes must be labeled at 20-foot intervals, at places of entrance to and exit from a room, and 2 feet on both sides of turns or branches to indicate the type of gas and the pressure. All special-purpose supply pipes must be labeled to prevent their being diverted to other uses.

1.10.3.5 All valves must be labeled as to purpose, normal position, and persons authorized to change the valve settings.

1.10.3.6 All gas cylinders must be handled in conformance with ORNL safety standards and must be properly chained or strapped when in use or in storage. (See Standard Practice Procedure 56A.)

1.10.4 Process, Hot-Waste (ILW), Storm, and Sewage Drains

1.10.4.1 Sewage drains are not to be used for any effluents from any part of an experiment or test apparatus.

1.10.4.2 All waste water which cannot contain radioactivities generated by the reactor or the experiment or test apparatus will be drained to the storm-drain system when feasible. This includes air-conditioner drains, diffusion-pump drains from external cooling coils, and similar waste-drain systems.

1.10.4.3 Waste water which contains small amounts of short-lived radioactivities with half-lives up to 24 hours (excluding those which evolve radioactive gases) up to 10^4 dpm/ml or which may in the event of equipment failure contain up to 5.8×10^3 dpm/ml for a total of 5 mc for Sr^{90} and Ra^{228} or 5.8×10^5 dpm/ml of any other long-lived radioisotope is to be discharged to the process-drain system. If the failure of equipment may increase the radioactivity of the water to more than the above, a radioactivity monitor and alarm must be provided. In certain instances, liquid-waste storage facilities must be provided with means for disposal to the hot-drain (intermediate-level-waste or ILW) system; such requirements will be made by the review groups if not provided by the designers.

1.10.4.4 Normally, all waste water or aqueous solutions containing long-lived radioactivities must be discharged to the hot-drain (intermediate-level-waste) system. Taps to the hot drain must be provided with valves or other flow controls. Such taps must be in the form of positive connections without an air break except inside of equipment cubicles which are vented to the off-gas system or cell-ventilation system if the negative pressure in the cubicle does not exceed that in the hot drain. Flows into the hot drain must be controlled to prevent pressurizing the system, and strainers should be provided to prevent particles greater than 1/8" diameter from entering the drain.

1.10.4.5 All pipe lines which run from an equipment location to a drain opening must be labeled at 20-foot intervals, at places of entrance to and exit from rooms, and at the drain opening to indicate the experiment or test to which they belong and the source of the effluent. Pipe lines which run to hot-drain openings must be adequately shielded as well as labeled and must be safeguarded from physical damage. The routing of all such drain extensions must be approved by the Reactor Supervisor.

1.10.4.6 Organic solvents are not to be disposed of through any of the drain systems without specific authorization from the Reactor Supervisor and the Laboratory Facilities Department Superintendent for each discharge.

1.10.4.7 Any new usage of any drain system must be approved by the Reactor Supervisor.

1.10.4.8 All new usages of the hot (ILW) and process drains must be approved by the Laboratory Facilities Department Superintendent.

1.11 Disposal of Gaseous Wastes

1.11.1 General Requirements

Radioactive gaseous wastes must be disposed of in such a manner that the carrier gases are released to the atmosphere through one of the gas-disposal stacks with a radioactivity concentration below certain prescribed maximums. In general, the maximum permissible release concentration is a factor of about 10^4 greater than the maximum permissible concentrations in air recommended by NBS Handbook 69. The permissible average release concentration for routine discharge is a factor of 10 less than the maximum. Since the stacks serve a variety of facilities, these must all be considered when a new discharge of gases to the system is planned. Also, under controlled release conditions the concentration may be considerably increased during favorable meteorological conditions.

In order to more nearly guarantee that these maximums are not exceeded, all the gaseous-waste-disposal stacks are preceded by cleanup systems to remove or greatly reduce the more objectionable radioactivities. These systems remove greater than 99% of dust or aerosols larger than 0.3 micron in diameter and from 99% to more than 99.9% of iodine isotopes, depending upon the chemical form and other properties. Since these gas-cleanup systems are the last barrier encountered before the gases are discharged to the atmosphere, Laboratory management has ruled that they not be used as primary cleanup systems but as backup for other systems located at or nearer the source of the contaminant. These primary cleanup systems are to have the same or higher efficiencies as the systems at the stacks. Generally, the dilution factor contributed by the total gas flow through the stack may be taken into account when designing a local gas-cleanup system unless there is a reasonable likelihood that gases will escape the ducting (or other enclosure) before reaching the stack. If such a likelihood exists, then the local gas-cleanup system must reduce the concentration of radioactivities in the effluent to less than $\frac{1}{10^4}$ of that releasable from the stack.

The maximum risk criterion to be applied to any experiment with respect to failure of the system causing release of radioactive gases through the stack is that such a release will not result in personnel exposures exceeding the maximum daily permissible. Experiments which generate radioactive sources capable of exceeding this must be provided with multiple containment and with highly reliable gas-retention and/or cleanup systems.

The maximum risk criterion to be applied to a gas-cleanup system is that failure will not result in personnel exposures exceeding the maximum permissible for one quarter (three months).

The degree of hazards and the type of gaseous-waste-disposal systems differ for the ORR, LITR, and OGR.

1.11.2 Disposal of Gaseous Wastes at the ORR

The ORR is equipped with three distinct disposal systems for contaminated or potentially contaminated gases. Each of these serves an intended specialized purpose, and all three are exhausted through the 3039 stack.

1.11.2.1 The Cell Ventilation System provides a low-suction, high-flow exhaust (~ 7000 scfm) for:

1.11.2.1.1 Maintaining a slight negative pressure in the reactor building and exhausting the building air to the 3039 stack in the event of a release of airborne radioactivity into the building atmosphere;

1.11.2.1.2 Ventilating large equipment chambers which are subject to releases of airborne radioactivity. (Air is drawn from the building through the equipment chamber and into a duct of the cell ventilation system.)

1.11.2.2 The Normal Off-Gas System provides a high-suction, low-flow exhaust (500 scfm total at minus 35" w.g.) for:

1.11.2.2.1 Ventilating small equipment chambers;

1.11.2.2.2 Exhausting gases from experiments which cannot pressurize the off-gas system should downstream stoppage occur.

1.11.2.3 The Pressurizable Off-Gas System provides a high-suction, low-flow exhaust (500 scfm total at minus 35" w.g.) for gases discharged from experiments which may pressurize the off-gas system if downstream stoppage occurs. This system must not be used for exhausting equipment chambers which are not sealed.

1.11.3 Disposal of Gaseous Wastes at the LITR

The LITR is equipped with one general-usage off-gas system and one installed for use by one research group. Both of these discharge through the 3018 stack. The general-usage system has a flow capacity of about 600 cfm at about minus 30" w.g. and is used both for venting equipment cells and for exhausting gas-cooled experiments.

1.11.4 Disposal of Gaseous Wastes at the OGR

The cooling system for the OGR may be used as an off-gas system. Clean air may be dumped into any experiment hole if the negative pressure within the reactor is the sole means of providing flow. Positive-pressure systems must be piped to the coolant exhaust duct or the exhaust manifold.

1.11.5 General Requirements for Use of the Gaseous-Waste-Disposal Systems

1.11.5.1 All new uses of the gas-disposal systems must be approved by the Reactor Supervisor and are subject to review by the Operations Division technical staff, the Laboratory Facilities Department Superintendent, and the Reactor Experiment Review Committee.

1.11.5.2 The routing of all piping between an experiment location and an off-gas tap must be approved by the Reactor Supervisor.

1.11.5.3 All off-gas piping must be shielded to limit the radiation from the maximum credible accident associated with an experiment to 5 Rem/hr in areas where personnel are likely to be. Such an accident must initiate alarms to warn personnel. If the piping is subject to frequent or continuous discharges of radioactivity, the shielding must be adequate to reduce the radiation to less than 0.25 mrem/hr in populated areas, to less than 2.5 mrem/hr in infrequently populated areas (provided with warning signs), or must be blocked off to prevent personnel access except under controlled conditions.

1.11.5.4 Direct interconnections between the normal and the pressurizable off-gas systems at the ORR are prohibited.

1.11.5.5 The use of the off-gas systems as "vacuum cleaners" is to be discouraged unless a local dust filter is provided.

1.11.5.6 Discharge of water or other liquids into any off-gas system must be avoided.

1.11.5.7 Some special requirements for the use of the ORR pressurizable off-gas system are:

1.11.5.7.1 All piping connected to the pressurizable off-gas system must be capable of withstanding 100 psig internal pressure or be protected by pressure-relief systems which do not discharge to the building or directly to the atmosphere. This includes all parts of the experiment apparatus subject to backed-up pressure from the system.

1.11.5.7.2 All valved taps to the pressurizable off-gas system must be closed by pipe caps or plugs when not connected to equipment.

1.11.5.7.3 The pressurizable off-gas is not to be opened to to the building or to the atmosphere when any experiment or test is discharging gases into it which may cause a positive pressure in the system.

1.11.5.7.4 Although standard types of check valves may be used to prevent backup of pressure from the off-gas, these cannot be used as safety equipment because of their inability to be frequently checked for performance.

1.12 <u>Handling (Tools, Portable Shields, Techniques, etc.)</u>

Well tested handling tools, portable removal and storage shields, and insertion and removal procedures have been developed for most types of experiments and tests operated in ORNL research reactors. It is both economical and expedient for designers to make use of these rather than to develop unique and novel equipment and methods unless these are actually required. Designers should, therefore, check the existing supply of tools, shields, etc., and learn the various standard handling techniques before undertaking the actual design of new equipment.

New equipment and handling techniques must conform to the following specific regulations and to any other regulations in these criteria which apply:

1.12.1 Tools

1.12.1.1 Tools to be used under water in the LITR tank or the ORR tank or pool are to be made mainly of stainless steel or aluminum if usage is to be frequent or if they must be stored for long periods between uses. Generally, some portions of the tools must be made of mild steel, spring steel, or steel cable. Such parts must be easily replaceable since they become rusty. Copper or copper-alloy tool parts are not permitted. (See 1.2.1.)

1.12.1.2 Any lubricant used on tool parts must be of the heavy grease type and used sparingly. Light oil should be avoided since it may pollute the water. Graphite lubricants are strictly forbidden since any graphite which lodges on aluminum reactor parts will cause rapid corrosion.

1.12.1.3 Any tool used for lifting heavy objects in the LITR or ORR must have a strength safety factor of at least 10. Chokers and lifting or support tools which consist partly of cables must be routinely inspected by Inspection Engineering. Such tools and the use of backup safety provisions must be demonstrated to be adequate before usage and approved by the Reactor Supervisor and by such other personnel as he deems desirable.

1.12.1.4 All voids within a tool which will become filled with water during usage in the LITR or ORR must be provided with bleed holes to provide rapid drainage as the tool is lifted from the water.

1.12.1.5 Heavy underwater tools, if designed for manual handling, should be provided with floats for buoyancy and must have lifting rings to allow their being transported by an overhead hoist and to be stored in a vertical position.

1.12.1.6 Tools to be used in the ORR and LITR beam holes and in the OGR may be made of any suitable material. Surfaces must be smooth to allow easy decontamination of dust by wiping with moist cloths.

1.12.1.7 All tool designs must be approved by the Reactor Supervisor.

1.12.2 Portable Shields

1.12.2.1 All new portable radiation shields must, if possible, be designed to be versatile enough to be useful for more than one particular job due to their high cost. All shield designs must be reviewed by the Operations Division before fabrication is begun.

1.12.2.2 The weight of any portable shield must not exceed the rated capacity of any lifting hoist or other device which must be used in handling it. A survey of the available lifting equipment in the areas where the shield is to be used must be part of the design criteria and adequate lifting devices provided if they are not already available.

1.12.2.3 All lead-shielded casks to be used in the LITR tank, the ORR pool, or the ORR tank must be clad with stainless steel if usage will be frequent and decontamination is required between uses. In certain cases, cladding may not be necessary over the whole cask and/or may be painted mild steel. Such casks must be specifically approved by the Reactor Supervisor for limited usages.

All external surfaces of a cask must be accessible for decontamination. These surfaces, including weldments, must be smooth and free of weld spatter and crevices or pockets.

1.12.2.4 All casks must be equipped with drains which can be valved or plugged when required.

1.12.2.5 All casks to be used for transporting radioactive gases, liquids, powders, or water-soluble compounds must be capable of being sealed air-tight. This also applies to casks used for transporting materials which are likely to evolve or generate radioactive gases, liquids, or powders. Inner air-tight containers are an acceptable substitute for sealing the cask provided they can be tested prior to use and need not be opened to the atmosphere as part of the procedure for unloading the cask into a hot cell or other repository. A plastic sheath over the outside of a cask is not an acceptable cask seal. Such sheaths should be used, however, to prevent spread of surface contamination. All sealable containers which must be unsealed outside a repository must be equipped with a means of exhausting the cask atmosphere to an off-gas system before breaking the cask seal.

1.12.2.6 The shielding qualities of all casks must meet the criteria in the ORNL "Procedures and Practices for Radiation Protection," Procedure No. 28 and, if applicable, Procedure No. 30.

1.12.2.7 The lifting lugs or trunnions on a cask or shield must be capable of supporting at least 10 times the weight of the loaded cask or shield. All such lugs must be equipped with safety straps or other such arrangement which will prevent shackles, cables, hooks, etc., from slipping off the lugs.

1.12.2.8 Any lifting device on the top plug of a top-loading cask and the top-plug, latch-down system must be capable of supporting at least five times the weight of the loaded cask.

1.12.2.9 All casks used in the LITR tank or ORR pool must have no loose parts such as gaskets which might drop off or be washed off into the water.

1.12.2.10 Casks to be used at the OGR may be made of any suitable material so long as strength and shielding qualities are adequate. Cladding is not required except where necessary to prevent deformation of the shielding material due to handling abuses.

1.13 Procedures

Written procedures must be prepared for the performance of all important phases of an experiment or test before equipment installation or insertion of test specimens is begun. These procedures must be approved by the Reactor Supervisor and are subject to approval by the Operations Division technical staff, the Reactor Experiment Review Committee, and Health Physics. Where applicable, each procedure should include a list of personnel and equipment requirements for the work to be performed. Any safety precautions should also be listed. If a procedure consists of several sequential steps which must be done in precise order, and their having been done cannot be readily checked visually, a check-list type of written procedure must be used with a place provided after each step for the operator to write his initials to indicate that the particular operation has been completed and by whom.

Written procedures for the following are generally required:

1.13.1 Installation of the in-reactor portions of any test facility or experiment equipment;

1.13.2 Installation and removal of test specimens in a facility;

1.13.3 Establishing operating conditions and checking out equipment performance;

1.13.4 Sampling of coolants, sweep gases, or other materials which may contain radioactivity;

1.13.5 Cleanup of loops which may become contaminated due to test-specimen failure;

1.13.6 Changing of sensors on safety instrumentation and any other servicing which might require temporary disarming of a safety system during operation;

1.13.7 Coping with anticipated failures of equipment or specimens which might require emergency action;

1.13.8 Removal and disposal of in-reactor portions of any test facility or experiment equipment.

1.14 Maintenance

1.14.1 A listing of all components of an experiment or test must be prepared with a description of maintenance requirements and a time schedule for routine checks, lubrication, etc., required to avert undue failure. A copy of this listing should accompany the review questionnaire, and copies should be furnished the E & M and I & C field engineers.

1.14.2 If maintenance or repair work is to be done on any experiment or test facility during a reactor shutdown and if startup of the reactor during the maintenance or repair work will cause a hazard to personnel, the reactor, or the experiment or test facility, the Reactor Supervisor must be notified of the work to be done. If possible, notification must be given in time to include the work in the written shutdown schedule. At the OGR and LITR, notification and necessary descriptive material (procedures and blueprints) should be received one week before the scheduled shutdown. At the ORR a two-week notification is requested. In addition to the schedule notification, the Reactor Supervisor or his alternate must be notified when the work actually begins and when it has been completed.

2. Some Requirements for Specific Types of Experiments and Tests

2.1 Noninstrumentated Capsules and Nonreactive Solids

2.1.1 The OGR, LITR, and ORR have both general-usage and assigned facilities for irradiating noninstrumented capsules and nonreactive solids. Only those capsules and solids which have the following properties may be irradiated without instrumentation:

2.1.1.1 The capsule or solid has a heat production and dissipation rate such that loss of coolant flow will not damage it.

2.1.1.2 A capsule, if ruptured, will not:

2.1.1.2.1 Release into the reactor or irradiation facility a quantity of radioactive substance which will increase the general radioactivity level of exposed piping to greater than 1 R/hour;

2.1.1.2.2 Release materials which will result in contaminating the reactor tank and pool surfaces with long-lived alpha- or soft-beta-emitting materials to greater than 1100 dpm/100 cm^2 of alpha and/or 1.1 x 10^5 dpm/100 cm^2 of beta (Depending upon circumstances and with the initiation of special procedures restricting the lowering of the pool water level, these limits may be raised by approval of the Operations Division technical staff and such other groups or individuals as may be required.);

2.1.1.2.3 Release a quantity of radioactive gases or volatiles into the environment which will produce airborne radioactivity greater than masking tolerance in the general building atmosphere or a localized concentration, in an area occupied by personnel, which will produce an exposure exceeding the maximum permissible exposure for one quarter after breathing the contaminated air for one minute.

2.1.1.3 Capsules which are irradiated in hydraulic tubes, in-reactor trays, or other facilities submerged in water must not be buoyant enough to float. The weight of the capsule must be at least 1.1 times the weight required to sink it in order to allow for a possible slight amount of swelling due to accidental inclusion of organics or other materials which may evolve gases.

2.2 Instrumented Capsules and Nonreactive Solids

2.2.1 Any capsule or solid which may, due to excessive temperature or pressure, produce a hazard to personnel, the reactor, or expensive equipment must be instrumented and equipped with safeguards against excessive temperatures and/or pressure if these may be generated by conditions which exist or may be expected to occur during the irradiation. Such instrumentation and controls must comply with the regulations in Section 1.7. Instrumentation and control may be accomplished in the following ways:

2.2.1.1 Temperatures may be monitored directly by thermocouples or similar devices directly attached to or securely pressed against the surface being protected. (See Sections 1.7 and 1.8.) These thermocouples are connected to a recorder or control device which will limit the temperature by one or more of the following:

2.2.1.1.1 Supply a greater flow of coolant;

2.2.1.1.2 Reduce the heat supplied from a source external to the reactor;

2.2.1.1.3 Retract the irradiation specimen to a region of lower neutron and gamma fluxes;

2.2.1.1.4 Reduce the power level of the reactor. (This action is to be taken only if the above control measures fail.)

2.2.1.2 If the temperature versus coolant flow and coolant temperature characteristics are well known, safeguards may be in the form of only guaranteeing the coolant supply as is done in most hydraulic-tube facilities. In such cases the flow path must be simple so that chances of bypass are not credible.

2.2.1.3 If the internal pressure of a capsule or other enclosed volume is only temperature dependent, controlling the capsule temperature may be considered as controlling the pressure also; and pressure-measuring devices are not required.

2.2.1.4 If the internal pressure of a capsule or other enclosed volume is not solely temperature-dependent and the maximum upper bound of the pressure is unknown or is known to be above the yield strength of the capsule walls, a pressure monitoring and control system must be provided. An alternate to the monitoring and control system is an outer enclosure which will contain a rupture of the capsule and either retain the capsule contents or route them to a disposal system through adequate radioactivity cleanup systems without causing reactor down-time or hazard to personnel.

2.2.1.5 Any facility used for the irradiation of capsules or solids must be provided with radiation monitors and alarms if credible damage to the capsules or solids by temperature, pressure, corrosion, etc., will release radioactivities which will cause radiation levels in populated areas greater than 0.25 mrem/hr or greater than 1 Rem/hr in radiation zones. (See Sections 1.5, 1.6, 1.10, and 1.11.)

2.3 Noninstrumented Loops and Access Tubes

2.3.1 Loops and access tubes (including beam holes) may require no instrumentation under the following conditions:

2.3.1.1 Coolant flow is required only to protect data or is automatically supplied by the reactor cooling system, and flow stoppage is no more credible than flow stoppage through a reactor fuel element.

2.3.1.2 The loop or access tube is not required to operate at an internal pressure which is either above or below that which would result from loss of a seal; and it does not contain a substance which would be hazardous to personnel, the reactor, or expensive equipment if such a seal were broken.

2.3.2 Any capsule or solid which is put into the loop or access tube and which requires coolant flow or other conditions will be equipped with sensing devices and safeguard instruments as required in Section 2.2.

2.4 Instrumented Loops and Access Tubes

2.4.1 Apart from the monitoring of irradiation specimens in loops or access tubes, certain properties of some types of loops and access tubes must also be monitored and controlled. Some of the conditions which make instrumentation and control necessary are:

2.4.1.1 Coolant flow is required whether the facility contains an instrumented specimen or not. This can result from the presence of shield plugs, an inner annular tube, specimen support structure, or other fixture which cannot lose heat adequately to an external coolant. Such systems must have instrumentation and controls to guarantee coolant flow and/or to decrease the heat source if coolant flow is lost.

2.4.1.2 The loop or access tube must be maintained at a pressure either above or below that which would result from loss of a seal. Pressure controls are required for such systems with appropriate safeguard action if the pressure becomes too high or too low.

2.4.1.3 The loop or access tube contains any substance which can be released to the environment if a seal is broken and will cause a hazard to personnel, the reactor, or expensive equipment. Systems of this type must conform to the regulations governing containment, Section 1.5. Monitoring instruments must be provided to detect and announce failure of either the primary or secondary containment and to initiate required safeguard action.

2.4.1.4 The loop or access tube contains specimens which are not monitored directly and would produce a hazardous condition due to loss of coolant flow, loss of or increase of system pressure, elevation of coolant temperature, etc. In these systems, the monitoring and safeguarding of coolant flows and temperatures is a substitution for direct temperature monitoring of the specimens; therefore, coolant flow paths must be simple with no bypasses so that stoppage of flow over the specimens will be readily detected by the flow instruments.

2.5 Beam Facilities

2.5.1 An open beam-hole collimator is simply a penetration of the reactor shield, and safeguards are required to protect personnel from the emerging radiation. Regulations governing the use of radiation beams are as follows:

2.5.1.1 A "beam catcher" and side shielding must be provided as close as possible beyond the point of usefulness of the beam in order to minimize the likelihood that personnel will be inadvertently exposed to the direct beam. (It should be realized by all concerned personnel that most radiation survey instruments are calibrated for exposure of the total chamber volume in the radiation being monitored and cannot be used to measure the intensity of a small collimated beam. Their readings will be much lower than the actual beam intensity. The use of such instruments should be confined to only locating beams.)

2.5.1.2 If a radiation beam must cross a personnel thoroughfare, it must pass longitudinally through a pipe firmly anchored across the thoroughfare. A stile or other method for crossing the pipe must be provided for personnel.

2.5.1.3 The area around a beam-type experiment apparatus must be zoned according to standard Laboratory radiation control regulations.

2.5.2 Beam holes which contain voids that may become filled with water either intentionally (as a beam shutter) or accidentally must have the effect of such filling with water evaluated with respect to its effect upon the reactor reactivity and control ionization chambers. If the effect of filling and emptying the beam hole has a significant effect upon the reactivity and/or ionization chambers, arrangements must be worked out with the Reactor Supervisor for devising a safe procedure. Accidental filling should be avoided by providing a normally open drain or other system for guaranteeing that filling will not occur.

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