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PROCEDURES AND CRITERIA IN SAFETY EVALUATION OF NUCLEAR FACILITIES

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Note: The principles described in the following regulations apply to all nuclear facilities: reactors, critical facilities, chemical processing and fuel element plants, and shipping procedures for nuclear materials. Procedures described in Sections 2, 3, and 4 apply particularly to reactors and critical facilities; Sections 5 and 6 apply to processing plants and material shipments, respectively.

1. Site Selection

When consideration is given to the criteria and standards by which safety adequacy is evaluated for a proposed nuclear facility site, three basic principles become apparent:

1. The basic safety criterion to be satisfied by any proposed site is, that routine or emergency operation of the reactor to be located there shall not release radioactive materials in such way as to cause injury or damage to people and property outside the site area.

2. It is impossible to evaluate the safety adequacy of a given site independently of a consideration of the type of reactor to be located there, its characteristics, and the type of facilities to be associated therewith.

3. A reactor can be located at almost any site, provided sufficient containment and other safeguards are incorporated to insure that hazardous amounts of radioactive materials will not be released outside the site area.

Commission evaluation of the acceptability of a particular site for a proposed facility is accomplished early in the life of each project as an integral part of the total evaluation given in deciding

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whether or not the applicant's request for a Construction Permit for a proposed nuclear facility should be granted. Therefore, further discussion of site selection is deferred to the next section.

2. Construction Permit Procedures and Criteria; The Preliminary Hazards Report

It is required that each licensed reactor facility be evaluated with respect to adequacy of safeguards against public hazards, prior to issurance of a Construction Permit for the facility. This evaluation usually occurs in a relatively early phase of the project, before design details of the facility have been firmly established.

Before a Construction Permit can be issued, there must be a decision by the staff of the Commission, that there is reasonable assurance that a facility of the general type and anticipated usage of the one proposed can be designed, constructed and operated in the proposed location, without undue hazard to the health and safety of the general public.

The Commission reaches a decision on an application for a Construction Permit on the basis of information presented by the applicant in a Preliminary Hazards Report. This report, which usually consists of a single document, though further addenda may be presented as necessary, is a formal part of the application for a Construction Permit and, hence, becomes a part of the public record. Exceptions to inclusion in the public records may be made at the desire of the applicant on the basis of "Company Confidential" criteria, where such can be justified as described elsewhere.

Two essential functions must be accomplished by the Preliminary Hazards Report:

A. The conceptual plan and anticipated features of the facility must be described sufficiently to permit estimation therefrom of the hazards which might arise through operation of the facility, and the adequacy of safeguards of the public against these hazards, and

B. the applicant's own analysis of these hazards must be given, together with reasons for his belief that adequate safeguards exist for the protection of the public against these hazards.

Since design details and anticipated behavior characteristics usually are not confidently established at this period, it is usually not possible to present a firmly based description of the credible, potential hazards expected to exist, generally therefore, the applicant describes and analyzes some upper boundary for the hazards, beyond which no credible hazards would be expected to fall when later systematic analyses are made and shows that even for these hazards adequate safeguards for the protection of the public are incorporated.

From analysis of the Preliminary Hazards Report, the Commission will appraise the hazards which may potentially exist in a facility of the type proposed and determine the adequacy of safeguards incorporated by design, or inherently present, against these hazards. To accomplish this, careful examination will be made of the hazard and safeguard descriptions and evaluation presented by the applicant and, where necessary, independent analyses, estimations, and calculations will be made. Thus, the conditions, assumptions, bases, and methods of analysis used by the applicant in arriving at the magnitude and consequences of hazards should be sufficiently described to permit their clear comprehension. Further, the pertinent features of the site and of the facility should be quantitatively described, where appropriate, so that independent evaluation of the essential hazards, and consequences thereof, can be made.

To accomplish the intended functions, the Preliminary Hazards Report should contain four principal components, described here:

1. A Description of the Proposed Site

The objective here should be to give a complete, quantitative description of all environmental features relative to safety (or hazard) of the facility. The size and location of the applicant's property holding, the position of the facility on the property; population and industrial distribution in the surrounding areas; relevant features of pertinent meteorology, hydrology, and seismology. It should be noted, however, that a simple tabulation of these environmental data is not, per se, sufficient. There must be in addition a brief summary or synthesis of the information, including identification of the significant features, favorable or unfavorable, with respect to the safety aspects of the proposed facility. However, actual discussion of the relevance of these environmental data to safety of the public may be included in the fourth part of the report, mentioned below.

2. A Description of the Reactor

The general features of the reactor, as conceived, including purpose, power level and general plan of utilization, should be described. Design or structural details should be omitted unless they are pertinent to the overall safety considerations. All nuclear and physical data essential to potential hazards (e.g., dimensions, expected fuel loading and reactivity values, temperature coefficients, thermal features of the fuel) should be stated numerically, if possible. Shielding, reactor experimental facilities, cooling provisions, and instrumentation are considered part of the reactor. Only the functional features and a block diagram of the instrumentation are needed at this stage.

3. <u>Description of the Auxiliary Systems, Facilities and Housing</u>

The conceptual plan of the facility should be delineated fully, with particular emphasis on the features relevant to safety: dimensions, functional map of the building, containment specifications, plan of ventilation and waste disposal, power or other auxiliary systems and their potential interactions with the reactor. Again it should be noted that presentation of these data as independent and unrelated tabulations may not achieve the objective of the report. Where possible, the applicant should identify or summarize relationships or particularly significant features, favorable or unfavorable, to safety aspects of the facility where this would facilitate understanding of discussions presented later in the report.

4. <u>Discussion of Potential Hazards</u>

Potential hazards which could arise from operation of a reactor facility having the characteristics of the one proposed should be identified. Discussion should lead to a set of assumptions, as realistically linked as possible to the anticipated characteristics of the reactor and the conceptual design of the facility, resulting in an accident having consequent damages which could not be exceeded by those from any other accident arising out of any credible circumstances imaginable. Once the assumptions which could lead to this accident have been defined, rigorous and complete analysis should be made of the consequences, both to the occupants of the facility and to the inhabitants of the surrounding public areas. Relevant data from the site and facility sections, mentioned above, should be included in the analysis and a summary of conclusions should show clearly the applicant's estimation of the potential hazards, particularly the public hazards, which could result from operation of the proposed facility.

Thus, the applicant's presentation in the Preliminary Hazards Report, of the site, reactor and facility descriptions and his analysis of the potential hazards should be so made that the Commission can understand the assumptions made and methods used in arriving at the conclusions reached, and also can make independent analysis of the hazards where it might so desire. To achieve this, the Preliminary Hazards Report may, in some cases, need to be only a dozen or so pages in length, while in other cases a great deal more than this may be required. Where a relatively simple or well-proven, low power reactor, in a highly favorable location, is proposed, it may be possible to give the necessary descriptions, establish an upper limit of hazard, and demonstrate that no significant consequent harm would be expected therefrom, in a relatively short report. In other cases, particularly for reactors having large fission product inventories, marginally acceptable locations, or controversial or little-understood characteristics influential in the safety behavior of the reactor, detailed and complete analyses must be made. In these cases, it may be necessary for the Commission staff to hold conferences with the applicant for clarification of issues, seek the advice of advisers and consultants, or even to request experimental elucidation of pertinent features, before a decision on the "reasonable assurance of safety" can be reached.

It should be noted that a favorable decision on any proposed facility and the subsequent issuance of a Construction Permit does not impose on the Commission any obligation for eventual approval of the facility when construction shall have been completed. Issuances of a Construction Permit indicates that, in the opinion of the Commission, there is reasonable assurance that a facility of the general type proposed can be designed and operated in such way, in the proposed location, without undue hazard to the health and safety of the general public. This action may be taken to imply that, in the opinion of the Commission, there is a reasonable probability that the constructed reactor will be found safety-wise acceptable and, if this turns out to be the case, the eventual request for an Operating License for the reactor will be granted. The final decision, however, on the adequacy of safety in the completed reactor must rest on analyses and the evaluations made at that time, and is not prejudiced in any way by prior decisions which may have been made on the expected eventual safety of the project in question.

3. Procedures and Criteria for the Operating License; The Final Hazards Report

When a reactor facility has been completely designed and construction has progressed to such point that the time for initial operation approaches, application for an Operating License may be made. For such license to be issued, the Commission must first determine, from complete investigation and appraisal, that there is reasonable assurance that the facility as designed and constructed, and as proposed to be operated, in the location existing, will not cause undue hazard to the health and safety of the general public.

The Commission reaches a decision on this matter largely on the basis of information presented by the applicant in a Final Hazards Summary Report. This report, which may consist of a single document or of several documents presented over a considerable period of time, constitutes a part of the formal application for an Operating License, and hence, it becomes a part of the public record, subject to the conditions noted above for the Preliminary Hazards Report.

The purpose of the Final Hazards Summary Report is to present a description of the facility as actually constructed and an outline of the anticipated plans and procedures for operation, together with a composite body of convincing evidence that operation as proposed will not endanger the health and safety of the general public. Material presented earlier in the Preliminary Hazards Report, where it is still valid, need not be repeated, but where deviations in plans have occurred from these originally conceived and described, particularly if elements of safety are involved, these should be appropriately described. Reference should be made particularly to experimental or theoretical clarification of safety issues which may have occurred subsequent to presentation of the Preliminary report; to changes in components or systems arising from safety considerations; to justifications, foundations and analyses leading to final choices of crucial safety features or components; and to composite estimated consequences of potential hazards still existing. The overall emphasis in this report should be on those aspects of the facility as constructed and the plans for operation as anticipated which have a bearing on the safety for the facility.

Thus, in the Final Hazards Summary Report, the applicant establishes his own evaluation of the hazards which might arise from anticipated operation of the constructed facility, together with the basis and analyses which lead to this evaluation, along with sufficient information to permit the Commission to make an independent appraisal of the ultimate safety. To achieve this, the Final Hazards Summary Report usually contains four components, described here:

1. Description of the Facility as Constructed

   Attention should be given to features different from those originally described with complete details, numerical and quantitative where appropriate, on features and components involved in the safety aspects of the facility. For example, the basis for specifications on the vapor containment should be given along with analyses and data from experimental tests indicating expected performance with respect to specifications.

2. Detailed Description of the Reactor

   All characteristics of the reactor itself as finally designed and constructed are essential to evaluation of the overall safety. Quantitative description of the physical, nuclear thermal, hydraulic, mechanical and chemical features and characteristics should be given. Description of the instrumentation system should be given with respect to the bases for the final choice of performance specifications, and the functions to be performed.

3. Administration, Organization, Plans and Procedures

   Particular emphasis should be given to the organizational structure of the operating staff, the principal ground rules and policies of operation, and the plans and procedures to be followed in case of accidents or emergencies, insofar as these relate to ultimate safety and protection against the consequences of malfunction or misoperation.

4. Final Estimate of Hazards and Safeguards

   As the plant is finally completed, re-examination should be made of the potential accidents which could occur, including re-appraisal of hazards arising from the accident considered to be the maximum credible for the facility. It should be shown that adequate protection of the public exists even for this accident.

Thus, the Final Hazards Summary Report should be so presented that the Commission can clearly understand the specifications, bases and methods used by the applicant in arriving at the conclusion that adequate protection of the public is provided against hazard which might arise from operation of the facility. In addition, sufficient information should be included on essential details, to present independent evaluation of the crucial safety aspects.

4. Further Comments on Preliminary and Final Hazards Reports

No sharp line can be drawn between what should be included in the first report and what in the second. In some cases, where essential features can be firmly fixed early in the project, much of the total information can be presented in the Preliminary Hazards Report and relatively little added descriptions, revisions and re-appraisals will be required in the Final Hazards Summary Report. In other cases, where extensive portions of the design, and even research and development, are required during the construction period, the Final Hazards Summary Report must be a great deal more inclusive.

Convenience is greatly enhanced if references in Final Hazards Summary Reports to important matters presented in earlier reports are fully documented, i.e., by report and page number. Tabulation of some of the specific items commonly required in hazards reports may be of assistance in preparing these reports.

A. These items should be covered in the Hazards Reports on Reactors and Critical Facilities unless, in particular cases, they are not applicable.

<u>Summary</u>

General description, pertinent features, overall plans, objectives and concepts.

<u>Site</u>

Geographic Location

Site Description
Topography, elevations, distances to boundaries and to nearest residences, etc.

Population distribution in surrounding areas, land uses in nearby areas.

Meteorology
Summary of relevant features.

Hydrology

Geology

Seismology

<u>Reactor</u>

General Description

Nuclear characteristics
Flux distribution, parameters, such as n, f, p, L, B^2, neutron lifetime with and without moderator, metal to water ratio, critical mass, detailed tabulation of reactivity requirements (temperature, xenon, other poisons, voids, experiments, burnup, etc.) and reactivity worths (rods, elements, reflector, thimbles, etc.). Coefficients of reactivity (temperatures, void, pressure, power); Kinetics: ramp and step additions, effects of thermal characteristics; inherent factors causing termination of excursions, fuel cycles, burnup, poison buildup.

Mechanical and Thermal characteristics
Hydrological problems, pressure drops, temperature distributions in elements and reflector, burnout, margins, abnormal conditions, power level, power density.

Auxiliary Systems

Control and shim rods
Nuclear characteristics, mechanical features, rates, drive mechanism.

Instrumentation system
Basic plans and specifications, detectors, functional arrangement, scrams, alarms, interlocks, response times.

Coolant-power generating systems
Basic plan, flow diagram with numerical description of parameters
(Volume, flow, temperature, heat capacity); piping, values, exchangers, pressurizers, normal and abnormal functioning, time response to load variations, emergency cooling.

Pressure vessel
Design specifications, mechanical design, testing, thermal stresses, radiation embrittlement, corrosion,

Shielding
Thermal, biological, exposure rates, missile resistance

Building or Containment Shell

General plan and specifications, (pressure, leak, shock, missile), construction, insulation; penetrations, testing (initial and periodic).

Accident Analysis

Systematic review of potential, credible accidents;
Identification of maximum most probable potential accident;
Identification, description, and analysis of accident considered maximum credible one for this facility
Assumptions; numerical description of all essential factors; method of analysis and calculation of results; energy, fission product releases, consequences

If no credible accidents result in fission product release to the environment, define some conceivable, incredible accident which would cause such release, and analyze the consequences, thus demonstrating the added safety provided by environmental features of the site.
Conclusion as to adequacy of safeguards.

Administration, Organization, Procedures

Lines of authority, responsibility, organizational plan, principles of operation, review committees, supervisory achievement of safety consciousness, emergency procedures, disaster plan, drills.

B. A Check List for Critical Facilities

From the outline above, which is more particularly appropriate for reactors, selection of applicable items may be made in preparing hazards reports on proposed critical facilities. In addition, there is listed below a collection of generally accepted principles which have evolved from the accumulated experience on critical facilities:

1. Physical Design Features

In general, critical facilities must be highly flexible and variable in nature, have a wide variety of objectives, and are composed of many different combinations of materials. Hence, it is difficult to specify hard and fast rules. Nevertheless, some general principles have come to be more or less commonly observed everywhere.

(1) The variable excess reactivity must be kept to a minimum; where mock-ups require large excess reactivity, most of it may be controlled by fixed not variable poisons.

(2) There must be an inherent limitation on rate of reactivity addition.

(3) Means must be provided for fast acting reactivity subtraction.

(4) Criticality must always be achieved from a remote point, never with personnel in the immediate vicinity of the assembly.

(5) An adequate artificial source of neutrons must be present in all experiments.

(6) Positive periods shorter than 10 seconds should not be permitted.

(7) Fission product inventory must be kept at a minimum.

(8) The instrumentation system must contain at least two, preferably, independent, automatic trip-safety circuits.

(9) One trip-safety circuit must be very fast acting.

(10) The instrumentation system and safety trip-system must be fail-safe.

(11) There must usually be provided two independent methods of shutdown.

(12) Neutron detectors with audible indicators must be provided both in the proximity of the assembly and in the control room.

(13) Usually precautionary measures must be taken, if an assembly does not possess inherent shutdown characteristics.

(14) Combination of shielding and isolation must be provided to protect operators; due attention must be given to doses from scrattered gammas.

(15) Ventilation should be away from the operators; means should be provided for shutdown in case of accident.

(16) The mechanism should be as simply and substantially constructed as possible with a minimum number of interlocks, and bypassing of interlocks should be made very difficult.

2. <u>Containment, Isolation, Environment</u>

The basic principle here should be "Expect the best; prepare for the worst". In case accidents happen, adequate containment, isolation and environmental features should insure that hazards do not result to the public or to operating personnel. This leads to the necessity of establishing the upper limit of hazard which might result from any credible accidents in this facility and the consequences of these accidents should be compared with the features of safety provided by containment, isolation and environmental characteristics.

Critical facilities have two advantageous aspects: fission product inventory from routine operation should be low and fission products formed in a nuclear excursion are predominately shorter lived. However, in analyzing the possibilities of hazards, other factors should not be overlooked. For example, the direct radiation from a nuclear excursion or gamma rays from released fission products, and possibilities of other poisons being released, such as vaporized beryllium.

3. Regulations, Procedures and Supervisory Control

The achievement of safety, maintenance of a healthy esprit de corps with a proper attitude toward safety is essential; judicious, deliberate and careful procedures in normal operations are also essential.

(1) There should be a definite written plan of experiments to be performed and of procedures to be followed.

(2) There should be a Review Committee for examining proposed new experiments and deviation from established procedures which may appear desirable.

(3) All participants must consent to any proposed procedural plan.

(4) No experiments may be performed unless two persons are present.

(5) There should be a definite upper limit to the number of people present at any given time.

(6) One man in the operating room should be primarily concerned with objectives of safety.

(7) Conversation and irrelevant comments should be minimized during experimental operation.

(8) One man, and only one, must be in control during a given experiment.

(9) No experiment may be undertaken under the duress of a time limit.

(10) Experiments should not be continued beyond the point of weariness for the staff.

(11) Dry runs should be performed on all new physical setups.

(12) Instrument check-out and actuation of safety trips should precede each experiment or each day's experiments.

(13) There must be a well organized and periodically exercised emergency plan.

(14) Emergency safety and monitoring equipment should be strategically placed to be available when needed.

5. <u>License Application Procedures for Processing Plants</u>

For Chemical Processing and Fuel Element plants the safety information and analyses needed in support of the License Application may be submitted in a single hazards summary report. This report should be separate from other documents containing financial and other necessary information and should be clearly marked as the Hazards Summary Report. This report should contain the following:

1. A statement of the amount of material, its chemical and physical form and enrichment, to be possessed for processing through operations visualized by the applicant.

2. An outline and description of steps in any processing planned by the applicant, including an indication of the requisite amount and the physical and chemical conditions of material involved in each step.

3. A floor plan of the manufacturing area, with an indication of material flow, and demarcation of separate areas where material inventories would be necessary in the manufacturing process.

4. A tabulation of

   (a) The permissible accumulations of materials specified for each inventory point.

   (b) The "margins of safety" or difference between the permissible amount of material at each point and that amount which would result in accidental criticality for the material, under the conditions appertaining and under the most unfavorable conditions which could exist there.

5. An outline of calculations, or appropriately referenced sources of information on which the numbers in 4 above are based.

6. An outline of procedures, checks, or safeguards, by which adherence to the specified limits in the various process inventories are maintained.

7. An outline of emergency procedures which will be followed to minimize hazard to plant personnel and the public, in case a nuclear accident should occur.

8. An analysis by the applicant of the points in the process where probability of hazards are the greatest and an appraisal of the adequacy of the safeguards provided.

6. License Application Procedure for Shipping Nuclear Materials

For shipments of nuclear materials, the safety information and analysis needed to insure adequate protection from inadvertent nuclear criticality accidents should be presented in a single, clearly labelled Hazards Summary Report. This report should contain the following:

1. A description of the shipping container.

2. Tabulation of the quantities, and the physical, chemical and isotopic composition of material in each container and in each shipment.

3. Where quantities are to be shipped in excess of those which are exempt (i.e., those which may be shipped without prior approval) tabulation should be made for ~~the~~ material in the shipment of the quantity which would be critical (a) under normal conditions pertaining and (b) under the most unfavorable condition which could occur in emergencies during shipment. The purpose of this is to indicate the margin of safety between the quantity proposed to be shipped[2] and that which would cause a nuclear incident.[3]

4. Safeguards to be employed to assure that containers will not come into hazardous proximity to each other.

5. The method of transportation proposed.

6. The applicant's own evaluation of the adequacy of safeguards to be provided against potential hazards which might occur under the most adverse conditions.