1.5 PRINCIPAL DESIGN CRITERIA

There are two ways of considering principal design criteria. One way is to consider the criteria on a system-by-system (or system group) basis. The second way is to consider criteria classification-by-classification as given in Tables 1.4-2 A and B.

In the classification-by-classification approach, the criteria must be stated in sufficient detail to allow placement of each criterion into one classification category. Thus, there may be closely related criteria pertaining to any given system in each classification category. This is a natural outgrowth of the functional (unacceptable result) approach to classification. The actual design of a system must reflect all of the criteria that pertain to it; thus, the less restrictive (but more important) criteria pertaining to the system in the classification approach will be masked by the more restrictive (and less important) criteria.

Safety analysis requires the information gained in the classification-by-classification approach to criteria, but system description is more easily understood through the system-by-system method. Both approaches to criteria are given in this section; both are useful.

1.5.1 Principal Design Criteria Classification-By-Classification

The principal architectural and engineering criteria for the design and construction of the plant are summarized below. The criteria are grouped according to the classification plan given in Tables 1.4-2 A and B. Some of the more general criteria are so broad that they are applicable, at least in part, to more than one classification. In these very general cases, all of the affected classifications are indicated. Specific design bases and design features are detailed in other sections of this report. Criteria pertaining to operation of the plant are given in Appendix G.

1.5.1.1 General Criteria

Applicable Classifications		Criteria
PG-1,S-1,S-2,S-3	1.	The plant shall be designed so that it can be fabricated, erected, and operated to produce electric power in a safe and reliable manner. The plant design shall be in accordance with applicable codes and regulations.
S-1,S-2,S-3	2.	The plant shall be designed in such a way that the release of radioactive materials to the environment is limited so that the limits and guideline values of

applicable regulations pertaining to the release of radioactive materials are not exceeded.

S-1,S-2,S-3,S-4 3. The reactor core and reactivity control system shall be designed so that control rod action shall be capable of bringing the core subcritical and maintaining it so, even with the rod of highest reactivity worth fully withdrawn and unavailable for insertion.

S-1,S-2,S-3 4. Adequate strength and stiffness with appropriate safety factors shall be provided so that a hazardous release of radioactive material shall not occur.

1.5.1.2 Power Generation Design Criteria, Type PG-1 (Planned Operation)

1. The nuclear system shall employ a General Electric boiling water reactor to produce steam for direct use in a turbine generator.

2. The fuel cladding shall be designed to retain integrity as a radioactive material barrier for the design power range.

3. The fuel cladding shall be designed to accommodate, without loss of integrity, the pressures generated by the fission gases released from the fuel material throughout the design life of the fuel.

4. Heat removal systems shall be provided in sufficient capacity and operational adequacy to remove heat generated in the reactor core for the full range of normal operational conditions from plant shutdown to design power. The capacity of such systems shall be adequate to prevent fuel clad damage.

5. (Deleted).

6. It shall be possible to manually control the reactor power level.

7. Control of the nuclear system shall be possible from a single location.

8. Nuclear system process controls shall be arranged to allow the operator to rapidly assess the condition of the nuclear system and to locate process system malfunctions.

9. Fuel handling and storage facilities shall be designed to maintain adequate shielding and cooling for spent fuel.

10. Interlocks or other automatic equipment shall be provided as a backup to procedural controls to avoid conditions requiring the functioning of nuclear safety systems or engineered safeguards.

1.5.1.3 Power Generation Design Criteria, Type PG-2 (Abnormal Operational Transients)

1. The fuel cladding, in conjunction with other plant systems, shall be designed to retain integrity throughout any abnormal operational transient.

2. Heat removal systems shall be provided in sufficient capacity and operational adequacy to remove heat generated in the reactor core for any abnormal operational transient. The capacity of such systems shall be adequate to prevent fuel clad damage.

3. Heat removal systems shall be provided to remove decay heat generated in the core under circumstances wherein the normal operational heat removal systems become inoperative. The capacity of such systems shall be adequate to prevent fuel clad damage.

4. Standby electrical power sources shall be provided to allow removal of decay heat under circumstances where normal auxiliary power is not available.

5. Fuel handling and storage facilities shall be designed to prevent inadvertent criticality.

1.5.1.4 Nuclear Safety Design Criteria, Type S-1 (Planned Operation)

1. The Plant shall be designed so that fuel failure during planned operation is limited to such an extent that, were the freed fission products released to the environs via the normal discharge paths for radioactive materials, the limits of 10 CFR 20 would not be exceeded.

2. The reactor core shall be designed so that its nuclear characteristics exhibit no tendency toward a divergent power transient.

3. The nuclear system shall be so designed that there is no tendency for divergent oscillation of any operating characteristic, considering the interaction of the nuclear system with other appropriate plant systems.

4. Gaseous, liquid, and solid waste disposal facilities shall be so designed that the discharge and offsite shipment of radioactive effluents can be made in accordance with applicable regulations.

5. The design shall provide means by which plant operations personnel can be informed whenever limits on the release of radioactive material are exceeded.

6. Sufficient indications shall be provided to allow determination that the reactor is operating within the envelope of conditions considered by plant safety analysis.

7. Radiation shielding shall be provided and access control patterns shall be established to allow a properly trained operating staff to control radiation doses within the limits of applicable regulations in any mode of normal plant operation.

1.5.1.5 Nuclear Safety Design Criteria, Type S-2 (Abnormal Operational Transients)

1. The plant shall be so designed that fuel failure as a result of any abnormal operational transient is limited to such an extent that, were the freed fission products released to the environs via the normal discharge paths for radioactive materials, the limits of 10 CFR 20 would not be exceeded.

2. Those portions of the nuclear system which form part of the nuclear system process barrier shall be designed to retain integrity as a radioactive material barrier following abnormal operational transients.

3. Nuclear safety systems shall act to assure that no damage to the nuclear system process barrier results from internal pressures caused by abnormal operational transients.

4. Where positive, precise action is immediately required in response to abnormal operational transients, such action shall be automatic and shall require no decision or manipulation of controls by plant operations personnel.

5. Essential safety actions shall be carried out by equipment of sufficient redundance and independence that no single failure of active components can prevent the required actions. For systems or components to which IEEE-279 is applicable, single failures of passive electrical components will be considered, as well as single failure of active components in recognition of the higher anticipated failure rates of passive electrical components relative to passive mechanical components.

6. The design of nuclear safety systems shall include allowances for environmental phenomena at the site.

7. Provision shall be made for control of active components of nuclear safety systems from the control room.

8. Nuclear safety systems shall be designed to permit demonstration of their functional performance requirements.

9. Standby electrical power sources shall be provided to allow prompt reactor shutdown and removal of decay heat under circumstances where normal auxiliary power is not available.

10. Standby electrical power sources shall have sufficient capacity to power all nuclear safety systems requiring electrical power.

1.5.1.6 Nuclear Safety Design Criteria, Type S-3 (Accidents)

1. Those portions of the nuclear system which form part of the nuclear system process barrier shall be designed to retain integrity as a radioactive material barrier following accidents. For accidents in which one breach in the nuclear system process barrier is postulated, such breach shall not cause additional breaches in the nuclear system process barrier.

2. Engineered safeguards shall act to assure that no damage to the nuclear system process barrier results from internal pressures caused by an accident.

3. Where positive, precise action is immediately required in response to accidents, such action shall be automatic and shall require no decision or manipulation of controls by plant operations personnel.

4. Essential safety actions shall be carried out by equipment of sufficient redundance and independence that no single failure of active components can prevent the required actions. For systems or components to which IEEE-279 is applicable, single failures of passive electrical components will be considered, as well as single failure of active components in recognition of the higher anticipated failure rates of passive electrical components relative to passive mechanical components.

5. Features of the plant which are essential to the mitigation of accident consequences shall be designed so that they can be fabricated and erected to quality standards which reflect the importance of the safety action to be performed.

6. The design of engineered safeguards shall include allowances for environmental phenomena at the site.

7. Provision shall be made for control of active components of engineered safeguards from the control room.

8. Engineered safeguards shall be designed to permit demonstration of their functional performance requirements.

9. A primary containment shall be provided that completely encloses the reactor vessel.

10. The primary containment shall be designed to retain integrity as a radioactive material barrier during and following accidents that release radioactive material into the primary containment volume.

11. It shall be possible to test primary containment integrity and leak tightness at periodic intervals.

12. A secondary containment shall be provided that completely encloses both the primary containment and fuel storage areas.

13. The secondary containment shall be designed to act as a radioactive material barrier under the same conditions that require the primary containment to act as a radioactive material barrier.

14. The secondary containment shall be designed to act as a radioactive material barrier, if required, whenever the primary containment is open for expected operational purposes.

15. The primary and secondary containments, in conjunction with other engineered safeguards, shall act to prevent the radiological effects of accidents resulting in the release of radioactive material to the containment volumes from exceeding the guideline values of applicable regulations.

16. Provisions shall be made for the removal of energy from within the primary containment as necessary to maintain the integrity of the containment system following accidents that release energy to the primary containment.

17. Piping that penetrates the primary containment structure, and which could serve as a path for the uncontrolled release of radioactive material to the environs, shall be automatically isolated whenever such uncontrolled radioactive material release is threatened. Such isolation shall be effected in time to prevent radiological effects from exceeding the guideline values of applicable regulations.

18. Core Standby Cooling Systems shall be provided to prevent excessive fuel clad temperatures as a result of a loss-of-coolant accident.

19. The Core Standby Cooling Systems shall provide for continuity of core cooling over the complete range of postulated break sizes in the nuclear system process barrier.

20. The Core Standby Cooling Systems shall be diverse, reliable and redundant.

21. Operation of the Core Standby Cooling Systems shall be initiated automatically when required, regardless of the availability of offsite power supplies and the normal generating system of the plant.

22. Standby electrical power sources shall have sufficient capacity to power all engineered safeguards requiring electrical power.

23. The control room shall be shielded against radiation so that occupancy under accident conditions is possible.

1.5.1.7 Nuclear Safety Design Criteria, Type S-4 (Special Event

In the event that the control room becomes inaccessible, it shall be possible to bring the reactor from power range operation to cold shutdown (Mode 4) by manipulation of the local controls and equipment which are available outside the control room.

1.5.1.8 Nuclear Safety Design Criteria, Type S-5 (Special Event)

Backup reactor shutdown capability shall be provided independent of normal reactivity control provisions. This backup system shall have the capability to shut down the reactor from any normal operating condition, and subsequently to maintain the shutdown condition.

1.5.2 Principal Design Criteria, System-By-System

The principal architectural and engineering criteria for design are summarized below on a system-by-system or system group basis. The system-by-system presentation facilitates the understanding of the actual design of any one system, but significant distinctions in the importance to safety of different criteria pertaining to a system cannot be made clear, as they are in the classification-by-classification presentation. To make consistent judgments regarding plant safety, the classification-by- classification approach to criteria must be used.

In the system-by-system presentation of criteria, only the most restrictive of any related criteria are stated for a system. Where the most restrictive criterion is one which is classified as a power generation consideration in Table 1.4-2B, less restrictive, but more important, safety criteria may be hidden (not stated) in the system-by-system presentation.

1.5.2.1 General Criteria

1. The plant shall be designed so that it can be fabricated, erected, and operated to produce electric power in a safe and reliable manner. The plant design shall be in accordance with applicable codes and regulations.

2. The plant shall be designed in such a way that the release of radioactive materials to the environment is limited, so that the limits and guideline values of applicable regulations pertaining to the release of radioactive materials are not exceeded.

1.5.2.2 Nuclear System Criteria

1. The nuclear system shall employ a General Electric boiling water reactor to produce steam for direct use in a turbine-generator.

2. The fuel cladding shall be designed to retain integrity as a radioactive material barrier for the design power range and for any abnormal operational transient.

3. Those portions of the nuclear system which form part of the nuclear system process barrier shall be designed to retain integrity as a radioactive material barrier following abnormal operational transients and accidents. For accidents in which one breach in the nuclear system process barrier is postulated, such breach shall not cause additional breaches in the nuclear system process barrier.

4. The fuel cladding shall be designed to accommodate, without loss of integrity, the pressures generated by the fission gases released from the fuel material throughout the design life of the fuel.

5. Heat removal systems shall be provided in sufficient capacity and operational adequacy to remove heat generated in the reactor core for the full range of normal operational conditions from plant shutdown to design power, and for any abnormal operational transient. The capacity of such systems shall be adequate to prevent fuel clad damage.

6. Heat removal systems shall be provided to remove decay heat generated in the core under circumstances wherein the normal operational heat removal systems become inoperative. The capacity of such systems shall be adequate to prevent fuel clad damage.

7. The reactor core and reactivity control system shall be designed so that control rod action shall be capable of bringing the core subcritical and maintaining it so, even with the rod of highest reactivity worth fully withdrawn and unavailable for insertion.

8. The nuclear system shall be so designed that there is no tendency for divergent oscillation of any operating characteristic, considering the interaction of the nuclear system with other appropriate plant systems.

9. The reactor core shall be so designed that its nuclear characteristics exhibit no tendency toward a divergent power transient.

1.5.2.3 Power Conversion Systems Criteria

1. Appropriate power conversion systems shall be provided to efficiently convert the heat energy of the steam produced in the reactor vessel to mechanical energy for turning a generator to produce electrical power.

2. Means shall be provided for furnishing makeup (feedwater) to the reactor vessel to allow continued operation.

1.5.2.4 Electrical Power Systems Criteria

1. A generator capable of efficiently producing electric power shall be provided.

2. Electrical power for protection systems and engineered safeguards shall be available from two offsite sources so that no single failure in the facility can result in loss of offsite power.

1.5.2.5 Radioactive Waste Disposal Criteria

1. Gaseous, liquid, and solid waste disposal facilities shall be designed so that the discharge and offsite shipment of radioactive effluents can be made in accordance with applicable regulations.

2. The design shall provide means by which plant operations personnel can be informed whenever operational limits on the release of radioactive material are exceeded.

1.5.2.6 Nuclear Safety Systems and Engineered Safeguards Criteria

1.5.2.6.1 General

1. Nuclear safety systems shall act in response to abnormal operational transients to limit fuel damage such that, were the freed fission products

released to the environs via the normal discharge paths for radioactive material, the limits of 10 CFR 20 would not be exceeded.

2. Nuclear safety systems and engineered safeguards shall act to assure that no damage to the nuclear system process barrier results from internal pressures caused by abnormal operational transients or accidents.

3. Where positive, precise action is immediately required in response to accidents, such action shall be automatic and shall require no decision or manipulation of controls by plant operations personnel.

4. Essential safety actions shall be carried out by equipment of sufficient redundance and independence that no single failure of active components can prevent the required actions. For systems or components to which IEEE-279 is applicable, single failures of passive electrical components will be considered, as well as single failure of active components in recognition of the higher anticipated failure rates of passive electrical components relative to passive mechanical components.

5. Features of the plant which are essential to the mitigation of accident consequences shall be designed so that they can be fabricated and erected to quality standards which reflect the importance of the safety function to be performed.

6. The design of nuclear safety systems and engineered safeguards shall include allowances for environmental phenomena at the site (e.g., weather extremes and proximity to other high energy systems). Furthermore, electrical equipment in these systems shall be capable of performing their safety function as required under environmental conditions associated with all normal, abnormal, and plant accident operation.

7. Provision shall be made for control of active components of nuclear safety systems and engineered safeguards from the control room.

8. Nuclear safety systems and engineered safeguards shall be designed to permit demonstration of their functional performance requirements.

1.5.2.6.2 <u>Containment and Isolation Criteria</u>

1. A primary containment shall be provided that completely encloses the reactor vessel.

2. The primary containment shall be designed to retain integrity as a radioactive material barrier during and following accidents that release radioactive material into the primary containment volume.

3. It shall be possible to test primary containment integrity and leak tightness at periodic intervals.

4. A secondary containment shall be provided that completely encloses both the primary containment and fuel storage areas.

5. The secondary containment shall be designed to act as a radioactive material barrier under the same conditions that require the primary containment to act as a radioactive material barrier.

6. The secondary containment shall be designed to act as a radioactive material barrier, if required, whenever the primary containment is open for expected operational purposes.

7. The primary and secondary containments, in conjunction with other engineered safeguards, shall act to prevent the radiological effects of accidents resulting in the release of radioactive material to the containment volumes from exceeding the guideline values of applicable regulations.

8. Provisions shall be made for the removal of energy from within the primary containment as necessary to maintain the integrity of the containment system following accidents that release energy to the primary containment.

9. Piping that penetrates the primary containment structure, and could serve as a path for the uncontrolled release of radioactive material to the environs, shall be automatically isolated whenever such uncontrolled radioactive material release is threatened. Such isolation shall be effected in time to prevent radiological effects from exceeding the guideline values of applicable regulations.

1.5.2.6.3 Core Standby Cooling Criteria

1. Core Standby Cooling Systems shall be provided to prevent excessive fuel clad temperatures as a result of a loss-of-coolant accident.

2. The Core Standby Cooling Systems shall provide for continuity of core cooling over the complete range of postulated break sizes in the nuclear system process barrier.

3. The Core Standby Cooling Systems shall be diverse, reliable, and redundant.

4. Operation of the Core Standby Cooling systems shall be initiated automatically when required, regardless of the availability of offsite power supplies and the normal generating system of the plant.

1.5.2.6.4 Standby Power Criteria

1. Standby electrical power sources shall be provided to allow prompt reactor shutdown and removal of decay heat under circumstances where normal auxiliary power is not available.

2. Standby electrical power sources shall have sufficient capacity to power all engineered safeguards requiring electrical power.

1.5.2.7 Reactivity Control Criteria

1. Backup reactor shutdown capability shall be provided independent of normal reactivity control provisions. This backup system shall have the capability to shut down the reactor from any operating condition, and subsequently to maintain the shutdown condition.

2. In the event that the control room is inaccessible, it shall be possible to bring the reactor from power range operation to cold shutdown (Mode 4) by manipulation of the local controls and equipment which are available outside the control room.

1.5.2.8 Process Control Systems Criteria

1.5.2.8.1 Nuclear System Process Control Criteria

1. It shall be possible to manually control the reactor power level.

2. Control of the nuclear system shall be possible from a single location.

3. Nuclear system process controls shall be arranged to allow the operator to rapidly assess the condition of the nuclear system and to locate process system malfunctions.

4. Interlocks or other automatic equipment shall be provided as a backup to procedural controls to avoid conditions requiring the actuation of nuclear safety systems or engineered safeguards.

1.5.2.8.2 Deleted

1.5.2.8.3 Electrical Power Systems Process Control Criteria

Controls shall be provided in the electrical power systems to protect against faults and to increase the reliability of incoming and outgoing power.

1.5.2.9 Auxiliary Systems Criteria

1. Fuel handling and storage facilities shall be designed to prevent criticality and to maintain adequate shielding and cooling for spent fuel.

2. Means shall be provided to remove heat from process systems that is generated through operation of the plant.

3. Fire detection and protection systems capable of protecting the plant against all types of fires shall be provided.

4. Means shall be provided to adequately heat, ventilate, and air-condition plant buildings for personnel comfort and equipment protection.

5. Means shall be provided to furnish other auxiliary services as required for safe and efficient operation of the plant.

1.5.2.10 Shielding and Access Control Criteria

1. Radiation shielding shall be provided and access control patterns shall be established to allow a properly trained operating staff to control radiation doses within the limits of applicable regulations in any mode of normal plant operation.

2. The control room shall be shielded against radiation so that occupancy under accident conditions is possible.

1.5.2.11 Structural Loading Criteria

Adequate strength and stiffness, with appropriate safety factors, shall be provided so that a hazardous release of radioactive material shall not occur. Details of implementation are given in Chapter 12 and Appendix C.