SAFETY SERIES No 117

SAFETY GUIDES

safety series

Operation of Spent Fuel Storage Facilities

INTERNATIONAL ATOMIC ENERGY AGENCY, VIENNA, 1994

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OPERATION OF SPENT FUEL STORAGE FACILITIES

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FOREWORD

Nuclear power is becoming an ever more significant part of the energy programmes of many countries. The spent fuel resulting from reactor operations must be safely stored and managed pending its reprocessing or disposal. The International Atomic Energy Agency recognizes the increasing need for such interim spent fuel storage and has consequently established a programme to provide guidance to its Member States on the key safety aspects of safe storage. This programme complements the IAEA's Nuclear Safety Standards (NUSS) programme.

The IAEA has prepared and issued a series of related Safety Series publications addressing the design, operation and safety assessment of interim spent fuel storage facilities. This Safety Guide has been prepared for use by organizations or firms in the nuclear power industry, supporting organizations and related Regulatory Bodies in identifying and managing all relevant issues on the operational aspects for the safe interim storage of spent fuel from nuclear power plants.

This Safety Guide has been developed through a series of Advisory Group Meetings, Technical Committee Meetings and Consultants Meetings from 1990 to 1994, and presents an international consensus on useful operating principles. These principles incorporate features which will be effective in maintaining fuel subcritical, removing residual heat, providing radiation protection and containing radioactive materials for the lifetime of the facility.

CONTENTS

1. INTRODUCTION

BACKGROUND

101. This Safety Guide was prepared as part of the IAEA's programme on safety of spent fuel storage. It reflects the standards of the IAEA's Nuclear Safety Standards (NUSS) programme relating to nuclear power plants, and, in particular, the IAEA Code on the Safety of Nuclear Power Plants: Design [1].

102. The Safety Guide is related to two other Safety Series publications on the subject of spent fuel storage: Design of Spent Fuel Storage Facilities [2] and Safety Assessment for Spent Fuel Storage Facilities [3].

OBJECTIVE

103. The purpose of this Safety Guide is to provide details on the safe operation of interim spent fuel storage facilities. The information in this Safety Guide will also assist the operator in preparing the documentation required for operating the storage facility.

SCOPE

104. This Safety Guide is for interim spent fuel storage facilities that are not an integral part of an operating nuclear power plant. Interim spent fuel storage facilities provide for the safe storage of spent nuclear fuel after it has been removed from the reactor pool and before it is reprocessed or disposed of as radioactive waste. The facilities may be either co-located with nuclear facilities (such as a nuclear power plant or reprocessing plant) or sited independently of other nuclear facilities.

105. The type of spent fuel considered in this Safety Guide is typically that derived from water moderated reactors. The Safety Guide can also be applied to fuel types such as those from gas cooled reactors, and fuel assembly components can also be considered. Other items, such as canistered failed fuel, may be considered if an adequate safety analysis is prepared.

106. The Safety Guide on Fuel Handling and Storage Systems in Nuclear Power Plants [4] provides guidance on the design of fuel storage systems that are an integral part of an operating nuclear power plant. Similarly, publications on the design of high level waste facilities and spent fuel disposal facilities are included in the Radioactive Waste Safety Standards (RADWASS) series.

107. Transport requirements are provided in IAEA Regulations for the Safe Transport of Radioactive Material [5], and in related IAEA publications (e.g. the TECDOC entitled Interfaces between Transport and Geological Disposal Systems

for High Level Radioactive Waste and Spent Nuclear Fuel [6]). The interface between storage and transport is discussed in this Safety Guide.

STRUCTURE

108. Following this introduction, Section 2 describes key activities in the operation of spent fuel storage facilities. Section 3 lists the basic safety considerations for storage facility operation, the fundamental safety objectives being subcriticality, heat removal and radiation protection. Recommendations for organizing the management of a facility are contained in Section 4. Section 5 deals with aspects of training and qualifications; Section 6 describes the phases of the commissioning of a spent fuel storage facility. Section 7 describes operational limits and conditions, while Section 8 deals with operating procedures and instructions. Section 9 deal with maintenance, testing, examination and inspection. Section 10 presents recommendations for radiation and environmental protection. Recommendations for the quality assurance (QA) system are presented in Section 11. Section 12 describes the aspects of safeguards and physical protection to be taken into account during operations; Section 13 gives guidance for decommissioning.

2. KEY OPERATIONAL ACTIVITIES

201. Interim spent fuel storage facilities provide for the safe, stable and secure storage of spent nuclear fuel before it is reprocessed or disposed of as radioactive waste. A major consideration in operating a spent fuel storage facility is to achieve and maintain high standards of safety in terms of protecting operating staff, the environment and members of the public.

202. Various designs of wet and dry spent fuel storage facilities are in operation or under consideration in Member States. Although designs differ, all consist of relatively simple, often passive systems, which are intended to provide adequate safety over several decades. Associated handling and storage operations are relatively straightforward.

203. Spent fuel is usually transferred to interim spent fuel storage facilities only after an initial period of storage at the reactor station. This initial period of storage allows a considerable reduction in the quantity of volatile radionuclides, the radiation fields and the production of residual heat. Hence, the development of conditions which could lead to accidents at spent fuel storage facilities will generally occur comparatively slowly, allowing ample time for corrective action before limiting conditions are approached. The safety of spent fuel handling and storage operations can thus be maintained without relying on complex, automatically initiated protective systems.

204. The operator of a spent fuel storage facility must receive detailed information concerning the characteristics, design and construction of the spent fuel received for storage. This information should be supplied by the shipper of the fuel. The minimum information to be provided is:

— Fuel design, including scale drawings;
— Materials of construction of fuel, including initial and final mass of all fissile contents;
— Fuel identification numbers (e.g. serial numbers on fuel assemblies);
— Fuel history (e.g. burnup, reactor power rating during irradiation, residual heat and dates of loading and discharge from the reactor);
— Details of conditions present that would affect fuel handling or storage (e.g. damage to fuel cladding or structural damage);
— Confirmation that fuel can be correctly handled upon receipt at the storage facility;
— Specific instructions for storage (e.g. failed fuel).

205. In addition, information concerning the fuel transport cask must also be transmitted to the spent fuel storage facility operator by the shipper. This information should include:

— Type of cask and appropriate information on its design, and the arrangement of fuel and internal components inside the cask cavity;
— Cask radiological survey data before shipment;
— Cask identification (e.g. serial number) and certification of compliance with current transport regulations;
— Cask handling and sealing (e.g. safeguards) requirements and procedures;
— Results of the most recent inspection of the cask.

206. During cask handling, the following operations should be considered in order to ensure safety:

— *When cask is loaded with spent fuel:* cask decontamination when required;
— *During loading and unloading, both under wet and dry conditions:* cask internal gas space sampling prior to removing the closure lid, and examining the spent fuel (where appropriate);
— *When cask is empty:* decontamination when necessary, cask routine maintenance and cask recertification operations.

207. The management of stored fuel requires:

— Control and recording of internal movements between different storage areas, as permitted by the operational limits and conditions;
— Complete inventory and accounting of fuel, including characteristics and storage location.

208. There are several features of pool management which contribute to the safe operation of wet storage facilities. These include operations that maintain design parameters and minimize corrosion for pool structures, systems and components, and promote radiation protection, such as shown in Table I:

TABLE I. MANAGEMENT AND SAFETY CONSIDERATIONS FOR A WET STORAGE FACILITY

Element	Applicable safety considerations
1. Control of the amount of fuel loaded in the pool, taking account of residual heat, reactivity and floor static loadings	Subcriticality, containment
2. Protection of pool floors and walls from impact loads	Containment, radiation protection
3. Control of pool water chemistry (specific activity, temperature, chemical composition)	Containment, radiation protection
4. Control of pool water level	Radiation protection
5. Maintenance of ventilation systems	Containment
6. Maintenance of pool heat removal systems	Containment, heat removal
7. Maintenance of lifting equipment	Radiation protection, containment
8. Maintenance of underwater lighting	Radiation protection
9. Administrative controls to prevent misplacing fuel	Subcriticality

209. There are several elements in the management of a dry storage facility which contribute to the safe operation. Some of the key elements are listed in Table II.

210. Anticipated operational occurrences associated with spent fuel storage shall be taken into account in documented procedures or operating instructions, and during training.

3. BASIC SAFETY CONSIDERATIONS FOR OPERATION

BASIC AREAS OF CONCERN

301. The three basic areas of concern associated with the operation of interim spent fuel storage facilities are:

— Inadvertent criticality;
— Undue radiation exposure to workers and the public;
— Loss of heat removal capability.

Each of these has a number of possible postulated initiating events and conditions. The operating organization has the responsibility for developing adequate operating procedures to address these events in such a manner as to ensure that these sources of radiation exposure are kept to a minimum.

TABLE II. MANAGEMENT AND SAFETY CONSIDERATIONS FOR A DRY STORAGE FACILITY

Element	Applicable safety considerations
1. Controlling the amount of fuel in the storage compartments	Subcriticality, heat removal
2. Monitoring gamma and neutron radiation fields near the location of fuel in the storage area, as required by the Regulatory Body	Radiation protection
3. Monitoring heat removal and heat dissipation from fuel to ultimate heat sink (atmosphere)	Heat removal, radiation protection
4. Direct monitoring of fuel containment integrity (if permitted by design)	Radiation protection
5. Indirect monitoring of atmosphere in volumes/ spaces inside facility containing sealed fuel containers (if present in design)	Radiation protection
6. Maintenance and monitoring of the inert gas surrounding fuel in sealed containers (if present in design)	Heat removal

302. Some factors will be of particular importance in maintaining the safety of the facility. The significance of these factors should be clearly highlighted at important points in the procedures to give them a higher status than other procedures (e.g. by setting operational limits and conditions and administrative controls, as covered in Section 7). Such highlighting of operational limits and controls will help to avoid violations. Specific training for operating staff shall also highlight and draw the attention of the staff to these important limits and conditions.

SUBCRITICALITY

303. A fundamental safety objective shall be to ensure that subcriticality is always maintained in the storage facility. The interaction of all components of the fuel

storage facility during operation shall be analysed in detail to determine the effects of both correct and incorrect operations on the potential for criticality excursions in stored fuel. This analysis is needed to demonstrate that the facility will, by design and operation, always remain subcritical. If no safety analysis is available for a particular fuel then that fuel is not acceptable for storage in the installation.

304. The operating organization shall ensure that operating procedures relating to maintaining subcriticality are subjected to rigorous review and compared with the design and safety analysis. In most Member States, it is also necessary to have a review by the Regulatory Body. The factors to be considered in this review include:

- Fuel types;
- Safe fuel geometries;
- Fuel handling operations;
- Potential for abnormal operation;
- Confirmation of fuel parameters (e.g. initial enrichment, final enrichment, burnup);
- Dependence on neutron absorbers.

305. Credit shall not be claimed for neutron absorbing parts or components unless they are fixed and their neutron absorbing capabilities can be determined, and unless they are unlikely to be degraded by any postulated initiating events.

306. In the particular case of wet storage, credit shall not be taken for the presence of a soluble neutron absorber in the pool water unless this credit includes a verification requirement with an appropriately justified frequency and is acceptable to the Regulatory Body.

307. All fuel shall be assumed to be at a burnup giving maximum reactivity unless credit for burnup is assumed on the basis of justification acceptable to the Regulatory Body. Such justification should include direct measurements prior to storage of fuel, as required by the Regulatory Body.

308. Before implementing any changes or modifications to the facility, particular attention should be paid to changes in any of the factors identified above to ensure that the subcriticality analysis continues to be valid for any new circumstances. Storage facility modifications are considered in Section 8.

309. For facilities receiving fuel from a number of sources the facility operating organization shall ensure that each source provides data on fuel parameters in a clearly understandable form which allows the operator to demonstrate that subcritical conditions will exist during the handling and storage of this fuel. The facility operating organization shall further ensure that the data provided is supported by an approved quality assurance programme to provide a high degree of confidence to both the facility operating organization and the Regulatory Body.

SHIELDING

310. Loss of shielding during facility operation can lead to high radiation exposure; it may result from:

- Hoisting fuel higher than design limits during handling operations in the storage pool;
- Inadequate depth of pool water:
- Improper use of pool tools (e.g. hollow rather than flooded);
- Deficiencies in dry storage structures;
- Handling errors when closing or sealing dry storage structures;
- Improper operation or failure of protective interlocks on cell shielding;
- Melting of neutron shielding material due to high temperatures.

311. The operating organization shall ensure that, in addition to design provisions, such events are protected against by appropriate operating procedures. Organizations operating dry storage facilities shall ensure that the environment surrounding casks and vault canisters inside vaults can be monitored for increases in gamma and neutron fields that may indicate a degradation of shielding.

CONTAINMENT

312. Loss of containment has the potential for both exposing workers to radiation and releasing activity to the environment. Mechanisms by which loss of containment might occur shall be understood by the operating organization and addressed, as appropriate, in operating procedures.

313. Cladding failure can result in the release of isotopes such as ^{85}Kr, ^{134}Cs and ^{137}Cs, which are characteristic fission products detected following cladding failures in fuel that has been cooled for long periods. Cladding failures may be more probable when fuel and fuel cladding is subjected to high temperatures, and when chemistry conditions in the medium surrounding the fuel promote cladding corrosion. The operating organization shall ensure that adequate monitoring of environmental conditions within the facility (e.g. pool water chemistry and/or storage area atmosphere and moisture or water on fuel cladding) is undertaken to provide notice of such conditions. Procedures should be provided for detecting and dealing with failed cladding.

314. Additionally, the operating organization shall ensure either that procedures exist for the receipt, handling and storage of fuel with failed cladding or that such fuel is not accepted at the facility. In cases where it is accepted, in addition to containment considerations there may be criticality implications which should be fully assessed and, where appropriate, subject to specific procedures.

315. In wet storage facilities, a decrease in pool water level may result in:

- Increased radiation fields and dose rates to storage facility staff caused by decreasing the shielding water depth;
- Impaired fuel cooling if the reduction in water level interrupts or reduces water flow to the heat exchange equipment of the pool cooling system ;
- Increased water temperature and, consequently, increased release of radioactive materials into the water because of corroded fuel and fuel cladding.

316. The operating organization shall undertake suitable routine monitoring of such parameters to enable remedial action to be taken on a timely basis.

317. Operational procedures should be developed for spent fuel storage containment systems (e.g. closure seals on storage canisters and casks, and ventilation and filtration systems) to provide monitoring capability. This monitoring shall be such that the operator will be able to determine when corrective action is needed to maintain safe storage conditions. Specifically, for double seal systems, this monitoring should detect the loss of effectiveness of any single seal before any potential releases of radioactive materials to the environment. For single seal systems and ventilation systems, release of radioactive materials (eg. ^{85}Kr, ^{134}Cs and ^{137}Cs) should be monitored as required by the Regulatory Body.

HEAT REMOVAL

318. The amount of residual heat associated with irradiated fuel depends on a number of factors, such as the fuel type, the degree of irradiation or burnup and the time after discharge. The design of the wet or dry storage system shall have considered these factors and imposed limitations that shall be adhered to throughout the operating period of the storage facility.

319. The storage facility designer should have considered any adverse effect or damage to the structure of pools or dry storage systems from overheating. For pools it may be possible to cause damage to the structure by cooling the pool water to very low or freezing temperatures. Damage may also result from high rates of change of temperature in the pool structure caused by excessive rates of heating or cooling, thereby exceeding structural design limits. All of these issues related to heat removal shall be considered when defining operational limits and administrative procedures.

320. For dry storage systems, heat removal from the fuel occurs by conduction, radiation, and natural or, in some cases, forced air convection. For these facilities operational controls should consist of verifying that there are no impairments to air flow. If heat removal requires forced convection, additional operational controls and maintenance will be required on air moving systems.

321. Fuel storage operating organizations should consider the overall heat removal capacity of the storage systems and equilibrium conditions. For pool storage, operational procedures should be such that the pool heat removal systems are monitored to ensure maximum availability and to ensure that operating conditions remain within the design specifications. Impairments or degradation in pool cooling systems shall be responded to on a timely basis to return the system to designed operating condition. Also, maintenance of a pool cooling system that has the potential of impairing such systems shall be performed in a manner that minimizes the period during which the system is not fully available.

322. Heat transfer considerations may increase in importance as fuel is moved from low density storage to high density storage.

DROPPED LOADS

323. The operating organization shall consider categories of dropped loads such as casks or lids, fuel and fuel storage racks.

324. The casks used to receive spent fuel elements typically weigh approximately 30–120 Mg and may be lifted to heights of up to 10–15 m. Cask lids weigh significantly less (typically 2–8 Mg) and are usually lifted to lower heights. The prime areas of concern for pool storage designs are the facility zones between the cask entrance airlock and the cask preparation areas before loading/unloading, and the unloading pool area itself. In the unloading pool, the potential for mechanical damage resulting from a dropped cask would be amplified by the non-compressible properties of the pool water. The major potential hazard resulting from such a drop could be damage to the fuel in the cask or the loss of water from the pool either by direct expulsion or by gross leakage arising from structural damage.

325. Dropping fuel during transfer from the cask to the storage rack (or vice versa in the case of cask loading for dry storage) might result in:

- Partial defects in the fuel cladding, leading to leaks and resulting fission product contamination of the pool;
- Fuel deformation (e.g. bending) which may lead to difficulties in subsequent fuel handling;
- An increased probability or potential for the occurrence of a criticality accident should new or low burnup fuel fall alongside a basket or other fuel in storage racks;
- Personnel radiation exposure due to the release of fission gases.

326. Dropping a fuel storage rack or basket during transfer, in isolation or among other loaded racks, may result in:

- Contamination of the pool due to fuel cladding damage;

— Damage of pool structure and eventual leakage;
— A criticality event if several fuel assemblies are displaced from the rack, and if there is deformation of the fuel array or unacceptably close proximity to fuel assemblies or arrays in adjacent racks;
— Release of gaseous fission products.

327. Approved operating procedures shall be provided and followed to deal with all such identified possible events. In all cases the procedures shall require immediate assessment of the situation, followed by recovery on a timely basis.

328. A QA programme of operation and maintenance using approved procedures shall ensure:

— Maintenance and inspection of the lifting attachments on the casks and of the lifting apparatus (e.g. slings, beams, chains and hooks);
— Maintenance of storage facility cranes and fuel grabs.

OTHER CONCERNS

329. There are other concerns which should be considered. It should be noted that many of these are considered by the Member States either as anticipated operational occurrences or as design basis accidents. However, some of these events can also be considered as severe accidents, which are beyond the design basis. While the probability of such accidents occurring is extremely low, the operating organization should consider events such as these during the preparation of operating procedures and contingency plans. Some examples of these events are:

— Crane failure with a water filled and loaded cask, suspended outside the pool;
— Loss of safety related plant process systems such as electrical supplies, process water, compressed air and ventilation;
— Explosions due to the buildup of radiolytic gases;
— Misuse of chemicals (e.g. accidental introduction into the pool water of acidic or basic fluids used for ion exchange resin regeneration);
— Fires leading to damage to safety related systems (to reduce the risk of fire, the accumulation of combustible waste should be controlled, as should be the amount of other flammable materials);
— Extreme weather conditions which could alter operating characteristics or impair pool or cask heat removal systems;
— Natural events such as earthquake or tornado;
— External man-induced events (airplane crash, sabotage, etc.).

330. In addition to providing instructions and contingency procedures as described above, the operating organization shall also produce an emergency plan in accordance with the Safety Guide on Preparedness of the Operating Organization

(Licensee) for Emergencies at Nuclear Power Plants [7]. The emergency plan shall be approved by the Regulatory Body.

4. MANAGEMENT

401. Management shall have direct responsibility for safety. The organizational structure shall establish clearly the duties and responsibilities in respect to facility operations, for all positions in the structure.

402. The management system shall address the potential hazards associated with spent fuel storage facilities, identify the safety issues and define and control operator interaction to ensure good safety performance. The Regulatory Body may review and approve the management system and monitor its ongoing performance.

403. The management system should create and maintain a *safety culture* environment in all aspects of facility operations. The system should encourage the staff at all levels to view safety related operational issues in a critical manner and to take initiative in suggesting safety improvements to their tasks. The IAEA Safety Series No. 75-INSAG-4, Safety Culture: A Report by the International Nuclear Safety Advisory Group [8] deals with the subject of safety culture in detail and provides guidance on this matter.

404. The system established by the operating organization to manage the facility should address the issues identified in the IAEA Code on the Safety of Nuclear Power Plants: Operation [9], including commissioning and decommissioning, and apply those principles in establishing the arrangements for the safe operation of spent fuel storage. In particular, the arrangements should cover the following topics:

- — Operating procedures, including limits and conditions;
- — Commissioning;
- — Quality assurance and audits;
- — Maintenance, inspection, testing and examination;
- — Training;
- — Modification to facilities and equipment during design, construction, commissioning and operation;
- — Recording, reporting and investigating of events;
- — Radiation protection and safety performance;
- — Contingency and emergency arrangements;
- — Safeguards and physical protection;
- — Radioactive releases to the environment.

405. The degree of detail contained in specific arrangements shall be commensurate with the safety significance of the particular system or issue.

5. TRAINING AND QUALIFICATIONS

501. All persons supervising, performing and verifying commissioning and operating activities related to fuel storage facilities shall be selected, trained, qualified and authorized to operate those facilities within defined limits and conditions and in accordance with approved procedures. The training and qualification process should consist of classroom training, and on-the-job field training at similar facilities in operation or during commissioning of the facilities being constructed, followed by examinations and authorization. Records of the training and results of examinations of authorized staff should be kept for subsequent verification by the Regulatory Body. In certain cases the Regulatory Body might require licensing of some of the staff. In such cases the Regulatory Body shall establish the appropriate procedure.

502. The training programme should cover both the fundamental concerns related to the basic safety issues discussed in Section 3 and facility specific topics. The latter would cover such matters as system descriptions, safety analyses, procedures and controls to a sufficient degree that persons involved will be fully aware of all hazards and appropriate procedures to be followed under normal operating conditions. Operations staff should also learn to respond correctly to deviations from normal operating conditions to protect the facility, themselves and the public.

503. Table III lists key subjects that should be included by the management of spent fuel storage facilities in the training programme leading to the qualification and authorization of the operating personnel. These subjects are field and facility specific and do not cover possible prerequisites needed to fulfil certain tasks/jobs (e.g. engineering degree, other professional qualifications, crane operator's licence). The degree and extent of the training in each of the key subjects should be based on the assessment of tasks planned for each specified post, the level of responsibility expected from the person filling the post and the type and complexity of the decisions the person might be required to take in connection with the performance of his or her duties. Thus, the content of the training needed to prepare individuals to qualify for the different posts in the facility will vary greatly in different subjects. Some posts will require only a general appreciation of a particular subject, whereas others will require deep and detailed instruction leading to a fuller understanding of the subject.

504. It is good practice to group posts in the facility and provide the training for each group at the appropriate level. There are subjects with which all the persons involved in the facility should be familiar, e.g. radiation protection and emergency procedures. Others, such as physical protection and safeguards matters, should be presented on a need-to-know basis. Aspects of criticality, heat removal and corrosion should be explained in principle to the staff in charge of storage operation; similarly, cask handling and decontamination would be explained to the staff in charge of the cask handling operation.

TABLE III. KEY SUBJECTS IN A TRAINING PROGRAMME

Subject	Fundamental knowledge	Knowledge specific to interim spent fuel storage facility
Maintenance of subcriticality in stored fuel	Basic thermal, fast neutron multiplication in critical or sub-critical fissile material assemblies	Detailed physics of particular arrangement for fuel, absorbers and moderators in cask or storage facility
	Characteristics of soluble and solid neutron absorbers	Burnup characteristics of fuel normally handled in casks or stored in facility
Radiation protection	Basic radiation protection principles, techniques and measurements	Shielding arrangements, ambient dose levels, monitoring the radiological conditions of work areas
	Radiation hazards from irradiated fuel: — external hazards (beta, gamma and neutron fields) — internal hazards (airborne and surface contamination)	Specific external and internal radiation hazards of fuel in casks, storage facility and ancillary facilities, personnel monitoring, protective clothing
	Behaviour of radioactive substances released from failed fuel or deposited on cladding	Specific behaviour of radioactive substances released from failed fuel and crud deposits
Heat removal from the fuel to maintain cladding and fissile material integrity	Basic heat transfer from regular heated arrays by conduction, radiation, natural and forced convection	Heat transfer from particular arrangements of fuel in casks or in storage by conduction, radiation and convection; basis for design and operational limits
	Principles of heat exchange and heat removal to heat sinks	Heat transfer from a particular fuel heat source to external heat sinks; limitations
Materials corrosion control	Basic corrosion of materials exposed to water (e.g. in pool storage) or air (e.g. in dry storage)	Detailed water chemistry control to limit corrosion of specific fuel in storage (pool storage only) and basis of limitations. Corrosion control in a dry storage facility

TABLE III. (cont.)

Subject	Fundamental knowledge	Knowledge specific to interim spent fuel storage facility
Structural integrity of fuel	Characteristics of materials used in fuel assemblies (e.g. zirconium alloys, stainless steel, uranium dioxide)	Specific design characteristics of stored fuel assemblies
		Behaviour of specific assemblies with failed fuel elements
Information management, communications and reporting	Overview of internal and external information management, communications and reporting concerning spent fuel movements and internal operational activities, and notifications in the event of abnormal operating conditions	Specific, detailed information required by and to be produced by all groups in operating organizations, e.g. documentation, report controls, route sheets on fuel transfers, routine inspection reports and public communications
Procedures for normal and abnormal events	General principles of nuclear fuel integrity/safety: *Control* — confirm subcriticality *Heat removal* — confirm heat removal *Contain* — confirm barriers and shielding *Protect* — confirm workers' protection	Detailed study of operating procedures for: (a) normal operation, including conventional industrial safety (b) anticipated operational occurrences, e.g. loss of electrical power and restoration through stand-by electrical system (c) accident conditions, e.g. fuel drop, fire, loss of shielding, earthquake
Quality assurance, quality management	General principles of a QA programme	Detailed methodology for applying QA standards to all storage facility management levels (to convey importance of QA to all facility operating staff)
Cask handling	General fuel cask design and testing	Specific data on casks used for: (a) road, rail, public domain shipping (b) off-road/on-site shipping (c) storage casks, if transportable
	General Type B transport package shipping and the regulations, e.g. Ref. [8]	Specific training on cask handling procedures and equipment

TABLE III. (cont.)

Subject	Fundamental knowledge	Knowledge specific to interim spent fuel storage facility
Decontamination methods	General knowledge of radioactive contamination of surfaces	Specific knowledge of radioactive species expected to be found near fuel storage facilities (pool or dry storage) and cask surfaces
	General knowledge of general decontamination techniques	Specific methods and equipment used at the storage facility for decontaminating surfaces and equipment
Safeguards (if applicable)	General knowledge of safeguards and non-proliferation	Specific knowledge of safeguards containment and surveillance (C/S) applied to the storage facility and operational support required for safeguards methods and equipment
Physical protection	General knowledge of physical protection regulations and standards imposed by the Regulatory Body	Specific knowledge of physical protection equipment systems installed to protect the storage facility, including maintenance and testing; personnel access control procedures

6. COMMISSIONING

GENERAL

601. Commissioning involves a logical progression of tasks intended to demonstrate the correct functioning of features specifically incorporated into the design to provide for safe storage of spent fuel. In addition, operational procedures are confirmed and the readiness of staff to operate the facility is demonstrated. These procedures should cover both operational states and accident conditions.

602. The basis for commissioning should be established at an early stage as an intrinsic part of the project, and commissioning plans should be reviewed and, where appropriate, approved by the Regulatory Body. The responsibilities of the different

groups typically involved in commissioning (design, construction, commissioning, operating groups) should be clearly established. Arrangements should be established to cover:

— Specification of testwork;
— Documentation provision and approval;
— Responsibilities;
— Safety of testing;
— Control of testwork;
— Recording and review of test results;
Modifications and re-testing;
— Regulatory requirements;
— Progression through stages of commissioning;
— Reporting of results and approval for operation;
— Retention of records.

603. For modular storage systems, most of the commissioning is completed with the loading of the first storage module. However, some of the commissioning process becomes a part of routine operation as new modules are placed in service. A change in module design may also require some of the commissioning steps to be repeated for the new design.

604. Some commissioning steps also continue during facility operation. For example, the total heat removal capacity of a storage pool cannot be completely tested and verified until the storage facility is loaded to near capacity. Some large storage facilities use transport casks and fuel of various designs. Some commissioning steps should be repeated when new cask or fuel designs are first used.

COMMISSIONING STAGES

605. Commissioning will usually be completed in several stages:

— Construction completion;
— Equipment testing;
— Performance demonstration;
— Inactive commissioning (cold testing);
— Active commissioning (hot testing).

606. During the construction completion assurance stage, the facility should be physically inspected in detail to confirm that it meets the detailed design as approved by the Regulatory Body. Factors such as physical dimensions and initial background conditions should be established. A systematic check against the design drawings and project documentation should be carried out to establish the as-built status of the facility. In addition to providing information to facilitate operation of the plant, this

check can also be important when considering possible future modifications and ultimate decommissioning of the installation.

607. During the equipment testing stage the storage facility equipment and systems should be energized and the various controls, rotation direction, flow directions, currents, interlocks, etc., tested. Activities such as load testing of cask and fuel assembly lifting equipment should also be carried out and safe control of equipment should be demonstrated during these tests. In some cases limited physical interaction between equipment items should also be demonstrated.

608. After the individual equipment items have been tested, a range of tests should be performed to demonstrate the safe interaction of all equipment and the overall operational capability and capacity of the facility. At this stage, the safety and effectiveness of all instructions and procedures should be demonstrated. This should include demonstration of satisfactory training of operating staff for both normal operation and anticipated operational occurrences. The ability to conduct maintenance work safely and effectively should also be demonstrated.

609. The inactive commissioning (cold testing) stage should provide a formal demonstration that the equipment and procedures function in the manner intended, especially those identified as important to the safety of plant operation, usually derived from the Safety Analysis Report (SAR). The Regulatory Body may wish to approve the results of inactive commissioning prior to the introduction of radioactive materials into the facility.

610. The active commissioning (hot testing) stage begins with the introduction of radioactive material into the facility. This effectively marks the start of the operation of the facility and, hence, from this stage, the relevant safety requirements for plant operation shall apply. Active commissioning should involve a range of tests to demonstrate that the design criteria for radiological protection have been met.

611. Upon completion of commissioning, a final commissioning report shall be produced. This shall detail all testing and provide evidence of its successful completion. This report will provide assurance to the Regulatory Body that its requirements have been satisfied and may provide the basis for the subsequent licensing of the facility for full operation. Additionally, any changes to plant or procedures implemented during commissioning should be documented in an appropriate way.

7. OPERATIONAL LIMITS AND CONDITIONS

701. Operational limits and conditions form an important part of the basis on which operation is authorized and as such should be incorporated into technical and administrative arrangements which are binding on the operating organization.

Operational limits and conditions for storage facilities should be set and agreed with the Regulatory Body. The facility owner and operating organization may set an administrative margin below these specified limits as an operational target to help avoid any breach of the agreed operational limits and conditions.

702. While all operations can be directly or indirectly related to some aspect of safety, the aim of operational limits and conditions should be to manage and control the basic safety hazards in those facilities, and they should be directed toward:

- Preventing situations which might lead to unplanned exposure of people to radiation;
- Mitigating the consequences of such events should they occur.

703. Personnel directly responsible for the interim spent fuel storage facility operation shall be thoroughly familiar with the facility's operational limits and conditions to ensure compliance with their provisions. Systems and procedures shall be developed in accordance with quality assurance arrangements so that an operating organization shall be able to demonstrate compliance with the operational limits and conditions.

704. Operational limits and conditions for a spent fuel storage facility should be based on:

- The design specifications and operational parameters;
- The sensitivity of the components or systems with regard to safety and the consequences of the events following the failure of such systems or components, the occurrence of specific events or variations in operational parameters;
- Accuracy and calibration records of instrumentation equipment that measure safety related operating parameters;
- Consideration of the technical specification for each safety related system or component and the need to ensure that these systems and components continue to function in the event of any specified fault occurring or recurring;
- A requirement for specified safety related systems or components being available to ensure safety in normal operation (including maintenance) of safety related systems or components;
- A definition of the equipment which should be available to enable a full and proper response to foreseeable fault conditions or accidents;
- The minimum staffing levels which must be available either to operate the storage facility safely or maintain the shut down facility in a quiescent and safe state.

705. Table IV shows examples of technical operating limits and conditions which may be required for interim spent fuel storage facilities. In addition, Ref. [9], Chapter 3, should also be consulted.

TABLE IV. EXAMPLES OF OPERATING LIMITS AND CONDITIONS FOR SPENT FUEL STORAGE

Subjects	Operating limits and conditions
Subcriticality	Maximum allowable fuel enrichment
	Minimum allowable concentration of neutron poisons in fixed absorbers, if required
	Restricted movement and restrictions on storage configurations of fuel
	Restricted use of moderator
	Specified minimum fuel burnup, if applicable
	Fuel assembly characteristics
Radiation	Maximum allowable fuel burnup
	Minimum allowable water level in storage pool
	Specific requirements for radiation monitors, alarms and interlocks
	Minimum decay times after the discharge from the reactor
	Maximum activity concentrations in pool water
	Maximum radiation dose rates on cask surfaces
Heat removal	Specified availability of cooling systems with defined maximum and minimum system temperatures
	Minimum decay time after discharge from the reactor and maximum fuel burnup
	Maximum concrete and cask surface temperature
Water chemistry	Specification of water chemistry to prevent corrosion of fuel and storage components to ensure adequate water clarity and to prevent microbial growth
Safeguards	Specific safeguards methods to be used (if required by the Regulatory Body)
Physical protection	Specifications which lead to operation of physical protection equipment that complies with the regulations or standards of the Regulatory Body

706. Operating limits and conditions should be kept under review and, in particular, should be reviewed by the Regulatory Body in order to satisfy the legal requirements:

— In the light of operating experience;
— Following plant modifications;
— As part of the process of periodically reviewing the SAR for the facility, if required;
— If legal or regulatory conditions change.

8. OPERATING PROCEDURES

801. All storage facility operations shall be performed in accordance with approved written procedures prepared by the operating organization. These documents should be prepared in co-operation with the organizations responsible for the design of the interim spent fuel storage facility. However, the operating organization is responsible for ensuring that the procedures are prepared, reviewed, approved and issued. These procedures shall ensure compliance with the operational limits and conditions for the spent fuel storage facility.

802. Instructions and procedures shall be developed for normal operations of the spent fuel storage facility, anticipated operational occurrences and design basis accident conditions. Instructions and procedures should be prepared so that each action can be readily performed in the proper sequence by the designated responsible person. Responsibilities for approval of any required deviations from procedures for operational reasons should be clearly defined.

803. Adequate arrangements shall be made for review of operating procedures and for communicating any revisions to operating personnel. Revisions shall be undertaken only in accordance with written procedures, reviewed to ensure compliance with operational limits and conditions and safety limits approved by the Regulatory Body, and approved only by authorized persons.

804. Operating procedures should include sections defining:

- Title description with revision number, date and approval status;
- Purpose of the procedure;
- Initial conditions required before the procedure can be used;
- Precautions and limitations that must be observed;
- Limitations and action levels on parameters being controlled (e.g. pool water chemistry) and corrective measures to return parameters to within normal range;
- Procedures providing detailed, step by step operating instructions;
- Acceptance criteria, where applicable, for judging success or failure of activities;
- Checklists for complex procedures, either included or referenced;
- References used in producing the procedure;
- Testing to verify radiation dose levels and heat removal performance after fuel loading.

805. Operating procedures should be prepared. These might include the following particular subjects:

- Fuel handling procedures;
- Maintenance of subcriticality in stored fuel;

— Radiation protection and fuel containment procedures for the storage facility;
— Maintenance and verification of fuel heat removal;
— Maintenance of fuel shielding;
— Control of corrosion, material compatibility and coolant chemistry;
— Response to anticipated operational occurrences and accident conditions;
— Inspection of storage facility (if required by the Regulatory Body);
— Emergency planning;
— Control of plant modifications and inclusion in periodic reviews of the SARs;
— Maintenance of safeguards, if necessary (possibly confidential procedures);
— Control of physical protection for the storage facility (confidential procedures);
— Record keeping and document control.

806. The modification of any component of the facility shall be subject to specific procedures which require authorization before they are implemented. The procedures shall involve the categorization of the modification in accordance with its safety significance. Depending upon the safety categorization, each modification will be subject to varying degrees of review and endorsement by safety departments, plant management and the Regulatory Body. An operating organization should therefore expect to review and possibly modify an SAR from time to time.

807. All modifications shall be appropriately documented. The documents of record must be revised in a timely manner commensurate with their safety significance.

9. MAINTENANCE, TESTING, EXAMINATION AND INSPECTION

901. Before the operation of any interim storage facility commences, the operating organization shall prepare a programme of periodic maintenance, testing, examination and inspection of safety systems and safety related structures and components which are essential to safe operation. This programme should be available to the Regulatory Body for approval, if required. The programme will need to be re-evaluated in the light of commissioning and subjected to periodic review, taking account of operational experience. All these activities shall be described in written procedures.

902. The SAR for the facility will form a basis for preparing the programme in terms of the structures, systems and components which should be included and the periodicity of planned activities for each of these items. The standard and frequency of these activities shall ensure that the level of reliability and effectiveness remains in accordance with the design assumptions and intent so that a consistently high level of safety is maintained throughout the life of the storage facility.

903. It is equally important that the reliability and effectiveness of any component is not significantly affected by the frequency of testing, which may result in premature wear and failure or induced maintenance errors.

904. If particular maintenance, testing, inspection or examinations of the storage facility can only be carried out with equipment shut down, the maintenance schedule should identify a maximum operating period between such shutdowns.

905. The maintenance, testing, examination and inspection programme shall take into account the systems and components which are affected by the operating limits and conditions, as well as any other regulatory and safety requirements.

906. Suitably qualified and experienced persons should be involved in the approval and implementation of the maintenance, testing, examination and inspection programme and in the approval of working procedures and acceptance criteria for these activities.

907. Records should be kept of maintenance, testing, examination and inspection and should be subject to periodic examination to establish whether systems and components give the required reliability and to provide a basis on which to review and justify the programme of maintenance, etc.

908. In the case of spent fuel storage, some examples of structures, systems and components which may be included on a maintenance, testing, examination and inspection programme are listed in Table V.

10. RADIATION AND ENVIRONMENTAL PROTECTION

GENERAL

1001. The objectives of radiation protection programme are to:

- Ensure that radiation doses to the public and to the workers do not exceed regulatory limits;
- Ensure that radiation doses and radioactive discharges are kept as low as reasonably achievable (ALARA) for all activities performed at the facility;
- Review periodically the doses and radioactive discharges throughout the operating life of the plant to demonstrate that these continue to be ALARA;
- Ensure that the radiation exposure of workers from direct radiation, and surface and airborne contaminations, are separately monitored;
- Monitor the discharge of radionuclides from the storage facility and estimate dose rates and the concentrations of radionuclides in the environment due to the discharges, if so required by the Regulatory Body.

TABLE V. EXAMPLES OF EQUIPMENT FOR MAINTENANCE, TESTING, EXAMINATION AND INSPECTION

Item	Nature and subject of test
Lifting equipment: cranes, lugs, eyes, chains, cables, transporters and yokes	Brake systems, interlocks, mechanical integrity, load testing, taking into account national requirements
Storage structure or module	Structural integrity, accumulations of vegetation, snowfall or other effects which may impair heat removal capability Leak detection and monitoring Detection of corrosion of storage structures and tools
Loop components for cleaning, heat removal and monitoring of transport cask cavity	Flexible pipes for overpressure reliability Calibration, for example, of — temperature and pressure gauges — specified radiation monitoring equipment required for casks (e.g. for measurement of selected radionuclides, such as ^{85}K, ^{134}Cs and ^{137}Cs) — flow rate measurement
Special valve equipment to be fitted on casks	Mechanical maintenance, performance and testing of seals and valves
Grabs to handle fuel	Mechanical verification of ability of tool to fasten onto fuel, and check of locking mechanism functionality Verification of mechanical integrity of tool
Radiological monitoring equipment	Calibration and function tests of fixed or portable equipment
Storage racks	Confirm adequacy of neutron absorbers (if appropriate) Inspection of mechanical wear of casks, baskets and racks
Video cameras	Confirm functionality of cameras
Facility security	Confirm perimeter fences/gates functionality

1002. This programme shall include:

- Use of fixed and portable radiation measuring instruments of proper range and type to detect alpha, beta, gamma and neutron radiation (as appropriate);
- Wearing of beta, gamma and neutron dosimeters by the workers and visitors as required by the condition of the facility;
- Testing of filtration systems for removing airborne contamination to ensure the required degree of effectiveness;
- Confirmation that gamma and neutron shielding is adequate and as specified;
- Control and monitoring of intakes by ingestion or inhalation due to fuel handling;
- Routine cleaning of the workplace;
- Appropriate training of operating personnel.

1003. General advice on the structure of the radiation protection organization should be taken from Ref. [9] and the Safety Guide on Radiation Protection During Operation of Nuclear Power Plants [10].

SPECIFIC AREAS OF CONCERN

1004. Some activities will result in exposures of the workers to radiation. Therefore, special attention should be taken in developing radiation protection procedures for these activities:

- Spent fuel handling in pools;
- Handling of failed fuel;
- Cask loading, unloading, handling and decontamination;
- Maintenance of tools that come into direct contact with fuel or are exposed to radioactive contamination;
- Fuel loading cell manipulator maintenance;
- Radioactive waste handling, if appropriate;
- Handling high burnup fuels, possibly resulting in high neutron doses;
- Detection and handling of hot particles;
- Use of temporary or supplemental radiation shielding.

1005. To provide additional protection to the workers from airborne radioactive contamination, consideration shall be given to the provision of area zoning within the facility. Air movements shall be from low contamination areas to high contamination areas (or from relatively clean areas to relatively contaminated areas), which may be achieved, for example, through differential pressures in the air handling system. Special attention should be given to the administrative control of door openings and hatches during spent fuel handling operations.

1006. Ambient radiation fields should be monitored at a frequency sufficient to alert the operator to any loss of shielding as a result of structural deterioration.

11. QUALITY ASSURANCE

1101. The operating organization of an interim spent fuel storage facility shall be responsible for establishing and implementing a QA programme concerning the activities and systems specified in this Guide. The QA programme shall be in accordance with the principles and objectives specified in the IAEA Code on the Safety of Nuclear Plants: Quality Assurance [11] and related Safety Guides.

1102. The operation of safety systems and safety related systems and components of spent fuel storage facilities shall be subject to QA requirements commensurate with their safety importance.

1103. In particular, for spent fuel storage facilities, QA shall be applied to all activities that concern:

- Maintenance of subcriticality in stored fuel;
- Radiation protection;
- Heat removal from the fuel;
- Fuel shielding;
- Control of corrosion;
- Operating procedures concerning nuclear materials or fuel during commissioning, normal operation and anticipated operational occurrences;
- Maintenance, testing, examination and inspection of safety related equipment;
- Record keeping;
- Radioactive waste management;
- Maintenance of records concerning fuel characteristics during storage;
- Safeguards systems, if required;
- Physical protection systems.

12. SAFEGUARDS AND PHYSICAL PROTECTION

SAFEGUARDS

1201. 'Safeguards' refers to the IAEA safeguards system, the objective of which is the timely *detection* of any diversion of significant quantities of nuclear material from peaceful nuclear activities to the manufacture of nuclear weapons, other nuclear explosive devices, or for purposes unknown, and *deterrence* of such diversion by the likelihood of early detection. The IAEA safeguards system is based on the use of materials accountancy as a safeguards measure of fundamental importance, with containment and surveillances as major complementary measures. General information on the IAEA safeguards programme and the related technical measures are contained in IAEA documents such as IAEA Safeguards: an Introduction [12] and

IAEA Safeguards: Guidelines for States' Systems of Accounting for and Control of Nuclear Materials [13].

1202. In the operational context, arrangements shall be made to ensure that the facility operator is aware at all times of the location and quantities of nuclear materials in storage and to provide the necessary reports defined within the particular Safeguards Agreement.

1203. Attention should be given to specific nuclear materials accountancy and control procedures necessary to facilitate routine safeguards inspection activities. These will include:

- Design information provision and verification;
- Arrangements for material transfer;
- Records and reports;
- Material balance reports;
- Physical inventory taking;
- Physical inventory verification.

1204. In addition, the facility design may include provision of equipment and systems for containment and surveillance of the inventory subject to safeguards. Operational consideration should be given to the requirements for any services necessary to support this equipment.

PHYSICAL PROTECTION

1205. Physical protection systems to detect and deter the intrusion of unauthorized persons should be designed and installed during the construction of fuel storage facilities. The general requirements for these systems can be found in the documents. The Convention on the Physical Protection of Nuclear Material [14] and The Physical Protection of Nuclear Material [15].

1206. The operational requirements to control access effectively should consider a zoned approach working inward towards areas of greater security requirement in a structured manner. The detailed arrangements should form an integral part of plant management activities but should be divulged only on a controlled need-to-know basis.

1207. A programme of verification of the effectiveness of the physical protection arrangements should be established.

13. DECOMMISSIONING

1301. A decommissioning plan shall be prepared. This plan should be reviewed and approved by the Regulatory Body. An initial version of the decommissioning plan should be prepared during the design of the facility and should be updated during facility operation if any operational issues or problems are identified that affect decommissioning plans.

1302. Interim spent fuel storage facilities should be considered to be operating facilities until all the spent fuel has been removed.

1303. After the stored spent fuel has been removed, the facility can be decommissioned by removing residual radioactive contamination and dismantling the facility, as provided for in the approved decommissioning plan.

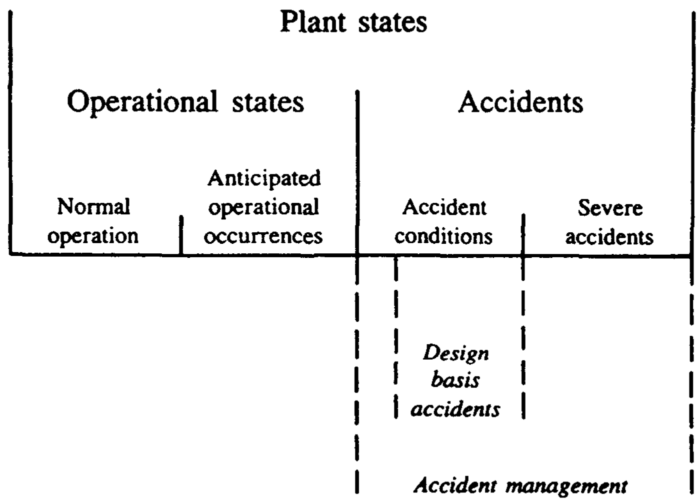
1304. If spent fuel cannot be removed using normal operating procedures, special operating procedures shall be developed to ensure safe fuel removal. These procedures should be reviewed and approved by the Regulatory Body.

DEFINITIONS

The definitions below are those specific to this document. Other terms in this document have the meaning as defined in other publications of the IAEA.

The specific definitions of plant states given below are taken from NUSS documents.

The relationships among the following fundamental definitions of plant states are illustrated by the accompanying diagram.



Operational States

States defined under normal operation or anticipated operational occurrences.

Normal Operation

Operation of a spent fuel storage facility within specified operational limits and conditions including fuel handling, storage, retrieval and fuel monitoring, maintenance and testing.

Anticipated Operational Occurrences[1]

All operational processes deviating from normal operation which are expected to occur once or several times during the operating life of the fuel storage facility and which, in view of appropriate design provisions, do not cause any significant damage to items important to safety nor lead to accident conditions.

Accident (or **Accident State)**

A state defined under accident conditions or severe accidents.

Accident Conditions

Deviations[2] from operational states in which the releases of radioactive materials are kept to acceptable limits by appropriate design features. These deviations do not include severe accidents.

Design Basis Accidents

Accident conditions against which the spent fuel storage facility is designed according to established design criteria.

Severe Accidents

Spent fuel storage facility states beyond accident conditions, including those causing significant fuel degradation.

Accident Management

The taking of a set of actions

- during the evolution of an event sequence, before the design basis of the plant is exceeded, or
- during severe accidents without allowing unacceptable radionuclide releases to the environment

to return the facility to a controlled safe state and to mitigate any consequences of the accident.

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[1] Examples of anticipated operational occurrences are loss of normal electric power, malfunction of individual items of a normally running plant and failure to function of individual items of control equipment.

[2] A deviation may be, for example, a major fuel failure caused by equipment malfunction, operator error, etc.

Other definitions used throughout this document are as follows:

Acceptable Limits

Limits acceptable to the Regulatory Body.

Applicant

The organization that applies for formal granting of a licence to perform specific activities related to siting, design, construction, commissioning, operation and decommissioning of a spent fuel storage facility.

Barrier

A natural or engineered feature which delays or prevents material migration to or from storage components. Facilities may include multiple barriers.

Burnup Credit

The assumption in criticality safety analysis that considers the reduction in reactivity due to changes of fissile material, and/or increase in fission product neutron absorbers in spent fuel that has occurred as a result of use in a nuclear reactor.

Concrete Canister (or **Silo**)

A concrete canister is a massive container comprising one or more individual storage cavities. It is usually circular in cross-section, with its long axis vertical. Containment and shielding are provided by an inner, sealed liner and the massive concrete of the canister body. Heat removal is accomplished by radiant transfer, conduction and convection within the body of the canister and natural convection at its exterior surface. Canisters may be located in enclosed or non-enclosed areas.

Containment System for Spent Fuel Storage

Systems, including ventilation, that act as barriers between areas containing radioactive substances and the environment.

Dry Storage

In dry storage, spent fuel is surrounded by a gas environment such as air or an inert gas. Dry storage facilities include the storage of spent fuel in casks, silos or vaults.

Fault

A failure of a single device or component to perform its safety function when required to do so by a demand on the safety system.

Fuel Assembly

A grouping of fuel elements which is not taken apart during the handling, storage, retrieval and monitoring activities of the spent fuel storage facility. It may include non-fuel components such as control rod spiders, burnable absorber rod assemblies, control rod elements, thimble plugs, fission chambers, neutron sources and fuel channels that are contained in, or are an integral part of, the fuel assembly but do not require special handling.

Fuel Element

The smallest structurally discrete part of a fuel assembly that has fuel as its principal constituent.

Licence

Authorization issued to the applicant by the Regulatory Body to perform specified activities related to siting, design, construction, commissioning, operation and decommissioning of the spent fuel storage facility.

Licensee

The holder of a licence.

Operating Organization

The organization authorized pursuant to a licence issued by the Regulatory Body to operate the spent fuel storage facility.

Operation

All activities performed to achieve the purpose for which the spent fuel storage facility was constructed, including maintenance, inspection and other associated activities related to spent fuel handling, storage, retrieval and monitoring.

Operational Limits and Conditions

A set of rules which set forth parameter limits, the functional capability and the performance levels of equipment and personnel approved by the Regulatory Body for safe operation of the spent fuel storage facility.

Postulated Initiating Events

Identified events that lead to anticipated operational occurrences or accident conditions and their consequential failure effects.[3]

Regulatory Body

A national authority or a system of authorities designated by a Member State, assisted by technical and other advisory bodies, and having the legal authority for conducting the licensing process, for issuing licences and thereby for regulating the spent fuel storage facility. The Regulatory Body will consider the siting, design, construction, commissioning, operation and decommissioning or specified aspects thereof.[4]

Residual Heat

The heat originating from radioactive decay in the spent nuclear fuel.

Silo (see **Concrete Canister**)

Site

The area containing the spent fuel storage facility, defined by a boundary and under effective control of the plant management.

Site Personnel

All persons working on the site, either permanently or temporarily.

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[3] The primary causes of postulated initiating events may be credible equipment failures and operator errors (both within and external to the spent fuel storage facility), or man induced or natural events. The specification of the postulated initiating events is to be acceptable to the Regulatory Body for the spent fuel storage facility.

[4] This national authority could be either the government itself, or one or more departments of the government, or a body or bodies specially vested with appropriate legal authority.

Spent Fuel Storage Facility

An installation used for the interim storage of fuel assemblies and related components after their removal from the reactor pool and before reprocessing or disposal as radioactive waste.

Storage Cask, Cask

A storage cask is a massive container which may or may not be transportable. It provides shielding and containment of spent fuel by physical barriers which may include the metal or concrete body of the cask and welded or sealed liners, canisters or lids. Heat is removed from the stored fuel by radiant transfer to the surrounding environment and natural or forced convection. Casks may be located in enclosed or non-enclosed areas.

Vaults

Vaults consist of above- or below-ground reinforced concrete buildings containing arrays of storage cavities suitable for containment of one or more fuel units. Shielding is provided by the exterior structure. Heat removal is normally accomplished by circulating air or gas over the exterior of the fuel-containing units or storage cavities, and subsequently exhausting this air directly to the outside atmosphere or dissipating the heat via a secondary heat removal system.

Wet Storage

Wet storage facilities for spent fuel are those facilities which store spent fuel in water. The universal mode of wet storage consists of storing spent fuel assemblies or elements in water pools, usually supported on racks or in baskets, and/or in canisters which also contain water. The pool water surrounding the fuel provides for heat dissipation and radiation shielding, and the racks or other devices ensure a geometrical configuration which maintains subcriticality.

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