STUK

OHJE GUIDE YVL1.13

Nuclear power plant outages

STUK • SÄTEILYTURVAKESKUS • STRÅLSÄKERHETSCENTRALEN
RADIATION AND NUCLEAR SAFETY AUTHORITY

Nuclear power plant outages

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Authorisation

By virtue of section 55, second paragraph, point 3 of the Nuclear Energy Act (990/87) and section 29 of the Council of State Decision (395/91) on General Regulations for the Safety of Nuclear Power Plants, the Finnish Radiation and Nuclear Safety Authority (STUK) issues detailed regulations concerning the safety of nuclear power plants.

YVL Guides are rules an individual licensee or any other organisation concerned shall comply with, unless STUK has been presented with some other acceptable procedure or solution by which the safety level set forth in the YVL Guides is achieved. This Guide does not alter STUK's decisions which were made before the entry into force of this Guide, unless otherwise stated by STUK.

1 General

The Finnish Radiation and Nuclear Safety Authority (STUK) controls nuclear power plant safety. In addition to controlling the design, construction and operation of nuclear power plants, STUK also controls refuelling and repair outages at the plants. It is of vital importance to maintain functions important to safety that are required during outages and to keep the radiation exposure of workers low. When started up after an outage, the nuclear power plant is expected to meet safety requirements in all respects.

According to section 9 of the Nuclear Energy Act (990/87), it shall be the licence-holder's obligation to ensure the safety of the use of nuclear energy. Requirements applicable to the licence-holder as regards the assurance of outage safety are presented in this Guide. STUK's regulatory control activities pertaining to outages are also described.

Requirements pertaining to individual maintenance assignments, inspections, repairs and modifications and STUK's regulatory activities relating to them are described in Guide YVL 1.8 and in separate YVL Guides pertaining to components and structures. Physical protection requirements are set forth in Guide YVL 6.11. In Guide YVL 7.4, requirements for emergency preparedness measures pertaining to outages and in Guide YVL 7.9 requirements for the radiation protection of workers are given. Outage notification requirements are set forth in YVL 1.5 and YVL 6.10.

2 General outage requirements

During refuelling outages, many onsite maintenance jobs, inspections, repairs and modifications are carried out to ensure reliable and safe plant operation and to meet the legislatory and regulatory requirements. The work carried out during a refuelling outage could include for example the following:

- replacement of reactor fuel
- inservice inspections and testing of systems, components and structures
- repair of failed components and structures
- periodic maintenance of components and structures
- plant modifications
- regulatory inspections.

A repair outage is a shutdown state into which the nuclear power plant is placed to repair a failed component or structure, or a shutdown state into which the plant has entered in consequence of component failures which must be repaired. No refuelling is conducted in a repair outage. Repair outages usually also include component maintenance.

The assurance of nuclear power plant safety during outages presupposes that the licence-holder already during the planning phases of outages takes into consideration factors affecting safety. Factors which have a bearing on safety are discussed in the following chapters.

2.1 Outage planning

The licence-holder shall appropriately prepare for refuelling and repair outages. The course of action relating to outage planning and implementation shall be presented in the licence-holder's quality assurance programme, as per Guide YVL 1.9. Appropriate outage planning requires i.a. that:

- the organisational units responsible for outage planning and implementation are named
- all work to be done during an outage is systematically identified and recorded into an appropriate work order system
- preliminary planning of pending work is systematic and takes place in a sustained manner
- the safety-significance of work to be done and the requirements presented later in this Guide in sub-sections 2.2 to 2.4 are taken into consideration during the planning
- all safety-significant work is assessed by a functional unit which is responsible for safety and is independent of the rest of outage planning
- written work plans and instructions are drawn up and updated
- any post-outage need to update the plant procedures and other documents has been assessed
- only qualified staff is employed in outage

work and that provision is made for giving additional training to any external workforce hired for outages
- provision is made for hiring experts with specific skills
- the necessary spare parts and tools are purchased and their appropriateness is ensured in advance
- information flow and co-operation between organisation units responsible for operations and maintenance is taken taken care of
- functioning of the work order procedures during outages and the recording of feedback data on accomplished work is assured
- procedures are introduced to ensure and monitor high quality of work
- preparedness exists to carry out extra work
- safety is assured even in case the mutual order of work assignments changes due to changed schedules
- sufficient time is reserved for checking plant start-up readiness
- operational experience feedback from outages is utilised to further develop outage functions.

With an eye to unplanned repair outages, a list shall be kept of maintenance, inspection, repair and modification work scheduled for the next hot or cold shutdown.

2.2 General safety requirements

According to section 7 of the Council of State Decision (395/91), radiation exposure arising from nuclear power plant operation shall be kept as low as reasonably achievable. In accordance with section 13 of the Decision, accidents leading to extensive releases of radioactive materials shall be highly unlikely. The licence-holder shall use appropriate probabilistic methods to assess the likelihood of a release of radioactive materials caused by shutdown states. Outage planning shall include evaluation of the validity of assumptions used for analysis. The plant unit's Technical Specifications shall be amended if a changed situation so requires, or an established safety level shall be ensured in some other way.

Outage work shall be planned in a way to make the unavailability periods of safety-significant systems and components as short as practically possible during an outage. Repair and maintenance of systems which perform safety functions shall take place one sub-system at a time to ensure that a sufficient number of sub-systems is simultaneously operational.

Safety functions required during an outage shall meet set requirements. The requirements for each plant and outage shall be established and defined in the Technical Specifications. What follows below are general operability requirements for essential safety functions.

The maintenance of reactor sub-criticality shall be assured to maintain at least a one per cent shutdown margin in the event of an individual component malfunction or single erroneous operator action.

A sufficient water volume in the reactor circuit shall be ensured in such a way that an individual component malfunction or a single erroneous operator action does not lead to loss of reactor cooling or loss of the make-up water injection option. For each plant, initial events during various shutdown conditions which may endanger the sufficiency of the primary circuit water volume shall be identified, as well as the arrangements for make-up water injection during these conditions. The reliable prevention of primary circuit water discharges outside the containment shall be possible under all circumstances.

The removal of decay heat from the primary circuit shall be ensured to prevent an individual component malfunction or a single erroneous operator action from resulting in a loss of the decay heat removal capability.

Containment leaktightness shall be maintained during shutdown states if
- spent fuel is handled inside the containment
- heavy loads are transferred above a loaded reactor or spent fuel pools
- actions are taken which increase reactor criticality or may lead to an uncontrollable reduction in the primary circuit water volume.

Timely, leaktight closing of the containment must be possible also during other situations.

The containment leaktightness requirement applies to nuclear power plants equipped with a pressurised water reactor. In nuclear power plants equipped with a boiling water reactor, it also applies to the secondary containment if, owing to plant design, primary containment leaktightness cannot be maintained during refuelling.

The emergency ventilation systems of the outer containment are to be operable in situations during which containment leaktightness is required.

When containment leaktightness is required, the repair, maintenance and testing of the primary containment isolation valves and access penetrations of a pressurised water reactor shall always be arranged in such a manner that at least one of two containment closing devices are kept in working order when the other is being serviced. Working order in this situation means the capability to maintain penetration leaktightness, automatic containment closure controlled by the plant protection system or preparedness of the personnel to close the penetration tightly enough and in a timely manner.

In addition to what is said above, the plant and outage specific operability requirements set for systems and components to ensure safety shall be given in the Technical Specifications. The following systems, among others, are required for ensuring safety during outage states:

- reactor circuit overpressure protection
- safety-significant automation systems and instrumentation
- systems controlling containment combustible gases
- containment airspace cooling and cleaning systems
- control room emergency ventilation system
- systems restricting radioactive releases
- fire protection systems
- power supply systems.

Transient and accident conditions assessed possible during outage situations shall be identified and appropriate written instructions shall be prepared concerning them.

2.3 Physical protection, emergency preparedness and fire protection

Requirements concerning nuclear power plant physical protection are given in Guide YVL 6.11. According to the Guide, the licence-holder is to prepare a physical protection plan for the nuclear facility stating i.a. the necessary outage arrangements. As part of outage planning, it shall be ensured that the physical protection plan is up-to-date and adequate to cover outage situations.

Requirements for nuclear power plant emergency preparedness arrangements are given in Guide YVL 7.4. The licence-holder shall prepare an emergency plan for the nuclear facility according to this Guide. The plan must also cover outage situations. When the emergency plan is drawn up the specific features of outage situations shall be considered, i.a. :

- the varying nature of the most likely accidents which can occur during outage situations
- the high number of people at the plant site.

The components, structures and systems required for fire protection must, as a rule, be operable in outage situations. Their operability requirements shall be given in the Technical Specifications. The reliability and adequacy of fire protection arrangements shall be evaluated as part of outage planning. Outage specific special arrangements shall be made if necessary to ensure adequate fire safety.

2.4 Radiation protection

Requirements concerning radiation protection of nuclear power plant workers are set forth in Guide YVL 7.9. Fundamental radiation protection principles and practical procedures shall be described in the relevant instructions. When outage work is planned, general radiation protection principles shall be taken into account, namely: justification, optimisation and limitation of individual doses.

2.5 Quality system

In order to identify potential development objects and needs, the licence-holder shall during refuelling outages and other corresponding

extensive repair outages systematically collect data about the efficiency and adequacy of the quality system.

The quality system encompasses the following factors:

- functional organisation
- definition of duties, responsibilities and authorities of organisational units and individuals
- definition of the organisation's operational processes and procedures
- appropriate procedures and instructions
- human and material resources.

Outage events and observations which have bearing on the quality system's development shall be reported to STUK according to Guide YVL 1.5.

3 Ensuring outage safety

3.1 Administrative work control

The licence-holder must have a work management system for appropriately handling large volumes of individual work assignments. There shall be administrative procedures and the necessary instructions covering the planning and implementation of work. The system must facilitate, by appropriate search functions, monitoring of the status of work assignments, their accomplishment and any feedback gathered. The system shall facilitate the monitoring of individual components whose operability is required in the Technical Specifications. It shall be possible to reliably implement the mutual scheduling and control of work pertaining to various subsystems of redundant safety functions.

If schedules for individual work assignments change, it shall be possible to assess how this affects the execution of other work, so that plant safety is ensured even in a changed situation. Guide YVL 1.8 also sets forth requirements concerning administrative work control.

3.2 Control of safety functions

The Technical Specifications of the plant unit shall give detailed requirements for design, systems and components of safety functions whose operability is required during outage situations. Control room operators at the nuclear power plant shall see to it that the plant's state is always in compliance with the Technical Specifications. Where possible, modern information technology shall be used to monitor the plant state.

In addition to the control exercised by organisational units and individuals responsible for operations, the licence-holder is responsible for arranging control independently of regular operations and maintenance. The objective is to assess, at appropriate intervals, compliance with regulations applicable to safety functions and also the efficiency of administrative arrangements. There shall be written instructions for this control.

To ensure reactor sub-criticality during shutdowns, attention shall be paid to

- reactor loading measures
- operability of reactor control instrumentation (temperature, boron concentration, neutron flux)
- work focused on control rods and their drives
- operability of systems which increase the boron concentration of the primary circuit
- isolation of the primary circuit from sources of clean water.

To ensure the primary circuit water volume, attention shall be paid to

- work focused on the reactor circuit which may endanger primary circuit integrity below the water level required at that time
- work on systems which handle make-up water injection
- availability and adequacy of make-up water sources and availability of water supply routes.

To ensure decay heat removal, attention shall be paid to

- control instrumentation (temperature, water levels) of the primary circuit and spent fuel pools
- realisation of reactor coolant natural circulation and operability of the reactor circuit water cooling system
- operability of the intermediate cooling circuit which contributes to decay heat removal
- availability of the final heat sink.

Attention shall be paid to containment leaktightness and the quick restoration of leaktightness in general. Thus, it shall be ensured that

- the containment is not made unleaktight in a way which prevents its potential quick closing
- all work on the containment penetrations and openings is in compliance with the safety requirement of sub-section 2.2 above
- the emergency ventilation systems of the outer containment are operable
- the outer containment is leaktight or can be quickly closed to make it leaktight
- the radiation detection systems and equipment for warning the personnel and indicating the need to close the containment are operable.

Power supply to systems and components performing safety functions shall be ensured to assure their operability. The below items shall therefore be monitored:

- operability of the plant's off-site grid connections and on-site back-up power supply equipment and batteries
- work focused on the on-site electrical systems and components ensuring power supply to safety-significant systems
- coupling measures and conditions which are a prerequisite for power supply sub-system replacements during maintenance.

3.3 Other safety-significant functions

The licence-holder shall oversee the fire protection arrangements during outages because during shutdown conditions

- the likelihood of fires increases due to the great volume of work
- the number and sizes of fire loads increase
- the structures separating fire compartments will have to be temporarily weakened
- the fire protection systems will have to be temporarily switched off totally or in part.

The licence-holder's monitoring activities shall also cover pre-outage preparatory measures since those may involve an increased fire hazard.

The plant shall prepare for an increased fire hazard by enhancing the control of compliance with the fire protection regulations and instructions and by increasing firewatching of hotwork objects.

The rooms, systems and equipment required for emergency preparedness measures shall be available even during outages. The licence-holder shall see to it that

- the rooms required for emergency preparedness activities are available and habitable
- the necessary access routes to the site access area available
- the necessary communications systems and equipment are operable
- the radiation detection and meteorological measurement systems required in an accident situation are available.

The licence-holder shall monitor

- in a more effective way during outages compliance with and the efficiency of security plans preventing unauthorised access to the nuclear power plant and malicious damage to its structures and components
- fuel transfers and lifting of heavy loads
- compliance with occupational radiation protection requirements, their relevance and adequacy.

The licence-holder shall pay attention to the quality of work, how carefully it is done, occupational safety and general orderliness. The following matters for example shall be checked and appropriately evaluated as regards a work area:

- cleanliness and orderliness of the work area
- how components and structures left open in connection with disassembly are protected
- safety arrangements and equipment required to maintain occupational safety, and their use
- arrangements at the workplace during breaks and when work has been discontinued for a longer while
- the amount of overtime work and hazards arising from potential fatigue
- existence of the necessary working instructions, and knowledge of and compliance with them.

3.4 Verifying nuclear power plant start-up readiness

The licence-holder shall verify the start-up readiness of the nuclear power plant before start-up from shutdown state is started. This inspection is to assure that maintenance, inspections, repairs and modifications have been acceptably carried out, that possible deviations from the work plan have been appropriately dealt with and that the plant meets the requirements for operational states prescribed in the Technical Specifications.

Written instructions shall be drawn up for the start-up of the plant after refuelling and repair outages. The inspections to be carried out before the start-up and the persons in charge shall also be given. A protocol shall be kept of the inspection in which individuals responsible for the various sub-inspections ensure with their signatures that work within their area of responsibility has been acceptably accomplished.

As required in Guide YVL 1.9, also separately defined organisation units which are independent of plant operations shall participate in the verification of the plant's start-up readiness.

4 Submission of documents to STUK

The following chapters describe what documents pertaining to outages shall be submitted to STUK. An explanation to be submitted in the form of a document can be complemented with a meeting arranged by the licence-holder, if relevant considering the nature of the matter.

4.1 General outage arrangements

A general description of refuelling outages and any planned extensive repair outages shall be submitted to STUK not later than one month before outage start. The description shall include

- administrative arrangements relating to the outage, such as e.g. organisation of the outage and responsible persons
- all safety-significant work to be carried out during the outage
- training of external workforce in general and their training for safety-significant work in particular
- radiation protection related special arrangements during the outage and an assessment of the collective occupational radiation dose arising from outage work; a more detailed description shall be submitted of individual work assignments having bearing on occupational radiation exposure
- arrangements for the enhancement of emergency preparedness and fire protection during outages
- the outage main schedule which includes the plant shutdown and startup schedules as well as the most important outage work, plus the necessary sub-schedules.

The aforementioned safety-significant work encompasses work which may adversely affect plant safety during the outage, or is intended to significantly increase plant safety.

Special arrangements pertaining to physical protection during outages, which deviate from the plant security plans, shall be submitted to STUK for information as a separate document.

If the information submitted essentially changes later, the document shall be supplemented accordingly without delay.

Work lists for individual maintenance work, inspections, repairs and modifications and work descriptions shall be available for review by STUK's representatives at the plant site and shall be forwarded to STUK's resident inspector well in advance of the outage start. All documents pertaining to the work are to be submitted to STUK according to Guide YVL 1.8.

As regards unplanned repair outages, a list of all work to be done and an outage schedule shall be submitted to STUK for information without delay. On the basis of the submitted documents, STUK assesses the need to issue a separate start-up permit and to conduct a start-up readiness verification inspection.

4.2 Reactor refuelling application

A reactor refuelling application shall be submitted to STUK for approval not later than two weeks before the planned refuelling is started.

The application shall include
- the reactor reloading plan
- all work and inspections affecting fuel and control rods
- a detailed schedule for work focused on the reactor.

Documents stating the reactor core configuration before and after the refuelling shall be available for review by STUK's representative at the plant site and shall be sent to STUK's resident inspector at the plant site.

STUK's approval of the refuelling application is a prerequisite for the opening of the reactor head prior to reloading.

4.3 Reactor operation and fuel behaviour reports

Descriptions of reactor operation and the behaviour of fuel loaded as per the loading plan shall be submitted to STUK for approval. The description, which covers the preceding operating cycle, shall contain the following calculations
- realisation of fuel rod specific maximum linear power
- realisation of fuel bundle or rod specific maximum burn-up.

The following data, which covers the forthcoming operating cycle, shall be given:
- number of fuel assemblies in the reactor by fuel type (including specific design characteristics)
- assessed fuel assembly and rod specific maximum power histories
- fuel assembly specific axial and radial power distributions
- thermal and shutdown margins
- fuel assembly and rod specific burn-ups
- fuel thermal analysis (or reference to previously accepted analyses covering the operating conditions in question)
- operational experience feedback on the types of fuel used.

The descriptions of reactor operation and fuel behaviour shall be submitted to STUK not later than one week prior to the closing of the reactor pressure vessel head.

4.4 Safety functions status report

A description of the status of safety functions, which must be operational during outages, shall be submitted to STUK for information. The description shall be so explicit that the fulfilment of safety requirements in chapter two above can be checked against it. The description shall cover the entire outage, including i.a. the following information:
- operability and status of systems and arrangements assuring reactor sub-criticality
- operability of systems assuring adequate reactor water volume
- operability and validity of systems and arrangements assuring reactor and spent fuel decay heat removal
- periods of time during which leaktightness is required of the containment
- arrangement of reactor overpressure protection
- operability of sub-systems ensuring electricity supply.

The description shall also include all safety-significant work and their dates of performance if they might prevent a required safety function. The description shall be submitted to STUK not later than two weeks before outage start.

5 Outage control by STUK

5.1 Outage reports

Daily reports as per Guide YVL 1.5 shall be sent to STUK even during refuelling outages and other corresponding extensive outages.

5.2 Onsite control

STUK ensures during outages that the licence-holder sees to the safety of the plant in a sufficient manner and according to paragraph three of this Guide. In its own regulatory control activities STUK pays attention to the following matters among others:
- changes in plant states and how plant systems are operated, and the operating and maintenance personnel's adherence to instructions

- implementation and quality of individual work assignments
- efficiency of administrative arrangements relating to work
- reactor loading and fuel inspections
- periodic tests and inspections of systems, structures and components as well as the maintenance, repair and modification of components and structures
- the functioning of radiation protection, emergency preparedness, physical protection and fire protection arrangements.

During outages, STUK makes inspections according to the periodic inspection programme set forth in Guide YVL 1.1. The licence-holder is notified about the inspections before the inspection date. In addition to these inspections, STUK also controls the mentioned inspection items and activities at the plant in the extent and at a time it deems necessary.

The presence of STUK's representative in the opening of the reactor pressure vessel head is not required. STUK witnesses the opening at its own discretion.

The closing of the reactor pressure vessel head can be started after

- STUK has approved the descriptions of reactor operation and fuel behaviour which cover the forthcoming operating cycle
- STUK's inspections of the reactor pressure vessel, the primary circuit and nuclear materials have been completed and nothing was observed which would prevent the closing of the reactor pressure vessel head
- reactor overpressure protection has been made operable
- an approval to close the reactor pressure vessel head granted by STUK's representative has been entered in a protocol.

Also the acceptability of accumulated result documentation pertaining to inspections of the fuel, control rods and reactor internals is assessed during the inspection of the reactor pressure vessel. During a safeguards inspection, the facility's nuclear material inventory is verified and it is assured that the core configuration is as per an approved fuel loading plan.

6 Nuclear power plant start-up from outage

STUK issues a decision for the start-up of the nuclear power plant from refuelling outages and other extensive repair outages. In practice, the decision is prepared in a situation where some onsite work is unfinished. STUK makes a separate onsite inspection to verify start-up readiness. It is a prerequisite for start-up that the approved final results of this inspection are entered in the inspection protocol.

6.1 Start-up permit application

An application for the start-up permit shall be submitted to STUK for approval about one week before the planned date of start-up. The application must include:

- a summary of all safety-significant work carried out during the outage and an overall assessment of the implementation of the outage in its planned extent
- all significant failure observations made during the outage and any additional work resulting thereof
- work to be done which the licence-holder has reported to STUK and which has been postponed to a later date, and justification for the postponements
- unaccomplished work, tests and inspections to be performed before plant start-up.

When in the process of being reviewed by STUK the application shall be supplemented without delay if the given information changes in a way which essentially affects start-up readiness.

6.2 Start-up readiness inspection

STUK conducts onsite inspections to ensure that

- any unfinished work included in the start-up permit application has been accomplished
- possible requirements presented in STUK's decision about the plant's start-up have been fulfilled
- the periodic tests required in the Technical Specifications have been acceptably performed

- the licence-holder has ensured start-up readiness according to plant procedures and has ascertained its acceptability.

In practice the above issues can be ascertained at a meeting where the licence-holder's representatives introduce the above documents to STUK's representatives when they are conducting an inspection. At suitable intervals, STUK's representatives shall be informed about the plant's state and the progress of inspections which are conducted to verify start-up readiness.

In addition to reviewing documents pertaining to the plant, STUK's representatives make audits to various plant quarters. A request for an inspection to verify start-up readiness shall be submitted to STUK not later than 24 hours before the planned start-up date. Sufficient time shall be reserved for the inspection which is conducted by STUK.

An inspection protocol granting approval for the plant's start-up can be issued if STUK's representatives ascertain by document review and plant audits that nothing prevents the start-up.

7 Post-outage reporting to STUK

7.1 Outage report

The licence-holder shall deliver to STUK for information an outage report which is in compliance with Guide YVL 1.5.

The licence-holder shall see to it that sufficient records are kept of all outage work and any significant observations. These records shall be available for review by STUK's representative at the plant site.

7.2 Other reports

A report shall be drawn up of all fuel and control rod inspections made during an outage. The report shall be sent to STUK for information within three months from the outage.

A report shall be drawn up of all periodic inspections made in accordance with Guide YVL 3.8 and it shall be delivered to STUK for approval within four months from the outage.

The report of a containment leaktightness test shall be sent to STUK for information within three months from the test. The containment total leakage rate and the reports of leaktightness tests of individual isolation valves and penetrations shall be delivered to STUK for information within three months from an outage.

Nuclear material safeguards reports and notifications shall be sent to STUK as per Guide YVL 6.10.

The reports of test runs pertaining to the repairs, maintenance jobs and modifications shall be sent to STUK as per Guide YVL 1.8.

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YVL 1.6 Nuclear power plant operator licensing, 9 Oct. 1995

YVL 1.7 Functions important to nuclear power plant safety, and training and qualification of personnel, 28 Dec. 1992

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YVL 4.3 Fire protection at nuclear facilities, 2 Feb. 1987

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YVL 6.2 Fuel design limits and general design criteria, 15 Feb. 1983

YVL 6.3 Supervision of fuel design and manufacture, 15 Sept. 1993

YVL 6.4 Transport packages for nuclear material and waste, 9 October 1995

YVL 6.5 Supervision of nuclear fuel transport, 12 October 1995 (in Finnish)

YVL 6.6 Surveillance of nuclear fuel performance, 5 Nov. 1990

YVL 6.7 Quality assurance of nuclear fuel, 23 Nov. 1993

YVL 6.8 Handling and storage of nuclear fuel, 13 Nov. 1991

YVL 6.9 The national system of accounting for and control of nuclear material, 23 Nov. 1993 (in Finnish)

YVL 6.10 Reports to be submitted on nuclear materials, 23 Nov. 1993 (in Finnish)

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YVL 8.2 Exemption from regulatory control of nuclear wastes, 19 March 1992

YVL 8.3 Treatment and storage of radioactive waste at a nuclear power plant, 20 Aug. 1996

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