Nuclear Regulation
NEA/CNRA/R(2017)4
August 2018

www.oecd-nea.org

Heavy Load Accidents in Nuclear Installations

Working Group on Operating Experience (WGOE)

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Nuclear Energy Agency

NEA/CNRA/R(2017)4

Unclassified **English text only**

10 August 2018

NUCLEAR ENERGY AGENCY
COMMITTEE ON NUCLEAR REGULATORY ACTIVITIES

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This document only exists in PDF format.

JT03434983

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The mission of the NEA is:

– to assist its member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally sound and economical use of nuclear energy for peaceful purposes;

– to provide authoritative assessments and to forge common understandings on key issues as input to government decisions on nuclear energy policy and to broader OECD analyses in areas such as energy and the sustainable development of low-carbon economies.

Specific areas of competence of the NEA include the safety and regulation of nuclear activities, radioactive waste management and decommissioning, radiological protection, nuclear science, economic and technical analyses of the nuclear fuel cycle, nuclear law and liability, and public information. The NEA Data Bank provides nuclear data and computer program services for participating countries.

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The Committee on Nuclear Regulatory Activities (CNRA) is responsible for NEA programmes and activities concerning the regulation, licensing and inspection of nuclear installations with regard to both technical and human aspects of nuclear safety. The Committee constitutes a forum for the effective exchange of safety-relevant information and experience among regulatory organisations. To the extent appropriate, the Committee reviews developments which could affect regulatory requirements with the objective of providing members with an understanding of the motivation for new regulatory requirements under consideration and an opportunity to offer suggestions that might improve them and assist in the development of a common understanding among member countries. In particular it reviews regulatory aspects of current safety management strategies and safety management practices and operating experiences at nuclear facilities including, as appropriate, consideration of the interface between safety and security with a view to disseminating lessons learnt. In accordance with the *NEA Strategic Plan for 2017-2022*, the Committee promotes co-operation among member countries to use the feedback from experience to develop measures to ensure high standards of safety, to further enhance efficiency and effectiveness in the regulatory process and to maintain adequate infrastructure and competence in the nuclear safety field.

The Committee promotes transparency of nuclear safety work and open public communication. In accordance with the NEA Strategic Plan, the Committee oversees work to promote the development of effective and efficient regulation.

The Committee focuses on safety issues and corresponding regulatory aspects for existing and new power reactors and other nuclear installations, and the regulatory implications of new designs and new technologies of power reactors and other types of nuclear installations consistent with the interests of the members. Furthermore it examines any other matters referred to it by the Steering Committee for Nuclear Energy. The work of the Committee is collaborative with and supportive of, as appropriate, that of other international organisations for co-operation among regulators and consider, upon request, issues raised by these organisations. The Committee organises its own activities. It may sponsor specialist meetings, senior-level task groups and working groups to further its objectives.

In implementing its programme, the Committee establishes co-operative mechanisms with the Committee on the Safety of Nuclear Installations in order to work with that Committee on matters of common interest, avoiding unnecessary duplications. The Committee also co-operates with the Committee on Radiological Protection and Public Health, the Radioactive Waste Management Committee, and other NEA committees and activities on matters of common interest.

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LIST OF ABBREVIATIONS AND ACRONYMS

AC	Alternating current
BS	British standards (United Kingdom)
BST	Buffer storage tube
BWR	Boiling water reactor
CASTOR®	Cask for storage and transport of radioactive material (Germany)
CNRA	Committee on Nuclear Regulatory Activities (NEA)
CONEX	Construction Experience Database of the Working Group on the Regulation of New Reactors (NEA)
CSNI	Committee on the Safety of Nuclear Installations (NEA)
CW	Cooling water
DIN	Deutsches Institut für Normung - Institute for Standardisation (Germany)
EDF	Électricité de France
EN	European norms
EPR	European Pressurised water Reactor
EU	European Union
FA	Fuel assembly
FC	Fuel channel
FFA	Flask filling area
FMF	Flask maintenance facility
FMS	Force monitoring system
FSAR	Final safety analysis report
FTC	Fuel transfer container
IAEA	International Atomic Energy Agency

IEA	International Energy Agency
INES	International Nuclear Event Scale
IRS	International Reporting System for Operating Experience (IAEA)
IRSRR	International Reporting System of Research Reactors
ISO	International standardisation organisation
I&C	Instrumentation and control
KTA	Kerntechnischer Ausschuss - Nuclear Safety Standards Commission (Germany)
LCs	Licence conditions
LCO	Limiting conditions for operation
LHT	Long handling tool
LWR	Light water reactor
NEA	Nuclear Energy Agency
NPP	Nuclear power plant
NRA	Nuclear Regulation Authority (Japan)
NRC	Nuclear Regulatory Commission (United States)
OECD	Organisation for Economic Co-operation and Development
OEF	Operating experience feedback
ONR	Office for Nuclear Regulation (United Kingdom)
PSA	Probabilistic safety analysis
PTB	Protective tube bundle
PWR	Pressurised water reactor
RB	Regulatory bodies
RF	Refuelling fixture
RM	Refuelling machine
RMCS	Refuelling machine control system
SAPs	Safety assessment principles

SAR	Safety assessment report
SFA	Spent fuel assembly
SFP	Spent fuel pool
SFST	Spent fuel storage tank
SNF	Spent nuclear fuel
SPND	Self powered neutron detector
SR	Surveillance requirement
SSE	Safe shutdown earthquake
SSM	Strålsäkerhetsmyndigheten (Swedish Radiation Safety Authority)
TAGs	Technical assessment guides
TC	Reactor water clean-up
TICS	Thermal instrumentation and controls shop
TF	Transportation fixture
TLD	Transport and loading device
TRBS	Technical rules for operational safety
TS	Technical specifications
SUVA	Swiss accident insurance (Switzerland)
UFSAR	Updated final safety analysis report
WGOE	Working Group on Operating Experience (NEA)
WWER	Russian water-water energetic reactor

EXECUTIVE SUMMARY

The lifting of heavy loads has always been a potential challenge to nuclear safety. Studies have been done over the years to identify potential risks and lessons learnt from those. A number of events related to heavy loads in recent years showed that these operations can have significant impacts on nuclear power plant safety, such as in the cases of the dropping of the 475-tonne main stator in Arkansas NPP in 2013 and the dropping of the 465-tonne steam generator in the Paluel NPP in 2016.

In the 19th Working Group on Operating Experience (WGOE) meeting in spring 2016, “Events Caused by Heavy Load Issues” was on the agenda as a special topic. Some countries presented events that showed a spread in weaknesses and causes resulting in the fall of loads or operated lifts with potential risks for nuclear safety. During this meeting, the WGOE determined that a report should be drafted to enable the exchange of operational experience and regulatory requirements regarding heavy load and special lifting.

This report is organised in two parts. First, a questionnaire on regulatory practice regarding heavy loads at nuclear sites was prepared and distributed among the group members. Second, the past 20 years operating experience (either existing in international databases or provided by the group members ad hoc for the study) was reviewed to obtain a general outline of the events recorded.

The answers to the questionnaire revealed both similarities and differences in the regulatory practice regarding lifting equipment in nuclear installations. National legislation usually covers regulation of lifting equipment within a general framework applicable to many industrial sectors. Some countries have developed specific regulations for the handling of heavy loads within the nuclear industry. Often, these regulations are used as well as a reference by other countries where rules for lifting equipment specifically applicable to nuclear power plants do not exist.

In many countries the standards developed by the industry provide guidance for the design, operation and maintenance of lifting equipment, and this is the base for its regulation. Although there are harmonisation efforts currently in progress, significant differences remain in some aspects, notably the application of the single failure principle, or the assessment of the seismic risk.

The brief review of more than 100 events reported by NEA member countries during the past 20 years has yielded some insights which are useful to characterise the issues most commonly found by licensees in the operation of lifting equipment.

The events collected illustrate some of the different scenarios involved: fuel or other radioactive load handling (with a potential for radioactive releases if the load is damaged), conventional load handling in the proximity of nuclear fuel (with a potential for radioactive release if the load causes damage to the fuel) or load handling over safety equipment (with the potential to cause an initial event or the loss of a safety train). In many cases, the risks are well understood by the operators, and usually rules regarding lift paths, horizontal or vertical load maximum speed, etc. are systematically applied to mitigate them. But in some instances, the operators failed to fully understand the potential consequences of failures during the handling of the load.

This report identified and compared regulations among 9 countries and more than 100 events that can be used as a reference material to compare the approaches taken by regulators and licensees to cope with the lifting of heavy loads.

1. BACKGROUND

The Working Group on Operating Experience (WGOE) is an international forum for the exchange and analysis of operating experience for the determination of safety issues from a regulatory viewpoint in NEA member countries.

One of the main objectives in the mandate for WGOE is to "compare, and where possible benchmark, international practices and methodologies applied by member countries in the assessment and utilisation of operating experience."

WGOE has observed that events with heavy loads are a contemporary issue to address after several operating experiences in recent years. The WGOE made a proposal to analyse events as well as to determine the regulatory approach to licensee management of the lifting of heavy loads in nuclear power plants within NEA countries. Specifically:

- To collect and review operating experience from events involving the lifting of heavy loads.
- To compare regulatory requirements for nuclear lifting systems.
- To identify lessons learnt for sharing knowledge among regulatory bodies (RB).

This task was approved by the Committee on Nuclear Regulatory Activities (CNRA) in June 2016.

To achieve a good result and be able to analyse the subject, each member country was asked to respond to a questionnaire (see Annex 1) and to search their national databases. Eleven countries responded to the questionnaire and 114 events from 16 countries have been analysed.

2. HANDLING OF HEAVY LOADS IN NUCLEAR INSTALLATIONS

Heavy loads are handled in many different locations of nuclear installations and with a wide range of loads.

The topic is particularly relevant for the construction phase of new nuclear power plants (and many decommissioning operations as well), when the heavy load handling operations are particularly frequent and involve many specific, one-of-a-kind operations.

For operating light water reactors, the most relevant heavy load handling takes place during the refuelling outage and includes the handling of fresh and spent fuel assemblies, reactor vessel head and reactor vessel internals, among many others.

If an irradiated fuel assembly or other loads containing radioactive components were to drop, they could potentially lead to radioactive releases. Similar consequences could result from non-radioactive loads being handled over irradiated fuel or other radioactive components. Furthermore, heavy loads transported in or over areas with safety systems have the potential to damage functions vital for taking a reactor into safe shutdown paths. Extremely heavy loads can also cause damages to building structures important for safety such as containments or other non-safety equipment leading to situations that have impact on safety such as fires, flooding, etc. Additionally, under some circumstances the control of reactivity in the core or in the spent fuel pool could be challenged by this type of events.

In the 19th Working Group on Operating Experience (WGOE) meeting in spring 2016 “events caused by heavy load issues” was on the agenda as a special topic. Some countries presented events that showed a spread in weaknesses and causes resulting in fall of loads or operated lifts with potential risks for nuclear safety. The WGOE determined on this meeting that a report should be developed to enable the exchange of operational experience and regulatory requirements to inform RBs in their regulation of heavy load lifting and special lifts.

3. QUESTIONNAIRE SENT TO MEMBER COUNTRIES

3.1 Questions on regulatory practice

Member countries were encouraged to answer a questionnaire on the topic of how heavy loads are regulated, how they are defined, what standards that are used and some other questions about documentation regarding heavy loads.

The aim of the questionnaire was to address the similarities and differences among the member countries regarding the handling of heavy loads and its associated regulatory practice.

The questionnaire was composed of the following questions:

- Q1) How is the lifting of heavy loads regulated in your country?
- Q2) Is there specific nuclear legislation for the lifting of heavy loads in NPPs in your country?
- Q3) How is a heavy load lifting system defined in your regulatory framework?
- Q4) How are heavy loads defined in safety assessment reports?
- Q5) What standards and guidelines are used for the design, manufacture, maintenance and testing of equipment used for the lifting of heavy loads?
- Q6) How are maintenance and control of heavy load lifting systems scheduled?
- Q7) How are single failure criteria considered?
- Q8) How is ageing of lifting equipment considered?
- Q9) Are seismic events regarding the lifting of heavy loads considered in the safety assessment reports?

3.2 Sources and criteria used for the search of events

Member countries were requested to search into their usual sources of operating experience looking for events related to the handling of heavy loads in nuclear installations.

The following criteria were specified for the search:

- location – nuclear installations (nuclear power plants, enrichment plants, fuel fabrication plants, reprocessing plants, research reactors and spent fuel storage facilities);
- life phase of the installation – construction, commissioning, operation and decommissioning;
- loads involved – any load above 0.5 Tm, or nuclear fuel assemblies regardless of weight;
- date – events occurred during the past 20 years (since 1 January 1997);
- consequences – with or without safety consequences (thus near misses or events with only potential consequences should be included in the search).

The following types of events were excluded from the search:

- events where the safety of the hoisting operation itself was not affected, but reported because of the radiation hazard to the workers or the public;
- events where fuel assemblies or other nuclear materials are positioned in the wrong place in the reactor core, fuel rack, etc. compromising safety functions related to reactivity control, fuel cooling or core performance, but not directly related to the hoisting operation;
- events where the loads are handled without any lifting movement.

In addition to the searches carried out by NEA member countries in their national data bases, the following sources of international operating experience were used as well: the International Reporting System (IRS/IAEA), the International Reporting System of Research Reactors (IRSRR/IAEA) and the CONEX database (NEA/Working Group on the Regulation of New Reactors).

4. ANALYSIS

4.1 Review of the answers to the questionnaire

4.1.1 Question 1: How is the lifting of heavy loads regulated in your country?

National legislation in all countries covers the regulation of heavy loads lifting from a general perspective (not specific to nuclear industry), usually setting requirements for the design, operation and maintenance of lifting equipment. In the European Union, the legislation complies with the European directive 2006/42 on machinery.

In most cases no distinction is made between "heavy loads" and other loads.

4.1.2 Question 2: Is there specific nuclear legislation for the lifting of heavy loads in NPPs in your country?

National legislation does not specifically cover the use of lifting equipment at nuclear power plants. However, some countries (Germany, Russia, and Switzerland) do have dedicated nuclear safety regulations in place concerning the lifting of heavy loads at nuclear power plants, and others (Sweden) are planning to introduce them. Apart from that, the requirements for nuclear safety assessment in most countries mention the lifting of heavy loads, and more specifically the handling of nuclear fuel, or the handling of loads which could result in damage to nuclear safety equipment.

4.1.3 Question 3: How is a heavy load lifting system defined in your regulatory framework?

Some countries do not have anything in the regulatory framework while others have very specific description on definitions of a lifting system. Some regulations point at KTA standards (Germany) or NUREG-0612 (United States).

4.1.4 Question 4: How are heavy loads defined in safety assessment reports?

Heavy load is in most cases not defined. But references for especially fuel handling are in many cases defined. Many safety assessment reports SARs are pointing at NUREG-0612, and that implies that "heavy load is any load, carried in a given area after a plant becomes operational, that weighs more than the combined weight of a single spent fuel assembly and its associated handling tool for the specific plant in question". But there are also references to NUREG-800 were loads are divided into 2 review chapters, light load handling system is defined as related to refuelling (Ch. 9.1.4) and heavy load is defined as all components and equipment for moving all heavy loads (Ch. 9.1.5) where the definition is as in NUREG-0612 above (loads weighing more than one fuel assembly and its handling device).

The SAR of NPP in many countries must contain an analysis of load dropping, particularly when the load is nuclear fuel, or when the load could damage nuclear fuel when dropped.

4.1.5 Question 5: What standards and guidelines are used for the design, manufacture, maintenance and testing of equipment used for the lifting of heavy loads?

National standards are used in most countries, in many cases together with nuclear standards from the United States or Germany. In general the applicable standard depends on the NPP construction period. European countries tend to harmonise over time their national guidance under European (EN) standards, like EN 13000 (Cranes - Mobile Cranes) or EN 13001(Cranes - General design).

4.1.6 Question 6: How are maintenance and control of heavy load lifting systems scheduled?

All countries that answered the questionnaire have rules for inspection of lifting devices stating that inspection is scheduled at least yearly. These intervals are regulated in both non-nuclear regulations for some and in nuclear regulations for others.

4.1.7 Question 7: How are single failure criteria considered?

The single failure criteria are applied in various ways in each country. Many countries apply the single failure criteria for operations posing nuclear safety or radiological risks (like fuel assembly handling, or loads travelling over the spent fuel pool or the open reactor vessel). There may be also differences in the particular components of the lifting system which are subject to the single failure principle.

4.1.8 Question 8: How is ageing of lifting equipment considered?

In some countries the actual number of load cycles is compared to the design assumptions, and this is taken into account for the replacement of parts or the authorised time of service within the maintenance programmes. Other countries use visual inspections to detect wear or corrosion in parts subject to these phenomena.

4.1.9 Question 9: Are seismic events regarding the lifting of heavy loads considered in the safety assessment reports?

The treatment of the seismic risk concerning the lifting equipment varies widely across countries and event across plants within the same country. Some counties do not consider seismic risk at all. This is probably caused by different levels of seismic risk and by different plant construction periods. While the lifting equipment design in most plants (but not all) does take into account the seismic risk (at least the lifting structures and devices posing a nuclear or radiological risk), there are variations in the particular assumptions and criteria applied. For instance, the case of a seismic event during handling operations may or may not be considered; and the lifting equipment may be required to remain operational after the safe shutdown earthquake, or may be required only not to cause damage to other required equipment.

4.2 Review of the events

A total of 114 events meeting the search criteria defined above were retrieved from the different sources, with the following breakdown (see Table 4.1).

Table 4.1: Distribution of events by source

Submitted by MS	**70**
Belgium	*6*
France	*7*
Germany	*38*
Sweden	*6*
Switzerland	*1*
United Kingdom	*12*
Retrieved from IRS	**40**
Canada	*1*
Hungary	*1*
Japan	*2*
Mexico	*1*
Spain	*2*
Russia	*16*
United Kingdom	*3*
United States	*14*
Retrieved from IRSRR	**2**
Bulgaria	*1*
Netherlands	*1*
Retrieved from CONEX	**2**
Finland	*1*
France	*1*
TOTAL	**114**

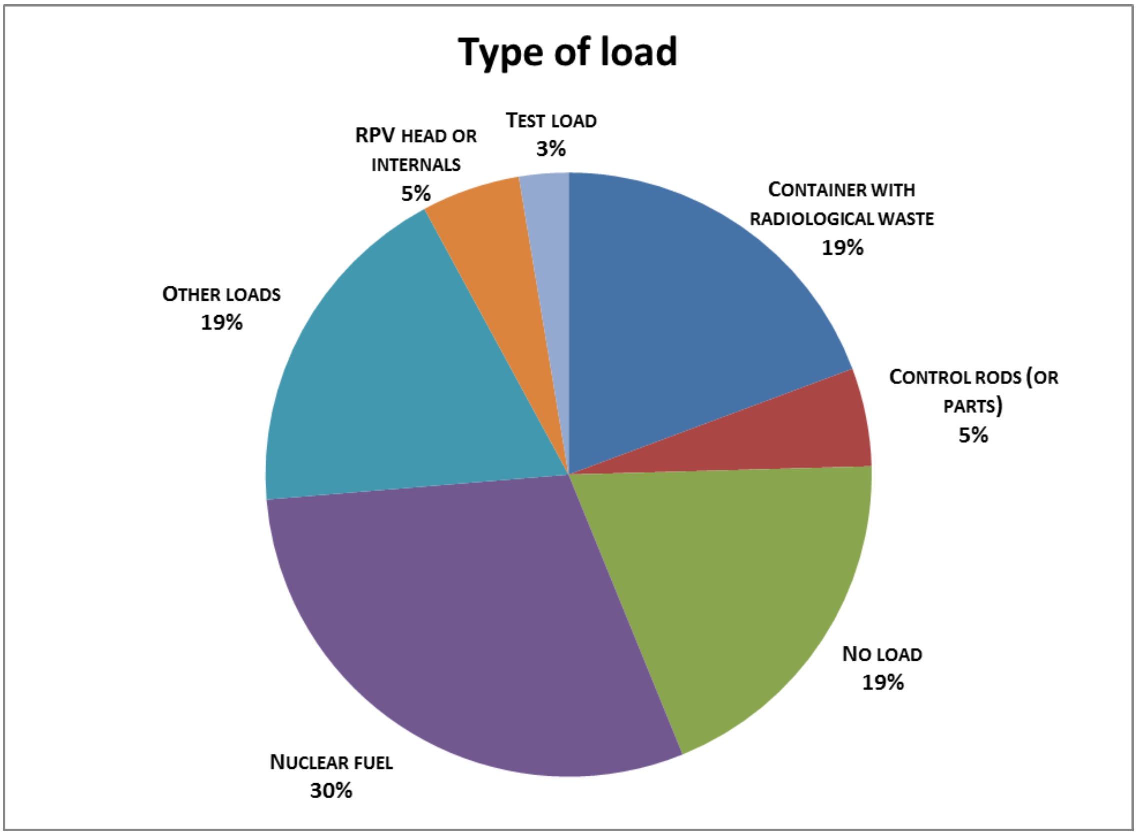
Most of the events were reported by nuclear power plants (104), and the rest by research reactors (4), radiological waste handling facilities (3) and reprocessing facilities (3). There are 114 unique events, no overlaps between the sources.

A short review of the events was conducted, based on the brief description provided in the abstract of the reports, in order to group the events by the type of load involved, by the failure mode of the handling equipment or by the cause reported.

4.2.1 Types of load

Loads may be grouped into 4 main categories: nuclear fuel (most often LWR fuel assemblies, but also single fuel rods or other types of fuel used in other reactor types), reactor pressure vessel (RPV) head or internals, containers with radiological waste (often irradiated parts) and control rods assemblies (or parts of control rod assemblies). Furthermore, some events did not involve any load (for instance when the event occurred during unloaded operation, or as a result of crane inspections or design reviews), or involved test loads and two additional categories were created for these cases. All other events where the load could not be determined or did not fit into any of the preceding ones were grouped under “other loads”.

Figure 1: Distribution of events by type of load



Not surprisingly, nuclear fuel is the load most often involved. Refuelling operations in light water reactors involve many fuel assembly handling operations, and whenever an event occurs, the chances of being reported are higher if the load is a fuel assembly rather than a conventional load posing no radiological or criticality hazards.

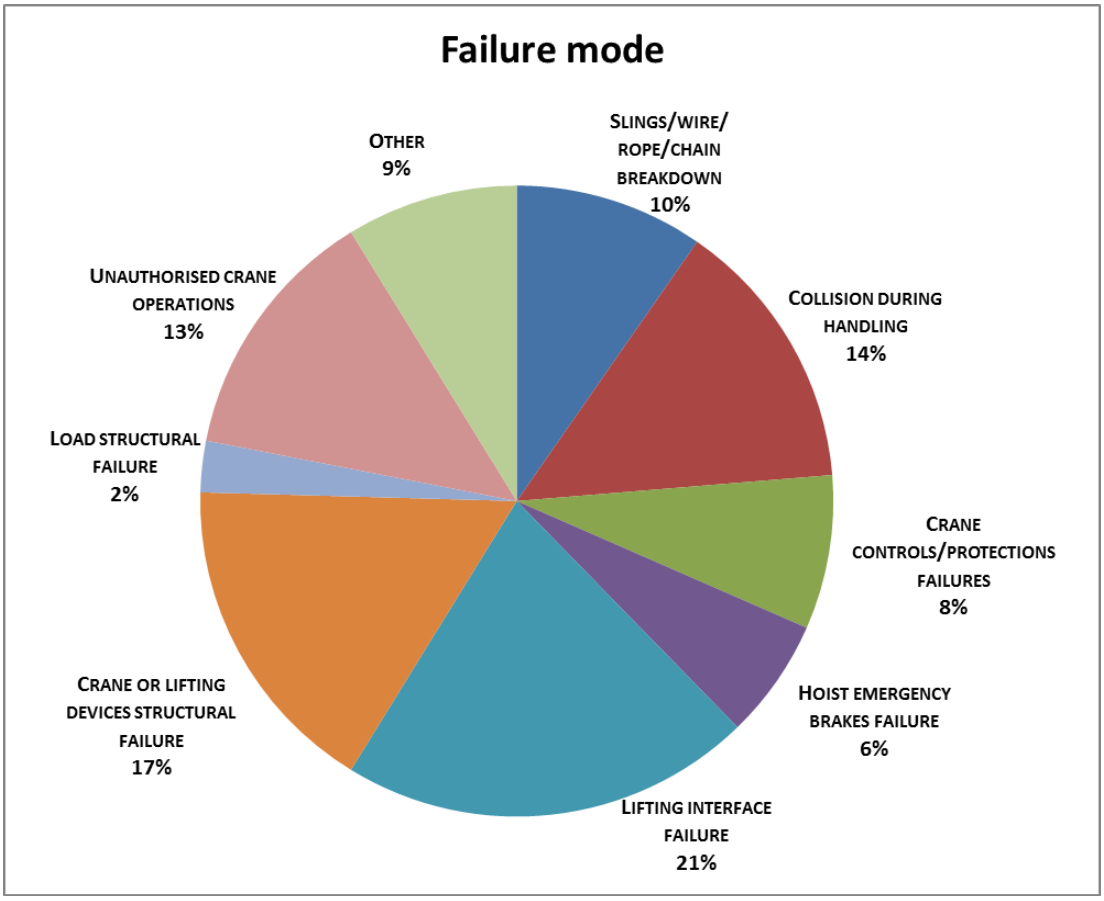
Another load type frequently involved in events reported is the container with radiological waste. These events consist of dropping of heavy loads such as casks and containers.

In the cases where no load was involved, most often the event was related to structural failures caused by design deficiencies, generally discovered during inspections or testing of lifting devices.

4.2.2 Failure mode

Eight different main failure modes have been identified, covering more than 90% of the events.

Figure 2: Distribution of events by failure mode



The "Lifting interface failure" (24 reports) is dominated by events with containers and nuclear fuel assemblies. In most events, the gripper disengaged from the fuel assembly or container, for different reasons.

The "crane or lifting devices structural failure" (19 reports) includes many events revealed during engineering design reviews or crane tests, which explains why in most cases no load was involved, and only potential consequences are described. However, this group includes also the actual collapse of the heavy lifting system during lifting of the main generator stator at Arkansas Nuclear One site in 2013.

Collisions during handling (16 reports) occurred mostly on nuclear fuel handling, and nearly always the direct cause was an operational error.

There are cases where misunderstandings among staff led the crane operator to start handling loads in unsafe conditions, or with loads exceeding the maximum allowable weight. These reports make up most of the "Unauthorised crane operations" category (15 reports).

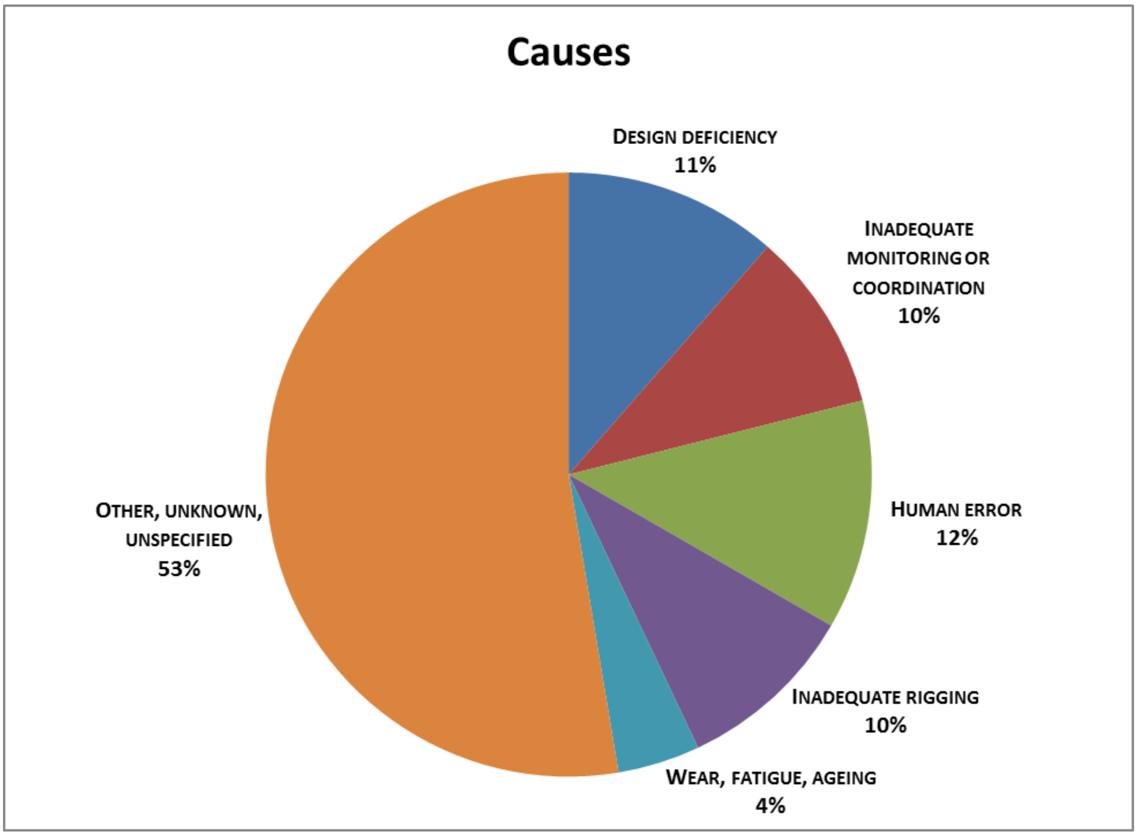
Out of the reports classified as "Slings/wire/rope/chain breakdown" (11 reports), 3 involved containers and 3 involved fuel assemblies. In some cases the breakdown was caused by fatigue (sometimes linked to chaffing or twisting), or by the use of improper, unqualified slings.

In the case of the group "Load structural failure" (3 reports), all 3 events involved nuclear fuel. In one case a rupture in the fuel element's central-water channel caused the fuel element to separate in 2 parts with the fuel assembly upper tie plate and the fuel channel remaining in the gripper.

4.2.3 Causes

Where known, the causes of the events have been classified into 5 different groups.

Figure 3: Distribution of events by cause



However, as the review of the events was limited to the summary descriptions, the root cause remains unknown or unspecified in more than 50% of the cases.

Human error is mentioned as root cause in 14 event reports. Six of them describe collisions during handling and other 6 unauthorised crane operations.

Design deficiencies lie behind many of the crane structural failures (actual or potential). It is worth mention that most of these events have been reported by the United States, including 7 events described by the Nuclear Regulatory Commission (NRC) Information Notice 2014-12 (crane and heavy lift issues identified during NRC inspections).

Most of the events within “Inadequate monitoring or co-ordination” are related to lifting interface failures (5 events) and collision during handling (3 events).

When “Inadequate rigging” was the cause of the event, nuclear fuel and containers were involved in 7 out of 11 cases, and the failure mode was “lifting interface failure” in 7 out of 11 cases.

Finally, the components more exposed to ageing/fatigue have been the slings, with 3 out of 5 events.

5 CONCLUSIONS

5.1 Lessons learnt

This study has been made as a review of operating experience from events involving the lifting of heavy loads or the operation of lifting devices. This is a broad study of what has happened with 114 events selected in a screening process and an active selection from member countries. The report is highlighting the status of regulation and events that have occurred within nuclear facilities. The number of events and the differences in regulation approaches across countries make it difficult to prepare a complete list of detailed lessons learnt with specific recommendations applicable to all report users. Instead, some examples of lessons learnt are given below, together with high-level recommendations for nuclear safety authorities in the next subsection.

Examples of lessons learnt in the regulation of heavy loads

Sweden is now working on a new regulatory code regarding lifting equipment and lifting operations in nuclear facilities. What has been identified is that detailed regulations regarding lifting equipment are needed. The Swedish regulation AFS 2008:3 for machines (transposition of European directive 2006/42/EG on machinery) have an exception for lifting equipment in nuclear facilities if the dropping of a load may lead to release of radioactive material. A new regulatory code is also needed in order to fully harmonise with IAEA Safety Standard SSR-2/1 regarding conservative design measures that shall be used to prevent the dropping of loads which can affect nuclear safety. This new regulatory code will have an impact on the design of lifting devices in many nuclear facilities, especially regarding the single failure criterion for the higher classified lifting equipment. The pilot study which SSM has performed showed that some lifting events in Sweden, which could have developed into more serious accidents, would probably have been prevented if these new regulations had been valid.

Example of lessons learnt from some of the events

In some cases, cranes and lifting equipment were originally not designed as single failure proof systems, but instead were upgraded later with a design modification to meet, at least partially, the single failure criterion. In this context, it is essential to fully update all testing procedures and settings of the upgraded system accordingly. For instance, a plant reported a case where emergency brakes for the polar crane main hoist had been added for redundancy, but then was not regularly tested, because (unlike the normal service brakes) they were not part of the standard regulatory requirements for hoisting devices.

Operators should ensure that structural calculations for cranes and other systems used for handling heavy loads comply with the standards referenced in the design bases. A highly significant event has been reported recently where the required load test or design review of a major load-bearing structure were not performed because the structure was believed to have been used to handle heavier loads in the past. In other events, independent inspections carried out by the regulatory body found load-bearing parts in special lifting devices with design safety factors lower than required. When detected by independent reviews, these deficiencies usually result in event reports of very minor safety significance; however, if not detected, they could potentially lead to catastrophic structural failure with major nuclear and industrial safety consequences.

Rigging operations should not begin unless the weight of the load has been confirmed. Field labels showing the weight of the loads should be used where applicable, or measurements with a dynamometer should be taken if the personnel is unsure about the actual weight.

The design of equipment subject to frequent handling operations in areas related to nuclear safety should avoid, as much as possible, the existence of protruding parts where hooks, slings or other lifting equipment components could accidentally engage during rigging operations. For instance, in an event that recently occurred in a RBMK reactor, one of the crane hooks used to lift a refuelling fixture (a special tool used for the handling of spent fuel casks) got caught on one of the refuelling fixture head handles (which are not needed during fuel-handling operations), tilting it and causing the drop of a spent fuel cask.

The use of mobile hoist equipment in nuclear power plants presents some specific risks. Indeed, mobile cranes usually need to be assembled, adjusted and disassembled, thus introducing new failure modes caused by inadequate assembly or wrong settings. For this reason, use of mobile hoist equipment should be subject to the following considerations:

- Mobile hoists should not be used in areas where nuclear safety or radiological control functions could be compromised, unless they have been designed beyond the conventional industrial standards. In particular, the additional requirements should include safety regarding the load-bearing capacity, overload protection, protection against structural failure, and robustness against assemble or setting errors.
- Mobile hoists should not be used in locations where recurrent operation (i.e.: several times per year) with assembly/disassembly is expected. Permanent equipment should be installed instead.
- Industry standards should include specific requirements from mobile hoist equipment.

5.2 Recommendations

Regulators should consider developing specific nuclear regulations regarding lifting equipment or at least consider including nuclear applications in their national regulations or at the very least use should be made of relevant international references.

Regulators should consider the need to include the single failure criterion as part of the assessment of heavy load drops in the SAR

Regulators should consider reviewing their regulations considering seismic events in relation to heavy loads and lifting equipment regarding the variations in the particular assumptions and criteria applied.

Regulators should review the provisions that licensees have in place to prevent the following types of heavy load handling events, which, according to the review of operating experience, are recurrently occurring in the industry:

- accidental disengagement of the gripper from the fuel assembly (because of inadequate rigging, gripper failure, fuel failure, etc.);
- collisions of fuel assemblies with different obstacles during fuel-handling operations;
- inadequate structural design of cranes and other hoisting equipment, particularly regarding seismic resistance;
- misunderstandings among operations staff leading to loads being handled in unsafe conditions (weight of the load unknown, other operations in progress at the same location, lack of supervision, etc.);

- wearing slings due to chaffing or twisting, or due to the use of unqualified slings.

5.3 Conclusions

The analysis of the answers to the questionnaire reveals that there are both similarities and differences in the approaches used for the regulation of lifting equipment in nuclear installations.

National legislation usually covers regulation of lifting equipment within a general framework applicable to many industrial sectors. In some countries, such as Germany, Russia or the United States, regulators have developed specific regulations for the handling of heavy loads within the nuclear industry. Often, these regulations are used as well as a reference by other countries where rules for lifting equipment specifically applicable to nuclear power plants do not exist.

In many countries, the standards developed by the industry provide guidance for the design, operation and maintenance of lifting equipment, and this is the base for its regulation. Although there are harmonisation efforts currently in progress, significant differences remain in some aspects, notably the application of the single failure principle, or the assessment of the seismic risk.

The brief review of more than 100 events reported by member countries during the past 20 years has yielded some insights which are useful to characterise the issues most commonly found by licensees in the operation of lifting equipment.

ANNEX 1: ANSWERS RECEIVED FROM MEMBER COUNTRIES

Q1. How is the lifting of heavy loads regulated in your country?

Belgium

The following royal decree provides nowadays general (not nuclear specific) regulatory regulations for the use of lifting systems in Belgium: Royal decree of 4 May 1999 on the use of work equipment for hoisting and lifting of loads. This decree is a transposition within the Belgian regulatory framework of 2 European directives: 89/655/EEG modified by 95/63/EG.

This royal decree replaces several articles of the general regulations on the protection of workers related to the use of lifting devices, which were still in place when the NPPs In Belgium were built and started their commercial operation.

Lifting systems are also covered by the royal decree of 12 August 2008 which is a transposition of the European directive 2006/42/EG on machinery. It has to be noted however that “machinery specially designed or put into service for nuclear purposes which, in the event of failure, may result in an emission of radioactivity” is excluded from the scope of this European directive. This European directive is however in practice also applied as a reference standard in nuclear facilities.

Please note that notion of “heavy loads” is not addressed in these regulations.

France

As requested by the Labour Code (law), working equipment (machines, devices, tools) in operation in any company have to comply with design rules as well as operating rules.

Design rules in force for manufacturers depend on the date at which the equipment has been commissioned:

- Machines designed before 1 January 1993: technical requirements detailed in the Labour Code.
- Machines designed between 1 January 1993 and 29 December 2009: technical design rules of the EU 98/37 directive (machinery directive).
- Machines designed after 29 December 2009: technical design rules of the EU 2006/42 directive (update of the 98/37 aforementioned directive).

Those directives have been transposed into the French regulation within the Labour Code.

Employers have to verify that any working equipment bought from a provider have been manufactured in compliance with the mandatory design rules. Specific rules for lifting of loads exist and are detailed in the Labour Code.

The order of 1 March 2004 from the Labour Ministry details the verifications (types and frequencies) which have to be conducted on lifting equipment.

Finally, there is also a specific regulation for equipment for lifting people.

Germany

The design of lifting equipment is standardised by a large number of norms covering different aspects of the equipment. While the former German DIN (e.g. the series DIN 15018 and DIN 18800 for steel construction) were already withdrawn in order to be replaced by new European norms, some of these new European norms are still in development (e.g. series EN 13001) so the former DIN may still be applied.

The operational safety of lifting equipment is regulated by European directives (e.g. the EC machinery directive 2006/42/EG, EN 60204-32:2008 Safety of machinery – Electrical equipment of machines – Part 32: Requirements for hoisting machines) and the German Ordinance for operational safety (Betriebssicherheitsverordnung – BetrSichV). The latter contains specific appendices for the safe operation and testing of lifting equipment complemented by Technical Rules for Operational Safety (TRBS) and rules for accident prevention. No distinction is made between "heavy loads" and other loads.

Hungary

The requirements for heavy loads are regulated in the annexes (Nuclear Safety Codes) of the Govt. Decree 118/2011 (VII. 11.) on the nuclear safety requirements of nuclear facilities and on related regulatory activities. The Annex volume 3 (design requirements for operating nuclear power plants) and 3a (design requirements for new nuclear power plants) includes the following requirements related to heavy loads.

1. In the design of (operating) nuclear power plants dropping of a heavy load when using lifting equipments must be considered as an internal hazard:

   "3.2.2.3100. The following internal hazards shall at least be considered in the design of the nuclear power plant:

   […]

   q) dropping of a heavy load when using lifting equipment;

   […]"

2. For new nuclear power plants the dropping of heavy load shall taken into account as internal hazard and shall be practically excluded:

   "3a.2.2.4700. In addition to the events listed in Section 3a.2.2.4500, the following event groups shall also be examined within the TA3-4 operating conditions, and the criteria corresponding to the frequencies of the initiating events shall be applied to the consequences of the specific initiating events associated with them:

   a) dropping of a heavy load when using hoisting machinery […]"

   "3a.2.2.7200. At least the following events shall be practically excluded by design solutions or the implementation of preventive accident management capabilities, i.e. it shall be demonstrated that their occurrence is physically impossible or the frequencies of their occurrence are less than 10-7/year with high certainty:

   […]

   c) all loads appearing in the short and long run, which may jeopardise the integrity of the containment, in particular, the dropping of a heavy load, steam and hydrogen explosion, interaction between the molten core and concrete load-bearing structures, and containment over pressurisation,

   […]"

Japan

The lifting of heavy loads at nuclear facilities is not regulated in Japan, with the exception of fuel assemblies and spent fuel.

In accordance with regulations related to the Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors, the followings are required in a design phase.

To prevent falling of fuel assemblies (for operation of nuclear power plants) and spent fuel (hereinafter called "fuel assemblies, etc."), into fuel-handling system which includes the spent fuel pool and the fuel-handling equipment.

To ensure the functions even if heavy loads fall onto the fuel-handling system.

Furthermore, in procurement management, the safety measures are required appropriately for supervision of construction works using cranes by the operational safety programme approved by the Nuclear Regulation Authority (NRA).

Russia

The special requirements for the cranes, which are using at nuclear facilities (including NPPs), are established in the document: "Rules of Arrangement and safe Operation of Cranes for Objects of Use of Atomic Energy (NP-043-11)". This document is the document of Russian Regulatory Body (Rostechnadzor) and its requirements are mandatory for all parties in atomic industry. NP-043-11 sets requirements for the design (design), manufacture, installation and operation of cranes of objects of use of atomic energy.

Slovak Republic

Regulation is based on Decree No. 430/2011 of the Nuclear Regulatory Authority of the Slovak Republic of 16 November 2011, on nuclear safety requirements.

Slovenia

Lifting of heavy loads is generally governed by Occupational Health and Safety Act (UL RS 43/11), where the heavy load lifting machinery is addressed in Rules on general industrial safety measures and standards in working with elevators/cranes (UL SFRJ 30/69).

Sweden

The Swedish work environment authority regulates general aspects and regulation regarding lifting of heavy loads in general. The most valid regulations for heavy loads are:

- AFS2003:6, Inspection of lifting equipment and other technical devices;
- AFS2006:6, Use of lifting equipment and lifting tools;
- AFS 2008:3, Machines (reaching the market later than 29/12-2009, transposition of European directive 2006/42/EG on machinery).

Switzerland

General aspects of the lifting of heavy loads are regulated in the ordinance of safe use of cranes (www.admin.ch/opc/de/classified-compilation/19995603/index.html) and in the technical bulletin of SUVA (Swiss accident insurance) on cranes in industry and trade (www.optimo-instandhaltung.ch/files/optimo-download/SUVA_Merkblatt-Krane-in-Industrie-und-Gewerbe.pdf).

According to ENSI-guideline G01, lifting equipment has to be safety classified if it could damage other safety classified components in case of failure.

In addition, German regulations of Nuclear Safety Standards Commission (KTA) are being applied. Especially:

- KTA 3902 Design of Lifting Equipment in Nuclear Power Plants (www.kta-gs.de/e/standards/3900/3902_engl_2012_11.pdf).
- KTA 3903 Inspection, Testing and Operation of Lifting Equipment in Nuclear Power Plants (www.kta-gs.de/e/standards/3900/3903_engl_2012_11.pdf).
- KTA 3905 Load Attaching Points on Loads in Nuclear Power Plants (www.kta-gs.de/e/standards/3900/3905_engl_2012_11.pdf).

United Kingdom

There is no definition of heavy loads in the United Kingdom legislation.

In the United Kingdom the overriding legislation for the lifting of heavy loads are the Lifting Operations and Lifting Equipment Regulations 1998 (LOLER) and the Supply of Machinery (Safety) Regulations 2008.

This legislation also applies to lifting of loads that have a mass below what might be considered as a heavy load. In most cases, lifting equipment is also classed as work equipment in the United Kingdom, so the Provision and Use of Work Equipment Regulations 1998 (PUWER) also apply.

These regulations are made under the Health and Safety at Work etc. Act 1974.

Q2. Is there specific nuclear legislation for the lifting of heavy loads in NPPs in your country?

Belgium

There is no specific nuclear legislation for the lifting of (heavy) loads in Belgium.

France

General "design" regulation from the Labour Code excludes "machines specifically designed or commissioned for a nuclear usage and failure of which would end up with radioactive releases". Regulation for the operation of lifting equipment does not specifically address cases of lifting within an NPP. However, the Order of 1 March 2004 (articles 25 and 26) addresses particular cases: Whenever it is technically not possible to undertake the mandatory testing, for example due to the load being too heavy, compensatory and experimental verifications must be in place to ensure security; dedicated rules for lifting equipment designed for one single use. A circular (official document aiming at specifying and explaining a general regulation, but which is not enforceable) from 24 March 2005 mentions that those cases concern mostly nuclear lifting equipment.

Germany

Lifting equipment in NPPs is covered by the German Nuclear Safety Standards KTA 3902 "Design of Lifting Equipment in Nuclear Power Plants", KTA 3903 "Inspection, Testing and Operation of Lifting Equipment in Nuclear Power Plants', and KTA 3905 "Load Attaching Points on Loads in NPPs". No distinction is made between 'heavy loads' and other loads.

Hungary

The safety guides issued (mostly the number 3.11 and N3a.11 safety guides for probabilistic safety assessments) by the regulatory body have some recommendations related to the safety analysis of heavy loads.

Japan

The lifting of heavy loads at nuclear facilities is not regulated in Japan, with the exception of fuel assemblies and spent fuel.

Fall prevention of fuel assemblies, etc. is required in the following regulations.

- NRA Ordinance Prescribing Standards for the Location, Structure, and Equipment of Commercial Power Reactors and their Auxiliary Facilities.
- NRA Ordinance Prescribing Technical Standards for Commercial Power Reactors and their Auxiliary Facilities.

Russia

As it is mention in the answer to the previous question, the special requirements for the lifting of heavy loads in NPPs are established in the Federal norms and rules NP-043-11. There are no special legislation in Russia for the lifting of heavy loads in NPPs. The main Russian atomic law is the Federal law No. 170-FZ "On the Use of Atomic Energy", which establishes legislative framework for the use of nuclear energy and for the regulation of the use of the nuclear energy, but does not contain any requirements for the lifting of heavy loads in NPPs. At the same time, a number of general requirements, which also relates to the cranes at nuclear power plants, are contained in other laws, for example, the law on technical regulation No. 184-FZ.

Slovak Republic

Lifting of heavy loads is mentioned in above Decree No. 430/2011, Annex No. 3 to Decree No. 430/2011 Coll., E. Safety and severe accident analyses:

> "(1) The design must include analyses of the responses of the nuclear facility at least to the following postulated trigger events:
> s) the fall of a load due to failure of lifting equipment".

Another legislative document is Safety guideline of Úrad jadrového dozoru Slovenskej republiky (NRA of Slovak Republic) "BNS I.1.2/2014 Requirements on SAR", Chapter 6.6.10 Nuclear fuel management "avoid fall of heavy load into fuel elements storage".

Slovenia

There is no specific nuclear legislation for the lifting of heavy loads in NPPs in Slovenia that differs from general rules stated above. However, the Krško NPP additionally adopted a part of US NRC legislation: NUREG-0612 "Control of Heavy Loads at Nuclear Power Plants".

Sweden

No, there is no specific nuclear legislation regarding heavy loads. However, analyses of the dropping of heavy loads shall be considered if the lifting operation involves radiological material or if dropping of the load can affect reactor safety. These aspects are regulated within Strålsäkerhetsmyndigheten (SSM) regulatory framework.

However, SSM is working with a new regulatory code where heavy loads will be included. This code will be named "Regulations on lifting equipment and lifting operation in nuclear facilities". The time schedule is that this regulation will be valid 2020.

Switzerland

See question Q1.

United Kingdom

In addition to the legislation listed in the response to Q1, the Nuclear Installations Act 1965 applies. This requires the Office for Nuclear Regulation (ONR), as the appropriate national authority to attach to any nuclear site licences it grants, such conditions as ONR considers necessary or desirable in the interests of safety.

Neither the legislation listed above nor the site licence conditions make any specific reference to the lifting of heavy loads at NPPs.

Relevant licence conditions (LCs) for nuclear lifting equipment include:

- LC23 – Operating Rules.
- LC28 – Examination, Inspection, Maintenance and Testing.

ONR's inspectors use Safety Assessment Principles (SAPs) together with supporting Technical Assessment Guides (TAGs), to guide their regulatory judgements and recommendations when undertaking technical assessments of nuclear site licensees' safety submissions.

Relevant TAGs include:

- Nuclear Lifting Operations (NS-TAST-GD-056 Revision 3).
- Examination, Inspection, Maintenance and Testing of Items Important to Safety (NS-TAST-GD-009 Revision 3).

The SAPs are at: www.onr.org.uk/saps/index.htm.

The TAGs are at: www.onr.org.uk/operational/tech_asst_guides/index.htm.

Q3. How is a heavy load lifting system defined in your regulatory framework?

Belgium

The notion of “heavy load lifting systems” is not defined in the Belgian regulatory framework.

France

The Order of 1 March 2004 defines a lifting equipment as follows: Machines, including those powered directly using human strength, and their associated equipment, operated by one or more operators who control its movement using mechanisms which they keep control of, with at least one functionality being to move a load composed of merchandise, material and possibly persons, with a significant height modification of the load during its movement, the load not being permanently linked to the equipment. Is not considered as significant a height modification corresponding to what is the strict minimum to move the load by lifting it from the ground and is not creating risks in case of failure of the load support.

Germany

In the German Safety Standard KTA 3902 for the ‘Design of Lifting Equipment in Nuclear Power Plants’ guidance is given on the classification of lifting equipment. It is classified depending on the consequences of failure (i.e. load drop) leading to “general”, “additional” or “increased” requirements for lifting equipment in NPPs and specific requirements for fuel-handling machines. Possible consequences of failure consider release of radioactivity, loss of reactor coolant and criticality accidents.

While no general distinction is made between “heavy loads” and other loads, the mass of the load is one of the criteria to assess the possible consequences of failure. Guidance to characterise “heavy” loads is provided for load handling in/over the open reactor pressure vessel (RPV) or in/over the fuel pool. If the mass of the load is larger than 200 kg, this is one criterion to demand ‘increased requirements’ for the design of the lifting device.

This definition of heavy load may differ from those made in other countries, e.g. in the US NRC NUREG-0612 “Control of Heavy Loads at Nuclear Power Plants”.

Hungary

The heavy load lifting system is not defined in the regulatory framework.

Japan

A heavy load (except for fuel assemblies and spent fuel) lifting system is not defined in our regulatory framework.

As in Answer 1 to Question 1, the heavy load lifting system corresponds to the fuel-handling system, which is stipulated in legislations as equipment used for loading, unloading and storage of fuel assemblies, etc. Necessary regulation is imposed on the equipment in the design phase.

Russia

In accordance with requirements of point 2 of NP-043-011 the requirements of NP-043-11 applies to the following hoisting machinery with a lifting capacity of 1 t or more applied to the objects of use of atomic energy:

- load lifting cranes of all types, including overhead stacker cranes with mechanical drive;
- electric cargo truck travelling on an overhead rail-cab control;
- electric hoist;
- the gripping bodies (including the hooks, grabs, lifting magnets, tongs);
- lifting devices (including slings, grabs, traverses).

Slovak Republic

Heavy load lifting systems are defined in legislation for industrial safety of Slovak legislative system – Decree of Ministry of labour and social matters No. 508/2009 Requirements on lifting, electric and pressure technical equipment (Heavy load lifting systems are not matter of Slovak nuclear regulatory body).

Slovenia

Heavy load lifting system comprises mobile or fixed devices for lifting and lowering free hanging load with or without horizontal load movement that operate with a wire rope or chain and are suitable to use a hook, shovel, bucket or other grabbing or lifting means.

Sweden

There are no specific nuclear regulations regarding heavy loads.

Switzerland

According to ENSI-guideline G01 lifting equipment are elevators, cranes, running kits, expansion aids, load-bearing devices and fuel element changing machines.

United Kingdom

There is no such definition.

Q4. How are heavy loads defined in safety assessment reports?

Belgium

The notion of heavy loads is not explicitly defined in the FSAR of Belgian NPP.

Only lifting devices and associated handling equipment which may impact the safety of fuel storage and handling systems were initially addressed in the FSARs of NPPs. These lifting devices include typically all cranes and other devices used to lift and handle nuclear fuel assemblies and spent fuel casks. The FSARs also cover the use of cranes for lifting other heavy loads (for example lifting of reactor vessel head and upper internals in the reactor building), the safety of which directly or indirectly impacts the safety of nuclear fuel storage.

These lifting devices have been classified later as single failure proof (SFP) or non-single failure proof (in the frame of a periodic safety reviews) depending on the weight of the load manipulated by the lifting device and the risk of radiological releases associated with a load drop. This classification was made in accordance with a more recent edition of NUREG-0800 (SRP sections 9.1.4 and 9.1.5), which make a distinction between “light load handling systems (related to refuelling)” and “overhead heavy load handlings systems”. See NUREG-0800 SRP 9.1.5 for a definition of heavy loads considered within the scope of the periodic safety reviews.

Within this reference framework a heavy load is (broadly) defined as any load, carried in a given area after a plant becomes operational, that weighs more than the combined weight of a single spent fuel assembly and its associated handling tool for the specific plant in question. Typical examples are spent fuel casks and the head of the reactor pressure vessel. Heavy loads that need to be moved over spent fuel pools, the reactor loaded with (spent) fuel or safe shutdown equipment, or that can be directly responsible for the release of radioactivity, are called “critical loads”.

France

Germany

According to safety assessment reports, dropping of heavy loads has to be taken into account as initiating event during shut down modes of the NPPs, yet no definition of “heavy loads” is provided.

Hungary

The heavy loads are not defined in the safety assessment reports.

Japan

Falling of heavy loads (except for fuel assemblies and spent fuel) during lifting is not addressed in safety assessment reports.

As in Answer 1 to Question 1, the lifting of fuel assemblies, etc. is regulated in the design phase under the Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors.

Russia

In Russia there are special requirements to the scope and content of the safety assessment reports for different types of reactors (NP-006-98 – for WWER type reactors, NP-018-2005 – for the fast neutrons reactors) and also to the scope and content of different types of Safety Assessments Reports. Each of them contains requirements for the justification of safety of the equipment important for safety of NPP, including safety justification, for example, of nuclear fuel transportation system.

Slovak Republic

The Safety Analysis Reports include 2 scenarios (SAR for Bohunice NPP, chapter 15.7.4):

- fall of container with fresh or spent fuel elements;
- fall of fuel element during reactor fuel loading.

Slovenia

There is no specific definition for heavy loads in Safety Analysis Reports. Definitions for heavy loads can be found in the appropriate legislation and internal procedures of the Krško NPP.

As per NUREG-0612, adopted by and thus valid for the Krško NPP, heavy load is any load, carried in a given area after a plant becomes operational, that weighs more than the combined weight of a single spent fuel assembly and its associated handling tool for the specific plant in question.

More specific, in the Krško NPP's internal procedure ADP-1.1.141 "Handling with heavy loads in Krško NPP", heavy loads are defined as loads with total mass (including lifting tools and tying means) exceeding 1 000 kg.

According to the NUREG-0612 and internal procedure ADP-1.1.141, handling of heavy loads is especially focused on administrative control during lifting and transferring heavy loads over fuel elements in reactor core (reactor building), over spent fuel pool (fuel-handling building) and generally over areas, where safe shutdown equipment is installed.

Sweden

Heavy loads equipment is described in the SAR, and there is a chapter in the technical specification regarding heavy loads in the reactor building.

Management of lifting devices that goes beyond normal Swedish regulations and standards for lifting devices follows NUREG-0554 and NUREG-0612. Heavy loads is defined in NUREG-0612: "Any load, carried in a given area after a plant becomes operational, that weighs more than the combined weight of a single spent fuel assembly and its associated handling tool for the specific plant in question."

Switzerland

The dropping of heavy loads is assessed in the safety assessment reports. Objects being assessed are mainly various cranes in reactor building, turbine building, auxiliary building etc.

United Kingdom

There is no such definition.

There is a legal duty on licensees to reduce risks so far as is reasonably practicable, and ONR expects this to be clearly set out in safety assessment reports. This will apply to activities involving the lifting of heavy loads.

ONR's inspectors use SAPs together with supporting TAGs to guide their regulatory judgements and recommendations when undertaking technical assessments of nuclear site licensees' safety submissions.

Q5. What standards and guidelines are used for the design, manufacture, maintenance and testing of equipment used for the lifting of heavy loads?

Belgium

Lifting devices which are since most recent updates of nuclear power plant (NPP) safety reviews considered as "light load handling systems" (e.g. related to the manipulation of fuel assemblies) or "heavy load handling systems" (see answer to Q4) have initially be designed and manufactured according to the general regulations and industrial standards in force at the period of design and construction of the NPPs (in sixties and seventies). For more recent NPPs (commercial operation started in early 1980s) also use was also made of US standards in force at that time (including as a reference US NRC RG 1.104 with BTP 9-1, which is now withdrawn and replaced by NUREG-0554).

The design of these lifting devices and their maintenance and testing have since initial plant start-up and to the extent possible been extensively revised during the periodic safety reviews of these plants on the basis of more recent US crane standards for nuclear facilities (see *A Guide to American Crane Standards for Electric Overhead Travelling Cranes, Hoists, and Related Equipment for Nuclear Facilities*, STP-NU-015, ASME, 2008 for an overview of US standards considered). Deviations from these standards have been accepted in some cases.

France

European harmonised standards aim at giving technical specifications for professionals for them to manufacture and market equipment which comply with essential requirements for health and security. Those standards are not mandatory but a machine build following those will be assumed to comply with the essential requirements from the Labour Code. Standards are the following:

- ISO-FEM 1-001: calculation rules for lifting equipment;
- AFNOR 13155-A2: lifting equipment with suspended load- security- removable equipment for lifting loads;
- Norm 4301-1 2016: lifting equipment with suspended load;
- Circular of 24 March 2005, Annex II and III.

Germany

Two standards are used for the design/manufacture and maintenance/testing of lifting equipment, namely KTA 3902 and KTA 3903 (see answer to Q2).

Hungary

NUREG 0554, NUREG 0612, safety guide for new nuclear power plants on design of auxiliary and support systems and other hungarian standards.

Japan

The fuel-handling equipment as object of national inspection is confirmed as conforming with required standards, in accordance with the Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors.

Cranes and other equipment which handle fuel assemblies or spent fuel are required to take appropriate fall prevention measures, etc. as regulatory requirements, and the NRA confirms design of cranes.

In the Article 26 of the following NRA ordinance, a requirement for, for example, the grip mechanism of the fuel-handling machine is stipulated. In an examination in the design phase, it is confirmed that the grip mechanism conforms with this requirement.

- NRA Ordinance Prescribing Technical Standards for Commercial Power Reactors and their Auxiliary Facilities.

Russia

As it is mentioned in the answer to the second question, the special requirements for the lifting of heavy loads in NPPs, including requirements for the design (design), manufacture, installation and operation of cranes of objects of use of atomic energy, are established in the Federal norms and rules NP-043-11. The requirements of NP-043-11 are mandatory and should be met during design (design), manufacture, installation and operation of cranes in nuclear facilities.

Slovak Republic

Answer for 5, 6, 7 and 8:

Heavy load lifting systems are defined in legislation for industrial safety of Slovak legislative system – Decree of Ministry of labour and social matters No. 508/2009 Requirements on lifting, electric and pressure technical equipment (Heavy load lifting systems are not matter of Slovak nuclear regulatory body).

Slovenia

Design, manufacture, maintenance and testing of heavy loads lifting equipment in Slovenia is governed by European Standards EN 13000+A1 for cranes and mobile cranes.

For additional maintenance and inspection in the Krško NPP the following internal procedures are applied:

- ADP-1.1.141, Heavy Loads Handling in Krško NPP;
- ADP-1.4.160, Preventive Maintenance Programme for Hoisting Equipment, Fuel-Handling Equipment, Forklifts and Auxiliary Carrying Equipment;
- ADP-1.1.142, Use of Lifts, Hoisting Equipment, Forklifts and Auxiliary Carrying Equipment in Krško NPP;
- ADP-1.14.201, Use of Mobile Cranes and Similar Working means in the vicinity of high voltage facilities;
- GMM-4.014, Elevator Maintenance;
- GMM-4.180, Maintenance of Fuel-Handling Equipment;
- PMM-4.180, Maintenance of Refuelling Machine.

Sweden

Swedish nuclear regulatory code states that structures, systems, components and devices of the nuclear power reactor shall be divided into safety classes and quality classes.

Lifting constructions in the boiling water reactors (BW) are safety classified with regard to ANSI/ANS 52.1. Lifting constructions in the pressurised water reactors (PWR) do not have any safety classification.

Swedish licensees are using a mix of Swedish, German and American standards.

- IKH is Swedish standard for cranes and elevators, it has been widely used during design of equipment, it ceased to exist year 2000.
- AFS is a Swedish regulatory code for Acts and regulations about work environment, AFS 1993:10 has been used in modernisations after year 1995, see also answer to Q1.
- ANSI/ANS 57.1-1992 has been used for modernisation of fuel-handling systems.
- NUREG-0612 and NUREG-0554 has been used for modernisation of some Swedish reactor building gantry cranes.
- The German standard KTA-3902 has been used for modernisation after year 2000.
- ISO 12482 is used for maintenance and control.

For new equipment, standards will be harmonised with European standard EN-13001, implemented by SS-EN standardisation.

Many national standards are or will be replaced by EN-13001 standards in the standardisation framework to avoid duplication.

In the new regulation in Sweden (see Q2), the German standards KTA-3902 and 3903 will be the recommended standards.

Switzerland

See question Q1.

United Kingdom

- For general BS2573 and the BS EN 13000 series are used.
- Additionally, in the nuclear industry, while ONR's SAPs and TAGs are written for use by ONR Inspectors, licensees also use them to inform their designs.

Q6. How are maintenance and control of heavy load lifting systems scheduled?

Belgium

The lifting equipment in the reactor building is maintained and controlled prior to every refuelling outage. Other lifting equipment is maintained and controlled based on industrial standards.

A dedicated and accredited inspection and certification organisation (for NPPs: AIB-Vinçotte) is in charge of an independent control of the maintenance and testing of lifting equipment, within the limits of their authority (general, non-nuclear specific regulations). Additional licensee internal independent controls by a safety department (including compliance with nuclear standards) may be in effect at certain NPP sites.

France

They are required by Order of 1 March 2004. Mandatory verifications are: commissioning verifications, back to service verifications (site change, modification of operating configuration, disassembly...), periodic verifications (every 6 or 12 months). The labour inspector can request supplementary verifications.

Germany

Unless specifically stated otherwise, in-service inspections shall be performed yearly, according to German Safety Standard KTA 3903 for the *Inspection, Testing and Operation of Lifting Equipment in Nuclear Power Plants*.

In cases, where lifting equipment is not used for a period of time exceeding the time interval between 2 in-service inspections, the next in-service inspection shall be performed at the latest prior to using such lifting equipment.

Hungary

For cranes: structural examination every half a year, main examination and load test every 18 months, periodic safety examination at least every 5 years.

Japan

Each licensee sets an inspection cycle and implements maintenance management while taking safety functions and risk information into consideration.

Under the Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors, the fuel-handling equipment as object of national inspection is confirmed to conform with technical standards in the pre-service inspection and at the timing of the periodic inspection with reactor shutdown during the in-service period on a regular basis.

Russia

NP-043-11 establishes special requirements for maintenance and control of heavy load lifting systems at NPPs. In the chapter VII of NP-043-11, there are a set of requirements for maintenance and control of special cranes at NPPs. In accordance with point 74 of NP-043-11 the partial technical examination of special cranes must be conducted not less than once in 12 months full technical inspection – at least once in 3 years, except for special cranes, used occasionally when repairs and maintenance works. The last ones should be subjected to a partial technical examination at least once in 2 years, a full technical inspection – at least once in 5 years.

In accordance with point 78 of NP-043-11 a special crane, the spent specified lifetime, must be subjected to diagnosis, including a full technical examination.

Slovak Republic

See Q5.

Slovenia

Lifting systems are maintained and inspected in accordance with the national regulation (UL RS 43/11, UL SFRJ 30/69) as well as manufacturers' recommendations, number of operations, duration of operation etc. Inspection intervals in the Krško NPP are more specifically defined by their internal procedure ADP-1.4.160 "Preventive Maintenance Programme for Hoisting Equipment, Fuel-Handling Equipment, Forklifts and Auxiliary Carrying Equipment". The following inspection intervals are generally applied for heavy load lifting systems:

- Inspection before each operation: all lifting equipment must be inspected every time before its intended operation.
- Inspection once per month: all lifting systems outside the reactor building are periodically inspected and maintained.
- Inspection once per fuel cycle: all bridge cranes and fuel-handling lifting systems outside the reactor building are additionally inspected before each outage. All lifting systems inside the reactor building are inspected before and after each fuel change during outages.

Sweden

An accredited organisation performs yearly inspection due to Swedish industrial standards regarding lifting devices (AFS 2003:6 and SS-7680004).

The licensees also perform testing according to the technical specifications.

The daily work is also controlled regarding Acts and regulations regarding lifting devices (AFS 2006:6) and ISO 12482-1 (Cranes – Condition monitoring) are used for controlling of cranes.

Personnel involved in maintenance on lifting equipment are trained and qualified through KIKA, which is an industrial network for personnel working with heavy loads in the Swedish nuclear industry.

Many lifting devices have also been subject to modernisation projects.

Switzerland

Maintenance and control are based on requirements according to KTA 3903. Unless specifically stated otherwise, in-service inspections shall be performed yearly.

United Kingdom

In the Nuclear industry, Licence Condition 28 encompasses the Examination, Inspection, Maintenance and Testing, this requires the licensee to make and implement adequate arrangements for the regular and systematic examination, inspection, maintenance and testing of all plant which may affect safety.

Guidance on this for ONR Inspectors is given in ONR's TAG Examination, Inspection, Maintenance and Testing of Items Important to Safety (NS-TAST-GD-009 Revision 3).

Q7. How are single failure criteria considered?

Belgium

Single failure criteria are considered in agreement with applicable US regulations and standards (for heavy/critical loads), see answer to Q4 and Q5.

France

Germany

Lifting devices classified into the class with "increased requirements" have to be single failure proof. This includes equipment for lifting heavy loads (> 200 kg) in/over the open reactor pressure vessel (RPV) or in/over the fuel pool. The following design requirements are applicable:

- Independent redundant brakes – operational and auxiliary break system.
- Either a double drive mechanism chain or a single drive mechanism chain with redundant ropes, rope pulleys and an additional safety brake.
- Operational and safety travel way limiters.
- Redundant travel way measurement systems, if a travel way measurement system is implemented.

Hungary

There are no specific regulations, recommendations related to heavy loads, however it is considered in the safety assessment reports. The Paks NPP made modifications to protect the cranes against single failure.

Japan

Single failure criteria are not required for the fuel-handling system. However, it is confirmed that how cranes, etc., in themselves affect the safety-related equipment during occurrence of an earthquake.

Russia

Requirements for the use of the single failure criteria during design of safety-related equipment of NPPs are established in NP-001-15 "General Regulations on Ensuring safety of NPPs".

Slovak Republic

See Q5.

Slovenia

Single failure criteria are considered in Reactor Building and in Fuel-Handling Building for heavy load lifting equipment that can damage fuel assemblies or safe shutdown systems (NUREG-0612).

Cranes in Reactor Building:

Reactor cavity manipulator crane: the operability requirements for the manipulator crane ensure that the core internees and reactor vessel are protected from excessive lifting force in the event they are inadvertently engaged during lifting operations. Interlocks can withstand a single failure in the following systems: bridge, trolley and winch drives (redundant), gripper interlock (redundant), excessive suspended weight (redundant switches), Hoist-Gripper Position Interlock (not redundant, but can withstand a single failure).

Polar crane: this crane inside the reactor building is not a totally single failure proof (SFP) lifting device. It satisfies most, but not all the requirements for SFP cranes as defined in NUREG-0554 and NUREG-0612. This is due to the fact that the polar crane at the Krško NPP was designed prior to the issuance of 2 above mentioned NUREGs.

Cranes in Fuel-Handling Building:

The bridge crane (Fuel Cask Handling Crane) cannot traverse the spent fuel and fuel transfer pits due to the layout of the cranes. The possibility of a fuel cask being dropped on stored fuel is thus precluded. The spent fuel pool bridge and hoist can lift only one fuel and control rod assembly at a time. The restriction on movement of loads in excess of the nominal weight of a fuel and control rod assembly and associated handling tool over other fuel assemblies in the storage pool ensures that in the event this load is dropped the activity release will be limited to that contained in a single fuel assembly and any possible distortion of fuel in the storage racks will not result in a critical array. This assumption is consistent with the activity release assumed in the safety analyses.

Sweden

Single failure is considered in many lifting devices if the lift may involve radiological material or if the dropping of the load can affect reactor safety. For components were single failure cannot be addressed a sufficient design safety factor are used. This is not a specific requirement in the Swedish regulatory code, but it is part of the SAR.

Cranes are designed regarding single failure with double lines, double brakes etc. and where single failure cannot be taken care of, for example the hook, a sufficient design safety factor in line with NUREG-0612, NUREG-0554 or KTA3902 is used.

Switzerland

Single failure criteria is applied concerning KTA for parts of heavy lifting equipment which are assumed possible to fail.

United Kingdom

Single failure criteria is considered via:

- ONR Safety Assessment Principle EDR.4 in the SAPs. This states: “During any normally permissible state of plant availability, no single random failure, assumed to occur anywhere within the systems provided to secure a safety function, should prevent the performance of that safety function.”
- ONR TAG on Nuclear Lifting Operations – Appendices (NS-TAST-GD-056 Revision 3).
- ONR TAG on the single failure criterion (NS-TAST-GD-011 Rev 2).

Q8. How is ageing of lifting equipment considered?

Belgium

The ageing has been considered in the design. Large margins for mechanical aspects are taken into account. Due to obsolescence, electrical control and command devices were changed recently.

The ageing of lifting equipment was also reviewed in the context of the Long Term Operation of units Tihange 1 and Doel 1&2.

France

Germany

Ageing in general is taken into account in the German Safety Standard KTA 1403 "Ageing Management in Nuclear Power Plants". Requirements concerning environment and specific ageing mechanisms have to be taken into account during the design of lifting equipment. In particular, a fatigue analysis has to be performed in the design of lifting equipment and has to be evaluated during operation depending on the number of load cycles during the lifetime of the lifting equipment in accordance with German Safety Standards KTA 3902 and 3903.

Hungary

There are no specific regulations, recommendations related to heavy loads.

Japan

The fuel-handling system is equipment required to take measures for ageing management. The fuel-handling system is evaluated for a degradation phenomenon supposed for each part of the system.

Russia

In accordance with point 78 of NP-043-11 a special crane, the spent specified lifetime, must be subjected to diagnosis, including a full technical examination. Also, in accordance with point 83 of NP-043-11 the value of actual practices and actual operating modes of the special cranes (including abnormal operations) must be considered and analysed when renewing its appointed time of service.

Slovak Republic

See Q5.

Slovenia

The Inspection of Overhead Heavy Load and Refuelling Handling Systems programme is an existing programme that is consistent with NUREG-1801, Section XI.M23, "Inspection of Overhead Heavy Load and Light Load (Related to Refuelling) Handling Systems." The Inspection of Overhead Heavy Load and Refuelling Handling Systems programme manages the ageing effect of loss of material due to general corrosion and rail wear for the in-scope steel cranes, trolleys, bridges and rails. The programme is implemented through periodic visual inspections of the crane, trolley, bridge and rail structural members.

Sweden

The standard ISO 12482-1 is used for maintenance control based on expected ageing.

Switzerland

Ageing is considered in KTA rules. Periodical changes, given numbers of load cycles and limited working hours of equipment parts are regulated.

United Kingdom

ONR consider ageing of nuclear related lifting equipment under Licensing Condition 28 (LC28), also considered are:

- ONR TAG on Nuclear Lifting Operations (NS-TAST-GD-056 Revision 3).
- ONR TAG on Examination, Inspection, Maintenance and Testing of Items Important to Safety (NS-TAST-GD-009 Revision 3).
- ONR TAG on Asset Management (NS-TAST-GD-098 Rev 0).

Q9. Are seismic events regarding the lifting of heavy loads considered in the safety assessment reports?

Belgium

The impact of a safe shutdown earthquake (SSE) has been taken into account in the design of the lifting equipment for heavy loads of the more recent NPPs (for heavy loads see answer to Q4).

For older NPPs the integrity of lifting equipment operating heavy loads in case of SSE has been reassessed as part of the periodic safety reviews (see answer to Q5).

France

[…]

Germany

An analytical proof of the adequate protection of lifting equipment against external events is required in cases when such requirement also exists for the building they are used in. The combination of a lifting operation and a seismic event does not have to be taken into account.

Hungary

Yes, the seismic events are considered related to lifting of heavy loads, mainly focusing on crane operations.

Japan

Seismic events at the time of lifting heavy loads (except for fuel assemblies and spent fuel) are not considered in safety assessment reports.

The seismic design classification is set to each equipment to consider seismic events.

Russia

In accordance with the requirements of Russian regulatory documents, safety assessment reports must contain information about seismic protection of the main buildings, systems and equipment of NPP. In addition, seismic categories of equipment should be specified in SAR.

The Slovak Republic

No.

Slovenia

Seismic events in USARs are, similar to NUREG-0612, considered in Reactor Building and in Fuel-Handling Building for heavy load lifting equipment that can damage fuel assemblies or safe shutdown systems.

The polar crane in reactor building is designed to withstand the operating environment and seismic event. It is equipped with earthquake restraints to preclude dislodgement from the rails during a safe shutdown earthquake (SSE). Permanent seismic protection on the trolley, restrictors of the horizontal movements and reinforcement of the secondary structure are provided according to revised seismic spectra and higher resulting horizontal and vertical acceleration.

The spent fuel pool bridge and hoist are classified as Seismic Category I structures according to Nuclear Regulatory Commission (NRC) Regulatory Guide 1.29. That means that they are designed to remain functional during the SSE.

Sweden

Seismic categories of equipment are specified in SAR, this categorisation differs between the NPPs:

- At one NPP there is no seismic classification but lifting systems are mechanically anchored when they are not in use.

- At another NPP the lifting devices are analysed with regard to earthquake and systems are verified to withstand earthquakes.
- At the third one there is no seismic classification for lifting devices.

Switzerland

Yes, seismic events are regulated. There are defined parking positions for lifting equipments as well.

United Kingdom

They are expected to be covered, as set out in ONR's SAPs.

ANNEX 2: LIST OF EVENTS

ID	Title	Abstract	Load	Failure Mode	Cause
1	Fall of a spent fuel assembly into the spent fuel storage tank	A spent fuel assembly was being transferred from the Spent Fuel Storage Tank (SFST) to a Rail Transport Car Shipping Cask when a wire rope of a Fuel Transfer Container (FTC) broke and the spent fuel assembly which by the time had almost reached the upper position fell down into the SFST. As a result a spent fuel assembly plug-gripper hit the guiding tube with a slit, the spent fuel assembly central rod was cut off and upper and lower fuel bundles fell down onto the bottom of the SFST. The event had no radiation consequences. The fall of the gripper transfer drive wire rope from the drum 218 mm in diameter on the shaft 80 mm in diameter and its subsequent chafing against the drum rim or prominent heads of the bolts fixing the reducer's cover is the direct cause of the event. The root causes: lack of a rope layer (a device for laying a wire rope at the FTC) which resulted in improper laying (coiling) of the wire rope on the gripper drive drum; lack of supervision over the laying of the wire rope on behalf of the personnel; poor supervision over FTC operation at the plant. According to the International Nuclear Event Scale (INES) this event is rated as Level 1.	Nuclear fuel	Slings/wire/ rope/chain breakdown	Inadequate rigging
2	Dropping of a steam generator's leg support during transportation	The load attachment rigging tore during the internal transport process of a steam generator's leg support. The leg support dropped about 25 m onto an open-top container. The event was caused by non-observance of the flame cutting area during the fastening of the plastic rope.	Other loads	Lifting interface failure	Inadequate rigging
3	Damage to spent fuel assembly (SFA) suspension bar during SFA transportation due to personnel errors	Unit 2 was in the overhaul outage with the reactor cooled down and refuelling operations in progress. After the completion of SFA loading into the 13-46 fuel channel (FC) and while the refuelling machine was moving off the above FC the operator heard some unusual noises and by pressing the "stop" button stopped refuelling machine movement. While examining the refuelling machine personnel found that the upper part of SFA's suspension bar was bent. Refuelling operations were interrupted. Breach of unit safe operation limits & conditions and personnel exposure did not occur. Direct causes of the event: incorrect and poor performance of technological operations to prepare the refuelling machine for work and of some refuelling operations. Root causes of the event: shortcomings in personnel training and deficiencies in the plant surveillance programme to reveal and eliminate personnel training deficiencies. The following corrective actions were foreseen: 1) Assure proper technical condition of fuel transportation & shipment equipment by assessing component faults and failures, maintenance scope and frequency, repair technology and make improvements if necessary. 2) Analyse and revise the programmes of periodic training of personnel involved in transportation and shipment operations from the viewpoint of assessment of their knowledge of equipment design, equipment preparation for operation, work methods, interaction with personnel of other divisions, significance of self-assessment and surveillance over the performed work. 3) Revise the criteria of personnel proficiency verification. According to the International Nuclear Event Scale (INES) this event is rated as Level 0.	Nuclear fuel	Unauthorised crane operations	Other, unknown, unspecified
4	Tool "stork" stuck during the refuelling. (Note: toolstork is a specific crane used to unload fuel assemblies)	The unit is in cold shutdown for refuelling. During the refuelling (65 fuel assemblies in-vessel), at the beginning of the sequence to migrate the tool "stork" position from M3 to D3 (opposite position to the loaded area), while lifting in the gripper tube mast of the refuelling machine, alarms "surge" and "lifting" cable break went out. A review through binoculars showed that the wings of the stork were not completely closed and in contact with the lower part of the gridder tube mast, thus preventing it to be lifted. Following the locking of the strok tool, the fastening of one of the lifting cables has	Nuclear fuel	Other	Other, unknown, unspecified

ID	Title	Abstract	Load	Failure Mode	Cause
		completely slipped and a beginning of slipping was also found on the other cable, despite the activation of the overloading protection. A similar event had occurred during a previous outage, and had not led to conservative measures during the outage.			
5	Fuel bundle dropping	On 21 November, at 05:46 hours, when the plant was in the 3rd fuel reload, while moving an irradiated fuel bundle from the core to the spent fuel pool, before going through the "cattle shuttle", the bundle dropped together with the mast and the grapple on a cell made up of 4 fuel bundles. The fall was approximately 30 feet. Immediately the Shift Supervisor followed a procedure for abnormal condition related to fuel-handling accidents. Measurement of radiation level of the atmosphere, at the refuelling floor and isotopic analysis of water from the reactor cavity were taken, and no abnormal values were found. At 06:25 with the aid of an underwater TV camera system the affected areas were inspected and it was observed that the nosepiece of the dropped fuel was damaged, and apparently there was no damage in the 4 fuel bundles of the cell. There were no workers injured. At 01:30 hours on 22 November, with a special procedure the dropped fuel bundle was taken to the spent fuel pool. For this purpose, cables when linked to the frame and hooks of the reactor building main crane and to the auxiliary hook of the refuelling platform.	Nuclear fuel	Hoist emergency brakes failure	Other, unknown, unspecified
6	Operational incidents at nuclear power plants while performing fuel-handling operations	Unit 2 was undergoing scheduled maintenance and refuelling work was under way using the refuelling machine in "fast" mode to unload and load fuel assemblies and additional absorbers in line with the work procedures. Fuel assemblies were being unloaded from fuel channels so that measurements could be performed and the fuel channels subsequently replaced. The fuel-handling division operator in the reactor division central hall informed the senior reactor division operator that the refuelling machine had been manoeuvred onto fuel channel 32-42 and that the fuel channel plug slots were positioned lengthwise along the central hall, i.e. in the same direction as the sealing key teeth. The senior reactor division operator confirmed he had received this information and withdrew the periscope, but did not turn the sealing key a quarter turn (the sealing key teeth and the fuel channel plug slots should be at an angle of ~90º to one another). That notwithstanding, the senior reactor division operator began to lower the docking connector to the lower end position. While docking the refuelling machine to the fuel channel, the docking connector movement drive was tripped when the sealing key teeth snagged on the plug slots. The senior reactor division operator raised the docking connector to the upper end position, lifting the fuel assembly hanger and plug along with the docking connector. With the docking connector at the upper end position, the senior reactor division operator initiated extension of the periscope but did not check that the operation had been completed satisfactorily. He ordered the fuel-handling division operator in the central hall to move from fuel channel 32-42 and to position the plug slots crosswise across the central hall. The fuel-handling division operator then, in turn, failed to check that there was no fuel assembly in the light gap between the bottom of the refuelling machine container and the reactor cover plate and moved from fuel channel 32-42. When the refuelling machine was moved from fuel channel 32-42, a crack was heard below. The fuel-handling division operator halted the refuelling machine. On checking the light gap, it was found that the upper part of the fuel assembly hanger and the fuel channel plug were between the bottom of the container and the central hall cover plate. Staff then withdrew the periscope manually and removed the severed part of the hanger and plug. The remainder of the hanger and the fuel assembly were stuck in the fuel channel. The fuel channel was sealed using a maintenance plug. There was no deterioration in the radiation situation in the central hall, the area beneath the reactor or on the power plant site.	Nuclear fuel	Unauthorised crane operations	Human error

ID	Title	Abstract	Load	Failure Mode	Cause
7	Operational incidents at nuclear power plants while performing fuel-handling operations	The unit was undergoing scheduled maintenance and the reactor core had been unloaded to the cooling pond. The integrity of the cladding of the fuel elements in the fuel assemblies unloaded from the reactor core was being monitored. At 10:50, while the refuelling machine was being moved from cooling pond cell 94-123 to failed element detection and location Canister 1, the fuel assembly spontaneously uncoupled from the refuelling machine gripper. This occurred in the cooling pond. It was detected from the dropping in the reading from the refuelling machine weight indicator. Fuel assembly movement operations were halted. The TV system was used to determine the location and orientation of the dropped assembly. On investigating the causes of the incident, no problems were found in refuelling machine operation or in the snapper. Immediate cause of the spontaneous uncoupling of the fuel assembly from the refuelling machine gripper during transport to failed element detection and location Canister 1: the gripper was not securely coupled to the fuel assembly top fitting owing to the fact that staff did not use the correct gripper height position. The gripper was coupled to the fuel assembly top fitting at a height of ~3 580 mm. The actual required gripper depth for coupling to a working fuel assembly has been determined experimentally to be 3 615-3 620 mm using the synchro system, which is within the tolerance limits (3 600±20). The gripper fell short of the required depth by approximately 40 mm. Contributing factors: - failure to use television monitoring when performing fuel-handling operations; - poor visibility in the cooling pond water. Root cause: deficiencies in the procedure – the refuelling machine operating instructions at Units 3 and 4 do not indicate the required height of the gripper for coupling to fuel assemblies in the cooling pond racks, the core or a can; the action to be taken by staff when the gripper is not at the correct height is not described in detail.	Nuclear fuel	Lifting interface failure	Inadequate rigging
8	Tilting of the lifting beam of the reactor pressure vessel	During periodic testing of the lifting beam of the reactor pressure vessel, one of 3 load attachment riggings broke. The lifting beam tipped to one side and slammed into 2 reactor cover slabs of the reactor cavity. The investigation of the event showed that the fastening was not suitable for the lifting beam. Furthermore organisational deficiencies were identified.	Other loads	Lifting interface failure	Inadequate rigging
9	Dropping of open concrete cask containing a filter	During a transfer operation with a bridge crane of an open concrete cask, which contained a used filter element, the cask was dislodged from the gripper and fell on 2 other open concrete casks in the cask storage room of the solid and liquid radioactive waste treatment building. As a result of the fall the filter ended on the storage room floor. Furthermore the 2 other casks were damaged. Each contained a used filter. The dose rate in contact of the filter on the storage room floor amounted to 180 mSv/h. The filter was manually manipulated with a hook and placed in a new cask, a few weeks after the incident. The damaged casks were subsequently shrouded and decontaminated after removal of the filters. The cause of the incident is related to the fact that 3 fingers of the gripper weren't properly engaged on the cask. There was no automatic detection system of the adequate engagement of the grippers. Furthermore the possibility of visual monitoring, performed by a camera mounted on the bridge crane, was quite poor. In the past precursor events of improper gripper engagement on casks had been observed but not adequately acted upon. A design modification of the gripper and an improvement of the visual control capabilities of adequate gripper engagement have been implemented as corrective actions after these incidents. The event was classified as INES Level 0. In 2004, a similar incident happened at another NPP during the transportation of a 400 l drum with conditioned middle-active waste. In this event the cause was a poor alignment of the camera mounted on the bridge crane with the hoist and	Container with radiologic al waste	Lifting interface failure	Inadequate monitoring or co-ordination

ID	Title	Abstract	Load	Failure Mode	Cause
		load, which made it difficult to monitor the correct positioning of the gripper. As corrective action the camera alignment problem has been corrected and additional controls of correct crane position (based on camera view) with reference points have been performed.			
10	Dropping of spent fuel assembly	During fuel unloading a spent fuel assembly (SFA) dropped. While a SFA was withdrawn from the reactor core, its channel fastener hooked at the overlying screw head of an adjacent SFA. Consequently, both fuel assemblies were withdrawn. Due to the high load indication the personnel stopped the procedure shortly after they started the withdrawal. But, the personnel continued to withdraw the fuel assembly slowly since the overload protection did not actuate and because they attributed the high load indications to frictional forces. An investigation performed after the event revealed that the overload protection of the refuelling machine was inadvertently unavailable. The withdrawing was stopped when the spent fuel assemblies reached their designated position of 80 cm above the upper core grid plate. One minute later the second assembly dropped onto the reactor core. The damages were small and no radioactivity was released. <u>Observation</u>: Fuel assembly involved.	Nuclear fuel	Collision during handling	Other, unknown, unspecified
11	Operational error occurred during reassembly of reactor pressure vessel internals	After the refuelling the personnel started reassembling the reactor pressure vessel internals. The feed water sparger ring was lifted to its set position. Afterwards the lifting beam should be withdrawn from the core. During the hoisting of the lifting beam a diagonal pull was observed. Therefore the hoisting was stopped in a lifting height of about 50 cm. The cause for the diagonal pull was a support bolt, which was not retracted correctly. The correct position of the support bolts should have been checked before the hoisting started. Therefore the root cause of the event was an incomplete visual inspection.	RPV head or internals	Collision during handling	Inadequate monitoring or co-ordination
12	Damage of a shielding device due to the dysfunction of a hoist's brake	For the transportation of bar-shaped contaminated components by crane a shielding device is used. The shielding device is slung to 2 synchronous hoists (master and slave). The hoisting of the unloaded shielding device was suddenly stopped, because the break of the slave hoist was blocked. During the investigations the master hoist loosened and the shielding device hit the hatch opening. As a result the fastening of the shielding device which is connected to the master hoist was bent. The event was caused by a malfunctioning brake control unit of the slave hoist.	Other loads	Hoist emergency brakes failure	Other, unknown, unspecified
13	Failure of a shielding's drive and gripper	For the transportation of bar-shaped contaminated components by crane a shielding device is used. The component is pulled by a gripper into the shielding device. During this process one separation tube could not be pulled completely in the shielding device. The separation tube was moved back to its starting point but the gripper didn't release the tube. The investigations showed that the drive chain between gear and reel had been dislocated and the control cable of the gripper had been disconnected.	Container with radiologic al waste	Slings/wire/ rope/chain breakdown	Other, unknown, unspecified
14	Risk of damaging a spent fuel element during loading of container during maintenance intervention on the inclined plane hoisting system	During the loading sequence of a spent fuel container it is discovered that the chariot of the inclined plane hoisting system, on which the spent fuel container is positioned, had been moved between 2 spent fuel element loading operations, due to an intervention on the inclined plane hoisting system by maintenance technicians (test of brakes) which was not co-ordinated and communicated with the fuel operators. The hoisting system drive (including the brakes) and the chariot of the system are situated in different rooms of the spent fuel building, when the chariot is in the lower position (when it is immersed in the spent fuel pool transfer channel). This means that there was no visual contact between both teams. A simultaneous container loading operation and a movement of the chariot would have resulted in serious fuel damage (near miss event). The event was classified as INES Level 1. <u>The identified causes were</u>:	Nuclear fuel	Unauthorised crane operations	Inadequate monitoring or co-ordination

ID	Title	Abstract	Load	Failure Mode	Cause
		- The keys allowing the intervention on the hoisting system should not have been submitted to the maintenance technicians. - A warning panel near the inclined plane hoisting system drive had been neglected (following a previous similar occurrence of unauthorised intervention of the hoisting system in 1999, a warning panel was installed during fuel loading/unloading of the container on the chariot). - There was no interlock between the inclined plane hoisting system and the crane used for the container loading (fuel elements manipulated with long handling tool suspended to an auxiliary hoist of the bridge crane above spent fuel pool); the original design provides in an interlock between the telescopic fuel-handling machine of the spent fuel pool and the inclined plane hoisting system but operating experience has shown that the use of the fuel-handling machine for fuel loading and unloading of the containers is not possible due to a lack of flexibility in the positioning of the load by the telescopic handling machine. - There was no tagout/lockout of the motor drive of the hoisting system during the container loading operations. - There was no effective management of activity planning (the work allowance for the brake test had been released on 10 November but the test was only executed on 15 November). <u>Corrective actions taken after this event include</u>: - improved tagging of inclined plane hoisting system during all future spent fuel loading and fresh fuel unloading operations; - review of the management system for the interlock keys; - improved planning of operations related to fuel manipulations and maintenance interventions; - improvement of the inclined plane hoisting system operating procedures (adding of cautions); - installation of a physical interlock between the operation of the inclined plane hoisting system and the bridge crane above the spent fuel pool.			
15	Potential for top nozzle separation and dropping of a certain type of Westinghouse fuel assembly (NRC information notice 2002-09)	The US Nuclear Regulatory Commission (NRC) is issuing this information notice to alert addressees to the recent nozzle separation and dropping of a Westinghouse fuel assembly during movement. Even though the nozzle separation affects only fuel of a type last manufactured almost 20 years ago, the fuel is perhaps being moved to dry storage or high-density racks and could drop during movement.	Nuclear fuel	Load structural failure	Design deficiency
16	Accidental contact of a fuel element and a fuel element frame in the fuel pool	During the fuel unloading into the fuel pool a fuel element was moved to its scheduled position. The fuel element was lowered and hit the fuel element frame. The process was stopped. Pendulum movements of the fuel element during the transportation were determined as the cause of the incorrect position of the fuel element.	Nuclear fuel	Collision during handling	Other, unknown, unspecified
17	Malfunction of HCL crane	18 May 2001 a container (~2 tonnes) was being hoisted with 5-tonnes secondary-hoisting device in the transport hall of HCL. * The container moved suddenly slowly downwards. * It was impossible to stop the movement. * No serious damaged had been observed.	Container with radiologic al waste	Hoist emergency brakes failure	Wear, fatigue, ageing

ID	Title	Abstract	Load	Failure Mode	Cause
		* Due to the limited hoisting height above the floor no safety consequences have been observed. Investigation showed that the spring, which de-activated the brake, was broken. * Pieces of the broken spring came between the anchor and the coil of the motor. * Brake was blocked completely and could not perform his function. * Defect was not earlier reported to supplier. * 40 years of extensive use could have induced malfunction. * Yearly maintenance/inspection did not avoid the incident.			
18	Dropping of a fuel element during the loading of a transport container	A fuel bundle was detached from a fuel assembly upper tie plate during the loading of a transport container. The fuel bundle dropped about 0.5 m and touched the top edge of the fuel element rack. The fuel bundle remained in a slanted position. The cause of the event could be led back to an operational error of handling the 40-t hoist.	Nuclear fuel	Load structural failure	Human error
19	Dropping of a load during the handling of a transport container	The decommissioning of the plant took place. Therefore a rotating lid of a reactor tank was put in a transport container and should be transported by crane. During the lowering of the load the hoist failed and the load dropped. The dropping height was about 1.8 m. The failure of the hoist was caused by a failure of a weld which connects the cable drum and the hub. The failure of the weld was caused by material deficiencies and the production of the weld.	Other loads	Crane or lifting devices structural failure	Other, unknown, unspecified
20	Failure of the grab engage/disengage interlock system on the fuelling machine	On 11 March 2002, a short shield plug was inserted into Buffer Storage Tube number 14 – or BST (14) – following discharge of a New Fuel Assembly from the BST to the fuelling machine. After apparently disengaging the grab from the shield plug, a number of attempts were made to move the fuelling machine away from the buffer store, but the drives tripped on each occasion. On the fourth attempt, the shield plug, which was, in fact, not disengaged but spanning the gap between the fuelling machine and the top of the standpipe, was sheared at a gimbal joint. The section of plug below the joint fell some 20 metres and impacted on the bottom of the storage tube. The tube was empty and there was no potential to cause direct damage to fuel. However, failure of the pressure boundary of a tube could prejudice the cooling capability of its “sister” tube via their common cooling system connections. Monitoring of the cooling water and CO_2 systems subsequently confirmed that the pressure boundary had remained intact. Visual inspection of the fuelling machine nose unit and the standpipe region of BST (14) did not identified any significant damage, but a more detailed assessment of the nose unit under the applied loading was required prior to return to service of the machine. There was no other potential for plant damage.	Other loads	Crane or lifting devices structural failure	Other, unknown, unspecified
21	Dropping of a test device’s upper supporting frame during the ultrasonic examination of the inside of the reactor pressure vessel	Two test devices are used for the ultrasonic examination of the inside of the reactor pressure vessel. During the testing procedure the supporting frames of the testing devices are relocated inside the reactor pressure vessel. The upper supporting frame was hoisted and fixated on the set position. Then the lower supporting frame was relocated with a tool and fixated inside the reactor pressure vessel. During this process the upper supporting frame was loosened by mistake. The supporting frame sank down into the flooded reactor cavity and rested on the tool used for the relocation of the lower supporting frame.	RPV head or internals	Unauthorised crane operations	Other, unknown, unspecified

ID	Title	Abstract	Load	Failure Mode	Cause
22	Missing shims in the upper core structure	During the visual inspection of the reactor coolant line a small metal sheet was found near the hot supply line of a steam generator. The metal sheet could be identified as a shim. The shim is used as an assembling aid. It is welded onto the bottom of the upper core structure. The breaking of the shim was caused by vibration cracking and an incorrect assembly. A visual inspection of the upper core structure was conducted. Another shim was found. The shim was sheared during the alignment of the upper core structure onto the set down ring of the reactor pool.	RPV head or internals	Collision during handling	Other, unknown, unspecified
23	Incorrect transport of a fuel element	As part of the test of a control rod the rod was inserted into a fuel element. Afterwards the gripper was withdrawn. During the withdrawal an error message concerning the gripper was displayed and the hoisting process was stopped. The gripper did not open completely and during the hoisting of the gripper a fuel element was withdrawn unnoticed. The crane operator cancelled the fault message and overrode the locking of the crane. The hoisting process was continued without consideration of the load display. The gripper was moved to the spent fuel pool, where another fuel element should be grabbed. A new error message was displayed. The unnoticed fuel element was lowered and touched the other fuel element that should have been lifted. Therefore the route of the hoist was blocked. The event was caused by a dysfunction of the gripper and an operational error.	Nuclear fuel	Collision during handling	Other, unknown, unspecified
24	Damage of a primary neutron source	The relocation of the primary neutron source in the spent fuel pool was planned. Therefore the primary neutron source was transported to its new position inside a spent fuel element. During the transport the gripper and the source could not be lowered completely. The gripper was opened and was withdrawn. The visual inspection showed that the primary neutron source was not in its intended position. Further investigations showed that the top of the primary neutron source was stuck into the centering bell. This was caused by an unnoticed damage of the primary neutron source. The damage could be traced back to an event in 1998, when an inspection device dropped.	RPV head or internals	Collision during handling	Other, unknown, unspecified
25	Sporadic malfunctions of the instrumentation and control of the refuelling platform's hoist	During the movement of the refuelling platform's hoist sporadic malfunctions were observed. These malfunctions could be observed when a change of the predetermined driving direction was conducted. The driving direction was set by manual steering on the control panel. The movement commands were executed in the opposite direction. The investigations showed that the threshold values for load rejection were not active during these malfunctions. The malfunctions were caused by a software defect.	Nuclear fuel	Crane controls/ protections failures	Other, unknown, unspecified
26	Interruption of the irradiated fuel assembly removal due to a fault of positioning of sling gripping of the lead cask (before hoisting)	The unit is on power, irradiated fuel removal is under way. The lifting beam is positioned on the cask: the fixed arms positioning of the lifting beams lie on the cask, the mobile arms gripping are closed correctly on the cask (record of the position on the console) and a first lifting (only of the lifting beam) shall be carried out in order to bring into contact the mobile arms with the collar (record of the position on the console). The load taken only refers to the lifting beam. The mobile arms are in their position of lifting but they are not locked. The next step is to lock the mobile arms. The operator has to perform this lock before the uprising of the cask. The lifting beam was released from of the lead cask before the manual lock is therefore performed before the lead casks are hoisted. Origin: incorrect positioning of the lifting beam non-relayed to the control console. An OEF notice has been drafted to destination of NPP and park.	Container with radiologic al waste	Unauthorised crane operations	Inadequate rigging
27	Disturbance during the handling of new fuel elements	The relocation of a new fuel element from the dry fuel storage facility to a defined position in the fuel pool took place. Because of an operational error by handling the hoist the fuel element remained slung. After this process another fuel element should be relocated. The unnoticed fuel element was lowered onto the other fuel element that should have been lifted.	Nuclear fuel	Collision during handling	Human error

ID	Title	Abstract	Load	Failure Mode	Cause
28	Fresh fuel assembly dropped during fuel-handling operations due to incorrect staff action	The Unit was operating at 1 000 MW(e). The status of the equipment satisfied the technical specifications for the safe operation of the Unit. Operations were in progress at the Unit to transfer fresh fuel assemblies from the fresh fuel storage facility to the reactor building's central hall (CH-3). During the transfer of the fresh fuel assemblies from the storage facility to CH-3 of the reactor building for fuel module assembly, a sling loop slipped off the hook block of the bridge crane, causing a fresh fuel assembly to fall firstly onto the tilter, then onto the tilter deck. The fresh fuel assembly dented on impact with the tilter. There was no rupture of the fuel element cladding. There was no breach of the limits or conditions for safe operation, no release of radioactive substances over the prescribed limits or exposure of staff. Causes: deficiencies in the training of staff responsible for fitting the sling and for the transfer of fresh fuel assemblies; inadequate supervision of these operations; deficiencies in the procedures for fuel-handling operations. Corrective actions: amendment of the instructions for fuel-handling operations; amendment of the staff refresher training programmes on responding to similar scenarios; unscheduled briefing of staff responsible for carrying out fuel-handling operations. This incident was rated at Level 0 on the International Nuclear Event Scale (INES).	Nuclear fuel	Lifting interface failure	Inadequate rigging
29	Heavy load issue with shielding slab	On 20 November 2003, as part of a routine maintenance outage activity, a shielding slab was lifted in order to allow access to a well enclosure where a moderator system rupture disc is located. Initially, the hoist motor was jogged for the lift of the shielding slab. The load was then lifted and momentarily immobilised at a height of approximately 4.5 m. While the signalman was attempting to resume the lift, the shielding slab began to descend, slowed by the brakes of the hoist motor, hitting the wall and the floor until it landed on the moderator system piping as the lift exceeded the rated capacity of the shackle and lifting beam. The direct cause of this event is attributed to the employees, who were dedicated to this task, assuming that the shielding slab was made of concrete with a weight of 3 500 lbs. The slab was later determined to be made of steel with an actual weight of 11 250 lbs., exceeding the permitted load capacity of the auxiliary hoist by 2.5 times. This event had no actual impact on nuclear safety, employee safety, or public safety; however, it highlights important issues related to the need for proper knowledge of a load prior to its lift.	Other loads	Unauthorised crane operations	Human error
30	Event during the handling of a control rod guide tube	As part of a regular visual inspection below the lower core structure a control rod guide tube has to be relocated to a vacant position. Therefore a special tool had to be slightly rotated. This rotation caused the opening of the bayonet locking device and the control rod guide tube dropped about 3 m before it was stopped by a special tool's hose connection. The event was caused by a design error of the special tool.	Control rods (or parts)	Unauthorised crane operations	Design deficiency
31	Lid of high level solid waste container dropped during container handling operations, resulting in worker injury	The unit was operating at rated power. During handling operations to move an empty high level solid waste container from one room to another, the container lid fell to the floor when one of the slings slid off the trunnion and the container tilted sharply to one side. The lid struck the toes of one of the 2 mechanics who were, at that time, in the operating area of the bridge crane handling the container. These mechanics were not involved in the container handling operations and were not authorised to be present in the operating area of the bridge crane. After the incident, the container handling operations were discontinued. The injured mechanic was given medical assistance at the power plant's first aid post and later sent to the medical unit. Immediate causes: unreliable attachment of sling to the container; failure to secure the container lid to the casing using the design-provided fastenings; errors by the mechanics. Root causes: shortcomings in the management and organisation of the high level solid waste container handling operations; inadequate training of personnel; container design deficiencies. This incident was rated at Level 0 on the International Nuclear Event Scale (INES).	Container with radiologic al waste	Lifting interface failure	Inadequate rigging

ID	Title	Abstract	Load	Failure Mode	Cause
32	Damage of the pivot bearing of the refuelling platform's auxiliary hoist	Two broken screws were found during the visual inspection of the refuelling platform. These screws are used to fixate the lift lock of the auxiliary hoist's pivot bearing. The investigations showed that the torn screws were caused by an event during the overhaul 2003. When a stuck control rod guide tube was hoisted the overload protection was activated. This overload led to forced rupturing of the screws. The overload was caused by an operational error.	Control rods (or parts)	Unauthorised crane operations	Human error
33	Damage of a fuel element handle	Contaminated measuring rods for core monitoring were cut into smaller pieces for proper disposal. Therefore a special gripper for handling rods was fixated to the telescopic mast of the refuelling platform. After the work was finished the fuel loading machine was traversed. The transport height of the gripper was too low. The gripper hit a fuel element handle and deformed it. The collision was caused by an operational error.	No load	Collision during handling	Human error
34	Disturbance during the handling of a container at the wet dismantling working area	A basket was used for the transportation of dismantled activated components. A hoist with a shielding device was used to transport this basket into a steel container. This fully automated process was observed by camera. When the basket was lowered into the steel container the gripper accidentally loosened from the basket. The basket dropped into the steel container. The event was caused by the incorrect centering of the transport device.	Container with radiologic al waste	Lifting interface failure	inadequate rigging
35	Lifting of upper internals 20 cm above the vessel mating surface with the cluster N09 partially attached	While disconnecting the control rod cluster rod, the control rod cluster N9 could not be locked. The analysis, conducted jointly by the provider and EDF on the basics of the technical parameters (altimetry and measurement of weight), led to the continuation of activities, namely the lifting of upper internals. The actors in charge of safety at the site have not been consulted at the time of decision making. The control rod cluster N9 remained attached. The decision to release the upper internals is based on the indicators of weight and altimetry which are insufficient in the particular case of the postulated initiating event. The technical analysis of lack of positioning of the screw in the L shape hole was insufficient in terms of potential impact on disconnection. <u>Immediate corrective action</u>: - Immediate stoppage from handling, decision to set the "fuel-handling ongoing" mode, implementation of continuous monitoring of the cluster to ensure the implementation of the appropriate procedure if dropped. - The study and execution of a tool and a modus operandi to ensure the maintenance of the connection site/control rod cluster during the handling of upper internal equipment in order to avoid inadvertent dropping in the vessel and to recover then the control rod cluster once it is completely extracted. The operation of handling of upper internal equipment with the cluster N09 in safe position with a tool took place during the night of 13 to 14 May and has been successfully completed the 14 May 2005. Origin: low position was impossible (incorrect low yoke position), the control rod cluster is attached (sleeve/grip interdependent), evacuation of the disconnection tool, decision to lift the upper internals with a non-locked rod, compliance with the schedule, cause-and –effect link in the wrong position of the guide screw.	Control rods (or parts)	Other	Other, unknown, unspecified
36	Deviations concerning the operation of the refuelling platform	Deviations concerning the operation of the refuelling platform were observed during an unloaded operation of the hoist. These deviations led to unanticipated driving movements. A few months later another maloperation of the refuelling platform was observed during the handling of a load. The maloperations were caused by the operational I&C of the refuelling platform. Also the investigation showed that the safety I&C was not able to limit all assumed maloperations of the operational I&C. Further deficits concerning the operational and safety I&C were discovered. The events were caused by dysfunctions of the operational and safety I&C and organisational errors.	No load	Crane controls/ protections failures	Other, unknown, unspecified

ID	Title	Abstract	Load	Failure Mode	Cause
37	gripper tube mast of the refuelling machine remains stuck 3 m above the assemblies with the equipment hatch open	The no load tests of the loading/unloading machine above the reactor pressure vessel are being carried out. At the beginning of the afternoon, the workers are trying to lift the gripper tube mast of the refuelling machine, their operation is futile, it diverts, and is finally stopped by the safety brake. The top of the gripper tube mast was still blocked at about 3 metres in altitude above the head of fuel assemblies. Its insertion in the vessel is such that it is impossible to achieve a translation movement in order to make it completely free from the vessel. Immediate corrective action: Positioning of the machine and its mast in edge of baffle (position R10) thus minimising the risk of a fall on an assembly. In order of magnitude, the dropping of the mast in that position would have impacted the surface of the latter on the baffle by 90% and the remaining 10% on an assembly. Immediate closure of hatch. Holding of a special working group to validate the technical solution issued by the mechanical department in order to lift the mast and place assembly in safe position with regard to the safety and organisational challenges. Expertise regarding the refuelling machine and then repair thereof. Emission of OEF notice to other sites. Origin: uncoupling of a sprocket for lifting chain of the refuelling machine.	No load	Slings/wire/ rope/chain breakdown	Other, unknown, unspecified
38	Event during the handling of new fuel elements	The relocation of a new fuel element from the dry fuel storage facility to its defined position in the fuel pool took place. The new fuel element was lowered to its new position and thereby touched the frame of the defined fuel element position. The fuel element was in a slanted position which led to the opening of its transport locking device. It dropped and hit the neighbouring fuel element as well as the supporting frame and remained in a slanted position. The fuel element was slung to the auxiliary hoist of the fuel loading machine. The cause of the event could be led back to an operational error.	Nuclear fuel	Collision during handling	Human error
39	Damage of a vertical lift rig's bearing shell of a transport container	A locked container filled with empty fuel assembly channels should be removed from the fuel pool. The vertical lift rig was not installed correctly. During the hoisting of the container by the reactor building crane a bearing shell's mounting flange was sheared off. The event was caused by the incorrect positioning of the vertical lift rig.	Container with radiologic al waste	Crane or lifting devices structural failure	Inadequate rigging
40	Tilting of a container in the fuel pool	A container filled with control rod parts was relocated in the fuel pool. For the container's transport of the container the refuelling platform was used. During the relocation an operational error occurred. The container hit the neighbouring position container's top. The container was hoisted again. This led to the tilting of the container. It remained in a slanted position above 3 neighbouring positions. Parts of the container's inventory dropped between and into the neighbouring containers. The event was caused by a misjudgment of the crane operator.	Container with radiologic al waste	Collision during handling	Human error
41	Inaccurate unlocking of a container after its lowering into a drier tank	A container was transported from the fuel pool to a drier tank in the conditioning area. The reactor building crane and a shielded cask were used. During the lowering of the container into the drier tank the personnel did not notice that the container was in a slanted position. Due to the slanted position one of the 2 shut-off valves of the shielded cask was blocked and therefore could not be closed after the unlocking of the container. The loading of the drier tank was stopped. The slanted position of the container was not noticed because checking the height display was omitted.	Container with radiologic al waste	Other	Human error
42	Flask filling area – power tongs failure	The fuel element manipulator comprises a power-operated set of tongs, that pick up irradiated fuel elements from the element reception trough and carries them over to an adjacent area and then places them into a fuel transport flask for despatch off-site. The new equipment was installed in February 2005. During filling of an Irradiated Fuel Transport Flask with irradiated elements, the flask filling area (FFA) power tongs became inoperable. All attempts to raise the tongs clear of the flask using remote techniques failed.	Container with radiologic al waste	Lifting interface failure	Other, unknown, unspecified

ID	Title	Abstract	Load	Failure Mode	Cause
		A project team was set up to manage the recovery of the FFA tongs and a recovery method was developed by the system designers. The recovery of the tongs extension cylinder was successfully carried out to plan. The tongs were manoeuvred to the wet bottling area ready for the investigation into the failure. It was discovered that the valve had failed to close, due to the failure of the return spring. This event highlights the need to identify failure modes and consider whether a recovery strategy for new equipment is required at the design stage. In other circumstances the provision of recovery facilities within a design could reduce the significance of any recovery actions in the event of failure.			
43	Incorrect handling during the loading of a CASTOR® cask	In the fuel pool a CASTOR® cask was loaded with spent fuel elements. After the loading the cask should be closed with the primary top cover. Due to a misinterpretation of a hoisting command a diagonal pull of the lift rig occurred. This led to the locking of the CASTOR® cask's primary top cover. The diagonal pull was caused by the hoisting of the lifting rig when the lifting rig was still attached to the CASTOR® cask's primary top cover. At this moment the reactor building crane was not centred above the CASTOR® cask anymore. The event was caused by an operational error.	Container with radiological waste	Unauthorised crane operations	Human error
44	Dysfunction of a handling tool during the withdrawal of a fuel element	A fuel element was withdrawn from the core for inspection. During the withdrawal the fuel element was loosened from the gripper. The fuel element dropped a few centimetres and rested on the thermal column. The event was caused by a dysfunction of the gripper.	Nuclear fuel	Lifting interface failure	Other, unknown, unspecified
45	Emergency brake of SFP hoist non-operational during handling of a container with spent fuel elements	During the operation of turning over a container enclosing spent fuel elements, in order to place it in a horizontal position (swinging operation which includes a descent of the load) and so transfer it to the truck for transportation, the motor of the main hoist of the bridge crane in the spent fuel building automatically switched off. Apparently one of the crane interlocks (detection of open service brake of the hoist subsequent to an energising of the hoist motor) wasn't set properly. After correction of the interlock setting, a qualification test was performed during which the emergency brake of the hoist was separately tested by opening its service brake. This test showed that the emergency brake was not operational: the hook and lifting device continued their descent, despite the closed emergency brake. The emergency brake is part of the single failure proof (SFP) design of the bridge crane providing an overspeed protection of the hoist (e.g. in case of a mechanical failure in the hoist chain). The analysis showed that the emergency brake was last tested separately in 1999 (as part of a post-maintenance qualification). Neither the test procedure for the brakes of the hoist nor the functional test procedures of the overspeed sensors required testing service and emergency brakes separately. The correct working of the service brake (which works independently from the emergency brake) masked in fact the inoperability of the emergency brake during these tests. The cause of the emergency brake failure has not been documented in our documentation of this event. The emergency brakes of this SFP hoist had not been tested despite earlier indications of brake problems on other SFP bridge cranes (see below). The event was classified as INES Level 1. In June 2006 a similar problem with inoperability of emergency brakes of a SFP hoist of the bridge crane above the spent fuel pool at the same unit had occurred during a qualification test subsequent to a (non-related) modification of the motor control unit of the hoist. In this case the emergency brakes failed because of rusting of mechanical parts in the brake transmission system due to insufficient lubrication. This event had also been classified as INES Level 1. Similar problems with inoperable emergency brakes on the main hoist of the polar cranes of other units at the same site were identified in 2003 and May 2007 during respectively a commissioning test prior to use of the crane and during requalification tests of the crane.	Nuclear fuel	Hoist emergency brakes failure	Other, unknown, unspecified

ID	Title	Abstract	Load	Failure Mode	Cause
		Other deviations identified in the past on SFP bridge cranes and hoists include bypasses of overspeed protections due to inadvertent overspeed protection trips of hoist or crane operation. In 2007, there was neither a specific test requirement nor a maintenance programme for the emergency brakes of the SFP hoists on bridge or polar cranes. Such tests were neither performed by an independent control organisation, because the emergency brakes (which are provided in compliance with nuclear standards applied on SFP lifting equipment) are not within the scope of the standard Belgian regulatory framework for hoisting equipment. Corrective actions after these events include the drafting of new test procedures for the emergency brakes of SFP hoists on bridge and polar cranes. After the 2007 event and taking account of recurrent problems in the past related to inadequate testing of SFP bridge crane protection devices, an action plan was agreed with the safety authority in order to re-establish full compliance with applicable nuclear standards for SFP use of the hoist equipment. In addition a special regime was immediately installed, which authorised the SFP use of all bridge and polar cranes on a case by case basis and supported by a report to be submitted to the safety authority providing sufficient confidence in the safe operation of the crane. This regime was adapted after a few years (after implementation of all corrective actions of the action plan) and is still presently in place: the present regime requires a periodic approval by the plant safety department of the SFP use of bridge or polar cranes and hoists, based on a periodic report documenting test results and testifying full compliance with applicable regulations and standards for SFP use.			
46	Dropping of heavy suspension structure in the unit central hall owing to breach of the rules for safe strapping	This report describes an incident involving incorrect action on the part of reactor workshop and subcontractor staff while dismantling, using a lifting crane, a heavy metal suspension structure used for hanging equipment in the central hall of Unit 4, the causes thereof and corrective actions. This incident was caused by staff failing to comply with work safety rules, in particular the requirements of labour protection standards for load handling operations using lifting equipment. As a result, the load straps of the bridge crane broke and the metal suspension structure fell into the transport corridor. Ensuring the safety of load handling operations involving heavy structures is a priority operational issue when such work is performed in the reactor workshop rooms. The immediate cause of this incident was the breaking of the bridge crane load straps. Root causes: deficiencies in the organisation and performance of work involving the dismantling and movement of heavy loads, in particular: incorrect strapping of a suspension structure which was being dismantled; use of untested and unregistered load straps, deficiencies in personnel training, inadequate pre-job briefings; breach of the work authorisation system, performance of work without work plans, failure to take measures to ensure work safety. This incident had no actual impact on plant safety and caused no harm to personnel in central hall 4.	Other loads	Slings/wire/ rope/chain breakdown	Inadequate rigging
47	Findings on the guiding pulley's support of the reactor building crane	During an unloaded operation of the reactor building crane 4 screws were torn. The screws (15 in total) are used to fixate the guiding pulley's support to the bridge's support. The cause of the event could be led back to a fatigue fracture of the screws.	No load	Crane or lifting devices structural failure	Wear, fatigue, ageing
48	Malfunction of the gripper on the auxiliary lifting mechanism of fuel element changer	After the refurbishment of the fuel element changing machine during an acceptance test procedure the existing auxiliary lifting gear has been used for the first time for the transport of used fuel channel in the fuel pool. When switching from the auxiliary lifting gear to the main lifting gear by means of the selector switch, the gripper of the auxiliary lifting gear opened and gave the attached fuel channel free. The fuel element slid onto a protective plate of the stripping machine and then remained next to it on a support at the bottom of the fuel pool. Two exchanged air hoses could be identified as the cause of the opening of the gripper. The auxiliary lifting gear was not affected mechanically by the restoration work. But the controlling had been modified with identical functions. The air hoses	Nuclear fuel	Lifting interface failure	Other, unknown, unspecified

ID	Title	Abstract	Load	Failure Mode	Cause
		for the controlling of the fuel channel gripper had been newly connected. Both the auxiliary lifting mechanism including controlling as well as the grippers had been checked before for their correct function. Nevertheless the 2 exchanged air hoses at the interface could not be recognised. The error was only detected at the integral test of the entire system.			
49	Fall of a 400 l drum with middle-active waste	During the unloading at a national nuclear waste storage facility of a container with several drums of conditioned middle-active waste, which originated from an NPP, a 400 l drum fell from the gripper of the crane. The consequence of the fall (of around 4 m), was a 2 mm opening of the lid of the drum, along 40 cm of its perimeter. A limited amount of concrete powder escaped from the drum. A beta-contamination of 30 Bq/cm^2 was measured on the drum surface (near the lid opening area). Neither alpha-contamination on the drum nor atmospheric contamination in the room was detected. A control of the gripper was performed but no technical defect was observed. The gripper was then retuned using a new 400 l drum as reference (corresponding to the drums manipulated in the event). It was found out that during the event the gripper was still tuned with an old drum design as reference, which had a 1 cm larger diameter than the new drum design. The tuning of the gripper at the national waste storage facility had not been adapted following the small design change of the drum at the NPP. The problem with the gripper was then attributed to this anomaly. The event has been classified as INES Level 0.	Container with radiologic al waste	Lifting interface failure	Design deficiency
50	Degradation of wire rope used in fuel-handling applications – NRC information notice 2009-20	In January 2009, during the twelfth refuelling outage the licensee noted that one of the 2 redundant wire ropes in the main hoist of the refuelling machine had broken wire strands at the entry to a terminal end fitting. A refuelling operator had noted a sudden movement in the refuelling machine while hoisting a fuel assembly to near the full up position. The refuelling staff placed the fuel assembly in a safe location, inspected the refuelling machine, and identified the damaged wire rope. The licensee quarantined the damaged rope for analysis, replaced the 2 wire ropes in the main hoist, and resumed refuelling operations. The licensee conducted an evaluation of the damaged main hoist wire rope. The main hoist raises and lowers the fuel grapple mounted on the bottom of a telescoping mast. Two separate wire ropes run from the hoist drum, over equaliser sheaves, and down the inside of the mast, where they terminate at the inner mast section. The 2 wire ropes normally share the load, but the design of the hoist allows either wire rope to independently support a fully-loaded mast with substantial reserve capacity. The broken wire strands occurred at one of the terminal connections. The wire rope had a rotation-resistant construction, where the inner core strands are twisted in the opposite direction from the outer strands. The licensee had previously noted that the wire rope may be subject to side (bending) forces at the terminal fitting when the mast was stowed in the full up position for maintenance. Analysis of the damaged rope section revealed that fatigue caused the wire strands to fail. The rotation-resistant construction of the wire rope used at the plant and the presence of the end fitting made inspection of the wire rope at the damaged location particularly difficult. The licensee's corrective actions included fleet-wide inspection of wire rope in similar use and establishment of a programme to replace these wire ropes on a set frequency.	Nuclear fuel	Slings/wire/ rope/chain breakdown	Wear, fatigue, ageing
51	Degradation of wire rope used in fuel-handling applications – NRC information notice 2009-20	In October 2007, during a refuelling outage at unit 1, the licensee noted that a stainless steel wire rope failed completely (all wire strands broken) on the fuel building up-ender. At the time of failure, a new fuel assembly was in the up-ender. When the supporting wire rope failed, the up-ender pivoted from a slightly inclined position to a fully horizontal position. The fuel building up-ender consists of a stainless steel frame that supports one fuel assembly at a time. The frame pivots from vertical to horizontal positions around a pin support on one end of the frame. To raise and lower the up-ender, operators use an electric winch connected by a wire rope through a series of 3 sheaves to the up-ender frame; thus, within a short distance, a section of the wire rope undergoes bending cycles in 3 different directions during each movement of the up-ender. The licensee determined that fatigue caused the wire rope to fail completely. The failure occurred between 2 offsetting	Nuclear fuel	Slings/wire/ rope/chain breakdown	Wear, fatigue, ageing

ID	Title	Abstract	Load	Failure Mode	Cause
		sheaves, when the wire rope was near its peak loading. The licensee found the wire rope had been in service for 24 years, and the failure occurred in a section of the wire rope that, because of interference from the sheaves, may not have received a complete underwater visual inspection. Since the failure was limited to the wire rope, the licensee replaced the failed rope and resumed refuelling operations but did not load the new fuel assembly into the reactor core. Other corrective actions included establishing new repetitive preventive-maintenance tasks to perform fuel transfer equipment cable and sheave inspections at both plant units.			
52	Degradation of wire rope used in fuel-handling applications – NRC information notice 2009-20	On 4 October 2007, while making preparations for dry run activities related to dry cask storage at the site, the licensee identified the degradation of one of the main hoist cables for the overhead crane in the reactor building. The degradation involved the partial untwisting of the wire rope strands within the stationary section of one wire rope. The reactor building has a single failure proof (SFP) crane with 2 independent wire ropes. Each wire rope is capable of safely handling the rated 125 tonnes (113 metric tonne) load. Each wire rope has one end clamped to the hoist drum, unspools from the drum to the first load block sheave, passes several times between the load block sheaves and the upper sheaves attached to the trolley, and travels from the final load block sheave to a terminal end fitting attached to the trolley. The wire rope is stationary (i.e. neither bends around sheaves nor moves with respect to the trolley) at the end between the highest position of the load block and the terminal end fitting. The crane was fitted with 2 right regular lay wire ropes. One of the wire ropes was installed slightly untwisted to reduce the tendency of the load block to twist. The action of the sheaves as the load block was lowered and raised concentrated the uneven twist in the stationary section of wire rope, causing the strands to untwist in this area. The licensee evaluated the physical condition of the wire rope, using the guidelines of the 1976 version of American Society of Mechanical Engineers Safety Standard B30.2, "Overhead and Gantry Cranes (Top Running Bridge, Single or Multiple Girder, Top Running Trolley Hoist)" ,which the licensee had committed to follow. Consistent with those guidelines, the licensee and the crane vendor determined that, although the wire rope was somewhat distorted, it retained sufficient strength to support continued operation. However, the licensee implemented an enhanced inspection schedule to monitor the condition of the wire rope until the distorted rope could be replaced. The licensee subsequently replaced the wire ropes.	Container with radiologic al waste	Slings/wire/ rope/chain breakdown	Wear, fatigue, ageing
53	Deformation of fuel gripper of refuelling machine	At unit-1 the Nuclear Power Station, which was operating at a rated thermal output, the fuel gripper of refuelling machine came into contact with the handrail of a spent fuel pool and became deformed. This occurred on November 17 while the refuelling machine was being moved from the spent fuel pool to above the reactor core for inspection prior to the 27th periodic inspection. Subsequent inspections found that the refuelling machine was unable to function as required, and the licensee determined on November 21 that this incident should be reported as an event pursuant to Article 62.3 of the Law for the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors. There is no influence of radioactive material on the environment. 1. Investigation results Investigations revealed the followings: • The check of the refuelling machine had been conducted prior to the 27th periodic inspection. • Although the work management procedures at the Nuclear Power Station required assigning an observer during the removal of the handrail, the work manual for the refuelling machine inspection included no procedure for checking the handrail. • An inspection of the deformed refuelling machine found deformations in the guide roller frames for the first and fourth	No load	Collision during handling	Human error

ID	Title	Abstract	Load	Failure Mode	Cause
		expansion pipes as well as in the fuel gripper shaft. 2. Estimated cause When moving the refuelling machine, the operator failed to check the surrounding area, consequently letting the machine come into contact with the handrail and become deformed. 3. Countermeasures (i) The deformed refuelling machine will be repaired by replacing the guide roller frames with new ones and replacing the shaft with an equivalent fuel gripper component removed from Unit 2, which has the same specifications as Unit 1. After removal of the component, a new replacement will later be installed in Unit 2. (ii) The work manual will be revised to add a procedure for checking the surrounding situation including the removal and reinstallation of the handrail, the need to review the surrounding situation during a pre-work meeting, and the need to assign a dedicated observer. Re-education on safety requirements will also be conducted. (iii) The programme for operations with the interlock for the refuelling machine released will be modified so that the machine automatically makes a stop before it reaches the fuel pool gate. This will give the operator an opportunity to check the handrail and the overall situation in the surrounding area.			
54	Dropping of a load during the unloading of an unloaded MOSAIK-shuttle cask	As part of the unloading of an unloaded MOSAIK-shuttle cask the cask's shock adsorbing top should be relocated. Therefore a special crane was used. The cask's shock adsorbing top was hoisted and dropped about 5 m. Two guide rods of the shuttle cask and a 200 l barrel which was filled with radioactive waste were damaged. The dropping of the cask was caused by the tearing of the lifting cable. The damages of the cable could be traced back to former transport processes where the cable chafed the guiding pulley's edge.	Container with radiologic al waste	Slings/wire/ rope/chain breakdown	Other, unknown, unspecified
55	Crane malfunction while manipulating with a spent nuclear fuel cask	The crane in the reactor hall blocked during manipulation with a loaded spent nuclear fuel cask. The cask (SKODA VPVR/M type, 12.5t in weight) was hanging 8 m above the floor. After a restart of the crane's control system the loaded cask was safely lowered to its designated place on the reactor hall floor.	Container with radiologic al waste	Crane controls/ protections failures	Other, unknown, unspecified
56	Bolt's fracture of a holding brake's caliper	During an unloaded operation of the crane a bolt of a holding brake's caliper was fractured. This led to a partial failure of the crane's holding brake. Also damage to other components of the caliper could be observed. The cause of the event could be led back to a fatigue fracture of the screws. The fatigue fractures were caused by a modification of the caliper's housing.	No load	Hoist emergency brakes failure	Other, unknown, unspecified
57	Failure of a mobile hoist	For inspection of a filter vessel in the reactor water clean-up system (TC), a mobile hoist available in the plant, was used to lift and move 2 concrete slabs. After lifting the first slab into the upper transport position, the trolley of the hoist slipped out of the crane runway and dropped down about 5 m including the attached concrete slab. The on-site inspection showed that during dropping of the load, damages occurred on components, holding devices and platform support structures. The integrity of the affected pipes had not been impaired. There were further minor external damages to the surface of the biological shield. Besides the deformation of the affected components, the event did not lead to any safety-relevant consequences. The operator stated that the cause for the dropping was an unfavourable combination of different influencing factors and assembly faults.	Other loads	Crane or lifting devices structural failure	Other, unknown, unspecified

ID	Title	Abstract	Load	Failure Mode	Cause
58	New fuel assembly dropping into the shipping cask in the course of refuelling operations	The unit was in the state of refuelling outage. While removing the new fuel assembly from the shipping cask to perform acceptance test the gripper of the lifting mechanism got detached from the fuel assembly followed by fuel assembly dropping into the shipping cask from the height of about 500 mm. Direct cause of the event: incorrect conduct of the technological operation to engage the gripper with the fuel assembly (personnel failed to visually confirm the correct position of the gripper's latch). Root cause: operational documentation deficiency: the procedure lacks description of the process of checking the reliability of gripper engagement with the fuel assembly. Event contributors: the polyethylene hood, in which the fuel assembly was packed, obstructed the viewing of the fuel assembly head during its engagement with the gripper; inadequate illumination of the working zone. The corrective actions taken were aimed at: making amendments to the instructions as regards the development of a procedure to check the reliability of fuel assembly engagement with the gripper by 2 supervising persons followed by appropriate record made in the operating log; assessing the instructions concerning nuclear fuel transportation to confirm the existence of requirements for the operation-by-operation monitoring capability; introducing a requirement to remove the upper portion of the fuel assembly’s packing hood prior to its engagement with the gripper; bringing the illumination of units 3 & 4 new fuel facility rooms in line with the requirements of the existing regulatory documents; giving additional briefings to plant personnel involved in nuclear fuel transport activities based on event investigation results.	Nuclear fuel	Lifting interface failure	Inadequate monitoring or co-ordination
59	Closing gate damage of the spent fuel interim storage pumping station	On the 2nd of March 2009 a maintenance-man of NPP units 1 and 2 noticed that the closing gate (500 kg) of the spent fuel interim storage sea water pumping station had shifted from its storage position and it was found lying on the ground. Some damages were found also on the corner of the pumping station. Incident had been happened between the previous checking round done on 26/02/2009 and on the date of observation (02/03/2009). No high wind was measured during this period of time. The control room staff had visited the station on 28/02 and 01/03 and found out the gate being still standing by the wall. The maintenance-man recorded the near miss into the corrective actions database (KELPO) of the operating plant units. As analysing the incident it was considered that the gate and the building were hit by the near-by crane (C8) of Unit 3 construction site during lifting a load.	Other loads	Collision during handling	Other, unknown, unspecified
60	Fall of a fuel element assembly during handling operation with long handling tool	An inspection campaign was organised of spent fuel elements, situated in the spent fuel pool of the nuclear auxiliary building, in order to investigate possible corrosion on the head of the fuel elements. The handling of the fuel elements for this operation was exceptionally carried out with a long handling tool (LHT) suspended to 5 Tm single failure proof (SFP) bridge crane hoist. The fuel-handling machine, which is normally used to move fuel elements in the spent fuel pool, could not be used for this operation because it cannot reach the fuel element inspection position in the pool. The fuel elements had to be lifted from the spent fuel rack one by one, transported to an inspection position and after the inspection moved back to their original position in the rack. The gripper of the LHT is operated with a compressed air drive system which latches the gripper in the required position and the closed position of the gripper is subsequently mechanically secured with a locking pin. During the operation of putting the fuel element back in its rack position after its inspection, the fuel element detached from the gripper of the LHT and fell from a height of 1 m to the bottom of the rack. The fuel element fell due to the inadvertent opening of the gripper of the LHT. This occurred due to a combination of a violation by the operators of the LHT operating procedure and of a previously committed error when operating the LHT gripper compressed air drive system during a training session. Although the LHT operating procedure provided no instructions for disconnecting and reconnecting the compressed air system to the LHT during the fuel element manipulation, the flexible tubes of the system were disconnected	Nuclear fuel	Lifting interface failure	Human error

ID	Title	Abstract	Load	Failure Mode	Cause
		from the LHT during the inspection campaign (after mechanically securing the gripper position with the locking pin), in order to facilitate a rotation of the fuel element during the inspection activities. In addition, when lowering the fuel element into its rack position, the operators removed the locking pin on the gripper (and subsequently reconnected the flexible tubes of the compressed air drive system to the LHT) before the fuel element was fully positioned on the bottom of the rack. According to the LHT operating procedure the fuel element should be completely deposited in its appointed location, before the locking pin on the gripper is removed. A practice was tolerated of removing the locking pin from the gripper at 1 m above the bottom position, because this operation on the LHT was easier to execute in this position (when the fuel element is in its bottom position the locking pin is situated beneath the walking platform above the pool and is therefore more difficult to reach). Although this practice was a clear violation of the procedure, it did not result in an immediate danger as long as the gripper is correctly latched in closed position by the compressed air drive system. Reconnecting the compressed air drive system to the LHT in this sequence of operations does not normally lead to an immediate opening of the gripper. However during a demonstration of the operating procedure of the LHT compressed air driving unit (being disconnected from the LHT) to an operator as part of his on-the-job-training, when the fuel element with the LHT attached was still in its inspection position, an error was made which resulted in a wrong position of a 5-way valve of the gripper compressed air drive system. This wrong valve position led to the inadvertent opening of the gripper when the flexible tubes of the compressed air drive system were reconnected to the LHT. Corrective actions taken after this event include improvement of the design of the long handling tools operating procedures (turning them into step by step procedures), obligatory use of these procedures, conducting a risk analysis prior to the use of long handling tools, additional training of fuel operators on application of human performance tools and on use of the long handlings tools. There were no actual consequences of this event (no impact on fuel element integrity) but an issue of safety culture was clearly observed. The event has therefore classified as INES Level 1.			
61	Dropping out of a self powered neutron detector from transport container in the reactor hall during refuelling outage	Unit 4 was on refuelling outage on 04/05/2009. According to a working programme an self powered neutron detector (SPND) was removed from the Protecting Tube System (VCSB) in pit N2 and transported from that pit into the high activity radioactive waste storage pit in the reactor hall. During transfer activities, the wire rope holding the grab broke inside the tubular transporting container including and bioshielding the SPND. The detector and its grab fell down onto the working area covered with protective cling film through the transfer path. As a result of the falling, the 4 m long SPND tube became bent and tilted onto the decontamination bath of control rod drivers. No damage of other equipment occurred. The event resulted in increased radiation in the reactor hall. After having the results of the radioactivity measurements all activities in the reactor hall and the surrounding premises were suspended, personnel were evacuated and the reactor hall was reclassified to non-accessible area. The workers in the reactor hall were not exposed to radiation over the daily screening level. The dose rate measured at 1 metre from the SPND tube reached 420 mSv/h. The area was secured, i.e. cordoned off and warning signs were posted. After the event a special maintenance meeting was summoned and the steps of emergency operation were determined. In the afternoon on 05/05/2009 the damaged detector was safely moved from the reactor hall floor to the pit number 1 of unit 3 (the adjacent reactor), the radiation protection restrictions were lifted and all outage works were continued on Unit 4.	RPV head or internals	Slings/wire/ rope/chain breakdown	Other, unknown, unspecified
62	Accident at work during the transportation of loads	The transport of a shielded measurement chamber took place. The chamber was hoisted and tripped. Due to this a worker got slightly hurt. The position of the attachment riggings was chosen without consideration of the centre of mass and thus the influence of the lead shielding. The event was caused by an operational error.	Other loads	Lifting interface failure	Inadequate rigging

ID	Title	Abstract	Load	Failure Mode	Cause
63	Failed activation of a 5 Mg-hoist's overload protection device	The hoist's overload protection device was tested. The activation of the protection device failed. The failed activation was caused by a defect of a load measurement device's analysis unit. The manufacturer assumed that relays contacts were damaged.	No load	Crane controls/ protections failures	Other, unknown, unspecified
64	Spent fuel assembly (SFA) dropping from the transport device into the shipping cask of the railway container car due to cable break	While the reactor was in the scheduled maintenance outage efforts were in progress to load spent fuel assemblies (SFAs) into the container car cask for further transportation to the spent nuclear fuel storage facility. In the course of next spent FA loading into the cask the handled FA stopped at the cask inlet followed by reduced force on the Transport & Loading Device (TLD) cable. TLD gripper's motor was not tripped by the TLD cable reduced force protection and continued to unwind the cable. Personnel involved in spent FA loading into the container car failed to notice TLD malfunction and did not trip the motor. As a result, the affected spent FA slipped off the location of its stop, TLD cable ruptured and the spent FA dropped from the height of 4 metres into the container car cask. The loading efforts were interrupted. The event had no radiological consequences. The cask was placed in the spent fuel pool and closed with the standard gripper-plug. Direct causes of the event: 1) lack of smooth transition between the docking nozzle (145 mm diameter) and container cask tube (89 mm diameter); 2) drift of strip chart recorder indications and failure to reach the setpoint of the TLD motor protection actuation due to the loosening of the screw which transfers the force to the strip chart recorder's sensor of the Force Monitoring System (FMS); 3) personnel failure to monitor TLD performance in the course of fuel-handling operations. Root causes: 1) design deficiency of the TLD-16-seat cask docking unit; 2) TLD design documentation had no criteria for tightening the nuts that fix the adjusting screw while tuning FMS sensors; poor performance of TLD alarms and protection system; 3) deficiency in personnel training to perform fuel-handling operations involving TLD use. The corrective actions taken were aimed at: TLD upgrading; providing remote surveillance over TLD operation by installing the monitors in the TLD control room; making amendments to TLD operating procedure; arranging extra exams for Reactor Service personnel to check their knowledge of fuel-handling operations organisation and conduct.	Nuclear fuel	Other	Inadequate monitoring or co-ordination
65	Spent fuel sub-bundle dropping from 50 cm onto other spent fuel racks in the fuel pool	During a refuelling outage, a spent fuel element (a sub-bundle) dropped from a height of 50 cm, from a lifting device, falling on the fuel preparation machine's platform, located at the spent fuel pool in the fuel building. The fuel, once the bottom side hit the platform, fell on its side and ended up almost horizontally over the fuel preparation machine's platform and the top of the spent fuel racks. The regulatory body sent an inspection team to supervise the retrieval process, which took 2 days to be completed. The event was classified as Level 1 in the INES.	Nuclear fuel	Lifting interface failure	Other, unknown, unspecified
66	Fracture of a hoisting device's drive stem	A fuel element should have been lowered to the set down pool's storage rack. During the last phase of the positioning a hoisting device with a drive stem is used to manually lower the fuel element. This manually operated drive stem broke as the fuel element was lowered. The fuel element was stopped only few centimetres above its set position. The drive stem broke due to fatigue failure. The event was caused by design errors and deviations due to the manufacturing process of the spindle drive.	Nuclear fuel	Crane or lifting devices structural failure	Design deficiency
67	Deviation in overload protection of reactor building polar crane	The polar crane of the reactor building of this NPP is supplied with AC and equipped with AC motors to allow circular movement of the crane and lateral movement of the main hoist. It is also equipped with an AC/DC converter providing DC power supply to the main hoist motor of the crane. The main hoist is used to lift the reactor pressure vessel lid and the upper internal parts of the reactor vessel. The polar crane was equipped with 2 independent and diverse protection devices against overloading of the hoist chain of the crane. The first one was a load cell in the hoist chain with a set point corresponding with 110% of the rated capacity of the hoist motor. The second one was an over-current protection on the alternating current electric power supply to the polar crane by means of a magnetic switch, which according to the design calculations of the	No load	Crane controls/ protections failures	Design deficiency & Human error

ID	Title	Abstract	Load	Failure Mode	Cause
		hoist chain should have a nominal set point of maximum 165 Amp AC corresponding with 175% of the rated capacity of the DC hoist motor (in accordance with RG 1.104). In fact, the original design of the polar crane did not provide in a specific over-current protection on the DC power supply to the hoist motor and the over-current protection was common with the AC power supplied to the motor for the swinging operation of the crane. It should also be noted that the polar crane and its hoist chain was initially not designed as single failure proof (SFP) and that safety factors in the design of the hoist chain, with an overload protection set at 175% of rated capacity of the DC hoist motor, did therefore not fully comply with RG 1.104. During an independent quality control of the test reports of the polar crane in preparation of the outage in 2010 it was noticed that the set point of the over-current protection of the crane was in reality set at a higher value of 192 Amp AC, which corresponded with 202% of the rated capacity of the hoist motor. This means that the over-current protection of the polar crane would not have been a valid back-up of the load cell protection on the hoist chain in compliance with applied standards. If the polar crane would have worked with an AC current higher than 165 Amp during a lifting operation with the hoist (e.g. in case the load is blocked in its movement), it was proven that certain components of the hoist chain would deform plastically. This deviation from the nominal set point value for this protection was already noticed when applying the test procedure of the crane during the plant outages of 2008 and 2009, but it was not properly managed (even though the deviations were reported in the test reports). Both in 2008 and 2009 the set point value was first changed to 165 Amp AC as required by the procedure and then changed back to 192 Amp, being the “as found” value. The reason for this action was that at the nominal set point of 165 Amp, as mentioned in the procedure, the power supply to the crane tripped during swinging operations of the polar crane. A non-conformity report was established with additional compensating measures (permanent control of DC motor current, temporary lowering of the trip set point of the magnetic switch during SFP operations of the hoist and additional verification of safety factors of the hoist chain) in order to allow the planned lifting operations during the 2010 outage to proceed. Corrective actions implemented after this event include a design modification of the polar crane (installation of a specific electromagnetic over-current relay on the DC power supply to the hoist motor set at 120% of its rated capacity), improving the documentation of the protections of the polar crane in the FSAR and inclusion of witness and hold points in the commissioning procedure of the crane applied at the start of each plant outage. This event was categorised as INES Level 1.			
68	Operation of flask crane beyond maximum number of cycles assumed in safety case	Safety cases for the pile cap cranes, flask cranes and charge machine gantries are due to expire at the end of 2011. During work being carried out to extend these safety cases, it was discovered that the gears fitted to Reactor 1 flask crane had been used to despatch 595 flasks, exceeding the 465 despatches assumed in the original safety case by 28%. An immediate embargo was placed on use of Reactor 1 flask crane while the position was reviewed. The corresponding number for Reactor 2 flask crane was checked and found to be 403 operations – i.e. within the number assumed in the safety case. However, at the current defuelling rate, it was recognised that there could be more than 465 operations before the end of 2011, prompting a need to prepare a safety case for continued operation of Reactor 2 flask crane to the end of 2011.	Container with radiologic al waste	Unauthorised crane operations	Other, unknown, unspecified
69	Transfer of heavy loads over the spent fuel pool exceeding the weight allowed by the technical specification	On 21 January 2011, both units of the NPP notified that they had been operating under condition prohibited by technical specification (TS) on moving gates over the spent fuel pool (SFP) whose weight exceeded the limit (1 000 kg) established by the limiting condition for operation (LCO). It was also notified that the associated surveillance requirement (SR) had not been fulfilled either. Both units are three-loop Westinghouse PWRs. When the event took place, both units were operating at full power. The TS	Other loads	Unauthorised crane operations	Other, unknown, unspecified

ID	Title	Abstract	Load	Failure Mode	Cause
		non-fulfilment was first discovered in Unit 1. The event was classified as Level 1 according to INES.			
70	Failure of an interim storage device's locking mechanism	An interim storage device is used for the storage of damaged fuel rods. These de-vices are merged in fuel rod quivers and collected in the fuel pool. During the relocation of 4 interim storage devices into another fuel rod quiver, the sealing plug of one interim storage device became loose. The plug remained in the gripper. The affected interim storage device sunk to its former position. The event was caused by a manufacturing deviation concerning the locking mechanism. This led to incomplete locking of the sealing plug.	Nuclear fuel	Lifting interface failure	Design deficiency
71	Failure of transportation fixture due to a short circuit caused by mechanical damage of the cable train	The unit was operating at 1 000 MWe power. Efforts were in progress to load the spent fuel assemblies from Spent Fuel Pool 2 (SFP-2) into the eight-piece shipping cask of the railway container car. When installing the fifth fuel assembly in the shipping cask socket and while lowering the transportation fixture's gripper to the extreme bottom position a short circuit occurred followed by loss of power to the transportation fixture's control panel. Spent fuel assembly (SFA) loading operations were interrupted. Equipment examination revealed the tripped automatic breaker feeding power to control and alarm circuits of gripper movement, to the ball-type crane and gripper force metre, as well as rupture of the rubber sheath of one of the cables plus loss of insulation integrity of 2 wires. SFA dropping or damage did not occur. Direct cause of the event: short circuit due to mechanical damage to insulation of the cable train wires as a result of cable train hooking the fuel channel pit enclosure. Root causes: 1) transportation fixture's operating procedure deficiencies – absence of requirements to monitor cable train movements while transportation fixture handling by operations personnel; 2) design deficiencies – fuel channel pit enclosure's design documentation lacks requirements for installing protective means to prevent cuts/ruptures of the cable train that moves in the enclosure zone. The corrective actions taken were aimed at: making modifications to the fuel channel pit metal enclosure to preclude cable train damage; developing and implementing a project for cable train interim attachment to preclude its hooking the fuel channel pit enclosure during transportation fixture movement; performing human monitoring of cable train movements in the course of fuel-handling operations; discussing event investigation materials with Reactor Service personnel responsible for fuel-handling equipment operation.	Nuclear fuel	Other	Other, unknown, unspecified
72	Polar crane brackets - welding defects	Existence of unresolved manufacturing non-conformities in welds of the polar crane brackets as they were being installed in the European Pressurised water Reactor (EPR) reactor building under construction. These defects were detected during the painting phase of the brackets (detection of surface defects after shot-blasting) after installation of the brackets on the inner wall of the reactor building. These defects were cracks in welds and have been detected by the contractor in charge of painting operation. These surface defects were repaired by the manufacturer before the polar crane was installed at the top of the reactor building.	No load	Crane or lifting devices structural failure	Other, unknown, unspecified
73		While carrying out the transfer of the lower half reception tube from the pond equipment maintenance room to the reception tube position in the pond (2B), it was found that when using the north auxiliary hoist which is attached to the pond crane, the brake on the hoist was slipping every time a creep command was given.	Other loads	Hoist emergency brakes failure	Other, unknown, unspecified

ID	Title	Abstract	Load	Failure Mode	Cause
74		At 11:45 on Friday 6 April a 1.3 tonne pile cap vertical shield slab was being re-fitted to 2D2 area when the eye bolt detached from the lifting point causing the slab to fall approx. 10 mm. The slab had been lifted out using the same eye bolt 3 days previous with no issues. The bolt thread sheared with the slab within 10mm of its final position. The slab was almost in its final position and partially fitted on 1 bolt. The operative responsible for fixing the final positioning bolts had requested the crane driver to lift the load slightly to align the bolt and the bolt hole. When lifting the load using the crane the eyebolt became detached causing the slab to drop 10mm to the final position. Persons involved include the licensee Operations pile cap lifting crew, contract partner rigger and contract partner mechanical technicians. The lifting equipment in use was the pile cap crane, 5 tonne nylon strop, 3 tonne shackle and a 7/8 BSW eyebolt. Initial investigations are that the eyebolt was not the correct size and a 1 BSW eyebolt should have been used.	Other loads	Lifting interface failure	Other, unknown, unspecified
75	Error while using polar crane during the handling of the reactor vessel head	The 06/06/2012, when the direct installation of the reactor vessel head (status change to maintenance shutdown, primary non-open enough), an error to use the polar crane led to carry out a manoeuvre of translation instead of the manoeuvre of lowering requested by the supervisor of the manoeuvre. The difference in translation estimated at 1,5 m at the trolley of the bridge led the cover vessel to slightly tilt and bring it into contact with the 2 guide pins. <u>Immediate corrective action</u>: Return to the cover stand to carry out inspection and diagnosis operations. <u>Origin</u>: The crane operator carried out a translation instead of a descent until the trip of the crane. Hand written signs are present around the 205 tonnes hook control lever. The crane operator used for the first time the 205 tonnes hook of the polar crane. The crane operator remained more than one hour without activity in his cabin, and the configuration of the players in handling does not allow seeing the movement of the trolley instead of the lowering of the hook.	RPV head or internals	Collision during handling	Other, unknown, unspecified
76	Damage to reactor building overhead crane travelling section	1. <u>Outline of event</u> Nuclear Power Station Unit 1 had been in shut down condition for its periodic inspection (Unit 1 was in its 20th periodic inspection, which was begun on 10 September 2011, after it was automatically shut down on 11 March 2011 as a result of the Tohoku-Pacific Ocean Earthquake). On 12 September 2011, when a reactor building overhead crane on the 5th floor of the nuclear reactor building was operated as part of its travel check, unusual noise was heard. A detailed inspection of the internals of the relevant travelling section was conducted. As a result, on 7 June 2012, it was found that an internal bearing (consisting of inner and outer rings and rollers) had been damaged. 2. <u>Results of cause investigation</u> The relevant crane was overhauled. It was found that the bearing inside the travelling section had been damaged and, in particular, guards which were affected with only horizontal load suffered severe damage. Metallurgical investigation for the damaged bearing inside the travelling section including the guards was implemented. As a result, a dimple pattern that is typical of a ductile fracture was observed across the fracture surface of the bearing. With regard to the effects of a horizontal earthquake load on the bearing, as a result of analysis, the horizontal load was found to exceed the required design seismic force and the fracture strength of the bearing guards. With regard to the effects of a vertical earthquake load on the bearing, as a result of analysis, the vertical load was found to be well below the load that would cause the fracture of the bearing. 3. <u>Estimated causes</u> The bearing of the relevant crane consists of a combination of a 3-row bearing and a 2-row bearing. Structurally, the	No load	Crane or lifting devices structural failure	Other, unknown, unspecified

ID	Title	Abstract	Load	Failure Mode	Cause
		horizontal seismic load was not imposed on the 3-row bearing; therefore, the load concentrated on the guards of the 2-row bearing, resulting in damage to the relevant part. It is assumed that the unusual noise noted during the travel check of the relevant crane resulted from the defective rotation of the bearing because fragments of the damaged bearing guard intruded into the bearing. 4. Countermeasure Regarding the bearings of the relevant crane, its structure was modified to disperse any horizontal load so that any load can be received by the individual guards on the 3-row bearings and the 2-row bearings.			
77		During the importing of a full stillage to the Import/Export cave, the crane was commanded south to place the stillage above the cave's primary stand. Instead it started to lower off at a faster than normal raising or lowering speed.	Container with radiologic al waste	Crane controls/ protections failures	Other, unknown, unspecified
78	Damage of a control fuel element's handling tool	An element upper tie plate got stuck behind a guiding plate during the hoisting of the control element. This was not noticed by the crane operator. Therefore the further hoisting of the control element led to a deformation of the handling tool. The event was caused by an operational error.	Nuclear fuel	Collision during handling	Human error
79		At approx. 23:15hrs on 2 October as part of the lifting operations for the re-build of Main Cooling Water (CW) Pump No. 3 the crane hook collided with the CW pump house crane steel frame. While carrying out lifting operations for the re-build of Main CW Pump No. 3 in the Main CW pump house the crane hook collided with the CW pump house crane steel frame due to the lift button being selected rather than the lower button. As the crane lift hook was already close to the upper limit of its travel this resulted in the hook colliding with the steel frame and jolting the cable reel which in turn resulted in the cable on the cable reel becoming loose making the crane inoperable. Administration controls were in place due to the unavailability of the top limit switch on the crane following failure of this switch on 27 September. The switch could not be immediately repaired due to obsolete components. At the time of the incident the CW pump 3 oil cooler was suspended from the crane hook in the loading bay approx. 6ft above ground level. No injury to persons involved occurred.	No load	Collision during handling	Inadequate monitoring or co-ordination
80		Flask E107 was being moved from the Flask Inspection Stand to the Pond Hall Area by the Flask Handling Crane. During the flask transfer, a series of loud bangs was heard by the crane operator. The crane was stopped and a visual inspection made of the rails and moving components for signs of an obstruction or damage. No damage or obstruction was visible and the crane was operated again. After a few seconds the same series of loud bangs was heard again and the emergency stop button was pressed. Following consultation with the duty Fuelling Technical Support Engineer and Fuel Route Engineering Group, a decision was taken to suspend flask movements and leave the flask suspended until further investigation could commence.	Container with radiologic al waste	Other	Other, unknown, unspecified
81	Dropping of the fuel bundle-containing flask in the spent fuel grippers due to personnel errors	In the shielded cell of the spent fuel assembly (SFA) dismantling shop of the NPP spent fuel storage and handling facility 2 operators in the night shift were simultaneously loading fuel bundle-containing flasks into the metal-concrete container using MK-1,2 and MK-3,4 console manipulators in the Technological Chains TC-1 and TC-2. At TC-2 while moving MK-3 manipulator in automatic mode an interlock of manipulator stoppage actuated. The operator, without identifying the cause of MK-3 manipulator platform stoppage, with no agreement with the second operator and having no permission from the Shift Supervisor decided to move MK-3 manipulator by engaging it with the operable MK-4 manipulator. On completing this engaged movement of MK-4 and MK-3 manipulators the operator failed to notice that MK-4 manipulator's gripper Z2 rose above the extreme top position with deflection from the vertical axis and thus obstructing the movement of MK-1 manipulator of TC-1 technological chain. MK-1 manipulator's gripper Z1 moved onto the deflected MK-4 manipulator's	Nuclear fuel	Other	Other, unknown, unspecified

ID	Title	Abstract	Load	Failure Mode	Cause
		gripper Z2 and got engaged with it. MK-1 manipulator platform movement stopped due to actuation of the interlock on hi-hi force on gripper Z1 of MK-1 manipulator. TC-1 operator via the inspection window visually checked the arrangement of the flasks in the shielded cell, found no obstacles on the way of flask movement and continued moving MK-1 manipulator. Gripper Z1 of MK-1 manipulator got disengaged from the flask and the latter dropped into the cell of the solid radwaste can with a slight damage that did not result in the loss of fuel rod leak-tightness and release of radioactive aerosols. The works to extract the dropped flask and place it in the metal-concrete container were continued under a special programme. Direct causes of the event: 1) fracture of the bearing in the drive wheel of MK-3 manipulator platform; 2) TC-2 operator was performing the operations that were not envisaged by the work programme and by the check list. Root causes: 1) failure to inspect the bearings of MK manipulator platforms; 2) poor operator training. The corrective actions taken: improve MK manipulators maintenance practice, enhance spent fuel storage facility operator training and upgrade storage facility equipment in the frame of its pilot operation.			
82		On the 8 March 2013 during planned maintenance of 2B2 TV penetration the Thermal Plug Grab was being lifted by a chain block attached by a sling to the pile cap crane. During this operation the load dropped approximately 2 metres into the boiler closure unit. No injuries were sustained.	Other loads	Lifting interface failure	Other, unknown, unspecified
83	Event review: Arkansas Nuclear One heavy lift equipment collapse (operating experience note 007)	This report summarises an event that occurred during a Unit 1 refuelling outage at the Arkansas Nuclear One site in March 2013. During a lift of the Unit 1 main generator stator, the heavy equipment lifting mechanism collapsed killing one worker and injuring several others. The collapse resulted in extensive damage in the turbine building and electrical equipment, internal flooding by fire fighting water and an automatic trip of Unit 2. The cause was determined to be an inadequate design of the lifting mechanism which resulted in the buckling of a structural member. The root cause was determined to be associated with inadequate control of contractor and subcontractor activities. The NRC responded to the event with several inspections and enforcement action.	Other loads	Crane or lifting devices structural failure	Design deficiency
84	Dropping of the spent fuel assembly (SFA) cask during fuel-handling activities in the spent nuclear fuel storage facility	An effort was in progress to transfer spent fuel casks to the protective chamber in the Disassembly Cell of the Spent Nuclear Fuel (SNF) Storage/Handling Division. After a spent fuel cask was installed into the refuelling fixture (RF), a hooker disconnected a double branch sling from the spent fuel cask and placed the hooks onto the RF head. A crane operator then activated a crane hook lifting mechanism without waiting for the hooker's command or sound signal indicating the beginning of the lifting operation. The crane's lanyard hook caught a protruding RF handle on the RF upper head. The RF tilted with the spent fuel cask popping out of the RF slot and falling down into the refuelling pool. No changes were observed in the air-borne activity in the SNF Storage/Handling Division or water activity in the spent fuel / refuelling pools. Fuel-handling operations were terminated. The fallen cask was then lifted from the refuelling pool and installed in spent fuel pool No. 1 as per specially developed programme. Direct causes: 1) A crane operator proceeding to lift a sling disconnected from the spent fuel cask without proper authorisation; 2) a lanyard hook getting engaged with a protruding RF handle on the RF head during an unauthorised crane sling lifting operation. Root causes: 1) Deficient initial and ongoing fuel route operator training; 2) a person responsible for checklist performance and safe crane operation providing inadequate supervision over spent fuel cask transfer operations; 3) an RF design does not preclude unexpected tool engagement with the RF during fuel-handling operations.	Container with radiologic al waste	Lifting interface failure	Inadequate monitoring or co-ordination

ID	Title	Abstract	Load	Failure Mode	Cause
		Corrective actions: The RF and rigging used to transport the spent fuel cask during the event were inspected; an RF operating manual was updated to specify all load lifting operations; an action will be taken to upgrade the design of spent fuel-handling rigging and equipment including a refuelling fixture to preclude parts that could cause accidental rigging engagement during fuel-handling operations; SNF Storage/Handling fuel route personnel received additional training. The event is rated as Level 0 according to the INES.			
85	Damage to one of the 2 drive shafts of the 320 tonnes trolley of polar crane while testing the load fall mode at the construction stage	On 07/09/2013: the overspeed test procedure in load fall mode of the 320 t crane is carried out without difficulty in no load operation. 16/10/2013: The overspeed test in load fall mode of the 320 t lifting crane began. The load fall device is then not set correctly for the test, which makes it possible to open the brakes too much. The first test does not allow activation of the overspeed. A reactor scram is activated. The test will be resumed. The speed of rotation increased, exceeded 1500 RPM (design value) and reached in particular the value of critical speed of the first bending mode (2 245 RPM). “The tubular shaft + couplings”. which has not been balanced in assembly operations, and the axial fastening of which is no longer satisfied as a result of a stopping disc dismantled on the motor side, becomes unstable and its bending is initiated and then magnified by the possibility of ejection by sliding the hub on the motor side. The shaft bending displacement created strength on the ends with, as a result, the extraction of coupling hub on the motor side and the tilting of the coupling in the gearbox side. The braking action which occurs in this phase or immediately afterwards will result in the ruins and the release of the tubular shaft on the motor side, and accentuates the left gearbox tilting up to the pin located at the front of the housing. The coupling at the gearbox side is cracks, the end of the tubular shaft (not screwed) released on the engine side, hits the upper part of the gearbox casing and the protection grid while the support of the brake shoe is impacted by the other end. The half-coupling, the tubular shaft and the disc fixed in its end are released and ejected while the motor slightly swivels. The load is stopped and held in position at approximately 5 m from the floor at level 19.50 m, emergency brakes closed and service brakes were manually closed. <u>Immediate corrective action selected</u>: In order to secure the position of the load, the test team has tightened both brakes of service in addition to the 2 auxiliary brakes already activated at the time of a reactor scram. The correct behaviour of the load has been checked before the worksite fallback and the work inside the reactor building containment have also been interrupted while waiting for the removal of the load. After a risk analysis established jointly by the manufacturer and the licensee, the removal of the load on the slab at level + 19.50 m was performed according to a load fall procedure adapted to the state of the kinematic chain of the 320 T trolley (one less drive shaft and on both shafts). <u>Origin</u>: The first test of the overspeed trip had been carried out with the same overspeed detection failure. Control flow limiter for the hydraulic pump of the system of load fall has not been carried out before the test, the choice of the printed cardboard which has not fulfilled its role of detection of speed threshold. The incorrect installation at the manufacture level between the drive shaft and the engine coupling. This is due to lack of control of factory subcontractor. Absence of balance of the coupling.	Test load	Crane or lifting devices structural failure	Other, unknown, unspecified

ID	Title	Abstract	Load	Failure Mode	Cause
86	Events at nuclear power plants when using lifting equipment	The plant unit was in outage for maintenance. According to the work permit, the contracted maintenance personnel had to carry out the operations on bringing the rotor out from the generator stator. During the operations on bringing the rotor out from the generator-3 stator and using the overhead-type crane, the sling rope strands were partially broken (one strand remained intact) in the area of a detachable hoister splice connection (See Figures 1 and 2), which resulted in lowering of the generator rotor, with the beyond-design-basis speed, on the aluminium pads installed in the bearing-11 housing. The lowering height did not exceed a nominal rotor-to-stator air gap, i.e. 95 mm. Direct cause – application, during the lifting operations, of a detachable hoister that did not meet the regulatory requirements. Root cause – the existing plant documentation does not provide for any procedure of monitoring of the functional inspections of the hoisters, containers and cranes, and process cards, roping and lifting maps, and of the other requirements established to be met prior to the works associated with the lifting equipment.	Other loads	Slings/wire/ rope/chain breakdown	Other, unknown, unspecified
87	Events at nuclear power plants when using lifting equipment	Damage of a protective tube bundle (PTB) and civil structures of the cooling pond on 04.07.2015 in the reactor building of unit 1 as a result of a breakdown of the strands at removing from the transport container. The unit 1 was under construction. In the reactor building being under construction an installation company carried out works with use of a polar crane, in order to remove a reactor PTB from its transport container on the cooling pond bottom at elevation +8.0 m, with further transfer to elevation +26.3 m in the central hall for the purpose of on-receipt inspection. The works were performed in accordance with a process card developed by the installation company. 08:00 – a pre-job briefing was given, and a work order was issued for 2 slingsmen to transfer PTB from the cooling pond bottom to elevation +26.3 m as per the Process Card for PTB Transportation. 08:05-11:00 – as a result of a repeated failure to couple to a connecting beam, a leader of the slingsmen team replaced steel ropes with synthetic covered round-strand ropes, and the PTB roping map was modified. 11:45 – trial lifting was done to the height of 100-150 mm from the cooling pond bottom. 12:00 – PTB was lowered on the container at the cooling pond bottom where the residual load on the crane pulling cable and the rope was 7 t. 13:25 – PTB was lifted to the height of 200 mm; the item was hung out and kept for 20 minutes; PTB lifting was started up to elevation +28.0 m. 14:00 – after PTB lifting up to elevation +28.0 m the slingsman instructed a crane operator to rotate the crane bridge clockwise. PTB started to sway and the crane operator stopped horizontal movement. Swaying disappeared but 3 strands were successively broken and PTB (weight 70 t) fell on the transport container on the cooling pond bottom. Damages to PTB would not let its further use as intended. Direct cause – destruction of the synthetic ropes due to operational loads at the rope-to-suspension element angle contact points (for 2 ropes – due to indentation and further through-cut of the synthetic sling rope strands; for one (last) sling rope – due to a high breaking stress as a consequence of PTB-mass resultant impacts upon the sling ropes) as a result of use by the installation company personnel of the roping map providing for use of the synthetic round-strand sling ropes that do not provide safe work performance. Root causes – deficiencies in organising the PTB lifting operations.	Other loads	Slings/wire/ rope/chain breakdown	Other, unknown, unspecified

ID	Title	Abstract	Load	Failure Mode	Cause
88		The Fuel team were attempting to carry a bottle stand to the far north of the pond hall when crane long travel tripped on "LT End Limit 3". The crane should have tripped on limits 1 and 2 before limit 3 was reached. Consequences: Potential if the 3rd switch had failed, the crane would collide with the mechanical end stop.	Other loads	Crane controls/ protections failures	Other, unknown, unspecified
89		Expected condition – Ponds skip crane to operate normally. As found condition – While attempting to pick up a fuel element skip a bang was heard and the empty mast appeared to drop and move sideways.	Nuclear fuel	Other	Other, unknown, unspecified
90	Crane and heavy lift issues	During an inspection at the Nuclear Power Plant, NRC inspectors reviewed a design calculation for the containment polar crane, which is classified as Seismic Category I. The licensee's updated final safety analysis report (UFSAR) specified the crane was designed such that the applied stresses would be less than or equal to the allowable stresses. The crane is designed to maintain the lifted load and structural stability during a Seismic Category I design-basis event. Instead, the licensee's calculation showed the crane trolley seismic restraints had applied stresses greater than the allowable stress for the design-basis seismic loading condition. The licensee performed a walkdown of the restraints to assess the design margin and discovered the restraints were never installed. Licensee corrective actions included installation of crane trolley seismic restraints.	No load	Crane or lifting devices structural failure	Design deficiency
91	Crane and heavy lift issues	During an inspection at the NPP, NRC inspectors reviewed a design calculation for the reactor building crane, which is classified as Seismic Category I. The licensee's UFSAR specified that the crane was designed to withstand seismic loads. The design function of the crane is to maintain the lifted load and structural stability during a Seismic Category I design-basis event. Instead, the licensee's calculation did not establish whether the crane rails, which transfer the loads from the crane to the crane support structure, could withstand the seismic loads. Licensee corrective actions included installation of additional crane rails clip restraints to ensure adequate design margin for the crane rail.	No load	Crane or lifting devices structural failure	Design deficiency
92	Crane and heavy lift issues	During an inspection at the NPP, the regulatory body inspectors reviewed a design calculation for the reactor pressure vessel (RPV) internal handling adapter to demonstrate conformance with American National Standard Institute (ANSI) N14.6-1978, Section 3.2.1, "Standard for Special Lifting Devices for Shipping Containers Weighing 10 000 pounds (4 500 kg) or More for Nuclear Materials", as referenced in the licensee's updated safety analysis report. The adapter pin had a yield strength greater than 80% of its ultimate strength, and the licensee did not address material fracture toughness. Instead of performing a brittle fracture analysis, the licensee took corrective actions to replace the pin with a material that had appropriate fracture toughness characteristics.	No load	Crane or lifting devices structural failure	Design deficiency
93	Crane and heavy lift issues	During an inspection at the NPP, the regulatory body inspectors reviewed the design calculation for the steam dryer and steam separator lifting device. The licensee's UFSAR specified the design for this lifting device was to be in accordance with ANSI N14.6-1978. The safety-related function of this lifting device was to hold the heavy load in position during transport and not drop the load onto safety-related systems or irradiated fuel. The inspectors identified that the socket lifting pin and adapter lift pin, which connect the steam dryer and steam separator to the lifting device were not designed based on their material fracture toughness properties as specified in ANSI N14.6-1978, Section 3.2.1.1. Instead, the calculation showed the socket pin and adapter pin had yield strengths greater than 80% of their ultimate strengths and the calculation did not address the design based on material fracture toughness characteristics. Licensee corrective actions included performing non-destructive examination of the socket lifting pin and adapter lift pin prior to each use to ensure an adequate factor of safety for brittle fracture.	No load	Crane or lifting devices structural failure	Design deficiency

ID	Title	Abstract	Load	Failure Mode	Cause
94	Crane and heavy lift issues	During an inspection at the NPP, the regulatory body inspectors reviewed a design calculation for the steam dryer and steam separator lifting device to demonstrate conformance with ANSI N14.6-1978, Section 3.2.1.1. The inspectors identified that socket pins, lock pins and hook pins were not designed based on their material fracture toughness properties as specified in ANSI N14.6-1978, Section 3.2.1.1. Instead, the calculation showed the socket pins, lock pins and hook pins had yield strengths greater than 80% of their ultimate strengths and the calculation did not address the design based on material fracture toughness characteristics. Licensee corrective actions included performing non-destructive examination of the socket pins, lock pins and hook pins prior to each use to ensure an adequate factor of safety for brittle fracture.	No load	Crane or lifting devices structural failure	Design deficiency
95	Crane and heavy lift issues	During an inspection at NPP, the regulatory body inspectors reviewed the design calculation for the steam dryer and steam separator lifting device. The Duane Arnold UFSAR specified the design for this lifting device was to be in accordance with ANSI N14.6 1978. The safety-related function of this lifting device was to hold the heavy load in position during transport and not drop the load onto safety-related systems or irradiated fuel. ANSI N14.6-1978, Section 3.2.1.1 specifies that the stress design factors for the load-bearing members of the special lifting device be limited to one-third of the yield strength and one-fifth of the ultimate strength. Instead, the licensee used an incorrect shear allowable value for steel members that was not based on one-third of the yield strength. Licensee corrective actions included performing reanalysis to establish the specified design margins for the steam dryer and steam separator lifting device.	No load	Crane or lifting devices structural failure	Design deficiency
96	Crane and heavy lift issues	During an inspection at the NPP, the regulatory body inspectors reviewed the design calculation for the steam dryer and steam separator lifting device. The licensee's UFSAR specified the design for this lifting device was to be in accordance with ANSI N14.6-1978. ANSI N14.6-1978, Section 3.2.1.1 specifies that the stress design factors for the load-bearing members of the special lifting device be limited to one-third of the yield strength and one-fifth of the ultimate strength. Instead, the licensee incorrectly did not include the weight of the lifting device and its intervening components in the determination of applied stress. In addition, the licensee did not analyse all the structural elements in the load path and connection for the stress design factors based on the yield and the ultimate strengths of the material. Licensee corrective actions included performing reanalysis to establish the specified margins for the steam dryer and steam separator lifting device. In addition, NRC reviewed the design calculation for the RPV head strongback and identified similar examples of where stress design factors were not met. The licensee performed reanalysis and identified that the existing RPV head strongback did not meet ANSI N14.6-1978, Section 3.2.1.1. The licensee replaced the existing RPV head strongback with a strongback that met ANSI N14.6-1978, Section 3.2.1.1.	No load	Crane or lifting devices structural failure	Design deficiency
97	Crane and heavy lift issues	During an inspection at NPP, the regulatory body inspectors reviewed the Control of Heavy Loads licensing basis for the RPV head strongback which is a special lifting device. The licensee's USAR specified that the periodic testing for the special lifting devices used for safe transport of heavy loads, specifically that the RPV head strongback was in accordance with ANSI N14.6-1978. Section 5.3.1 of ANSI N14.6-1978, specifies that each special lifting device be subjected to either a load test or dimensional testing, visual inspection, and non-destructive testing of major load carrying welds and critical areas. The NRC inspectors identified that the licensee had not performed non-destructive testing of the load carrying welds or a load test. Licensee corrective actions included performing, prior to each use, dimensional testing, visual inspection, and non-destructive testing of major load carrying welds and critical areas of the RPV head strongback.	No load	Crane or lifting devices structural failure	Other, unknown, unspecified
98	Crane and heavy lift issues	During an inspection at the NPP, the regulatory body inspectors reviewed the licensing basis regarding licensee inspections of the RPV head strongback and the steam dryer/steam separator lifting device. The function of the strongback and lifting device is to support the lifted load and safely transport the reactor pressure head, over the reactor pressure vessel and over safety-related equipment to the designated laydown area during a refuelling outage. The licensee's UFSAR specified that periodic testing for the lifting devices was to be in accordance with ANSI N14.6-1978, Section 5.3.1, which specifies that	No load	Crane or lifting devices structural failure	Other, unknown, unspecified

ID	Title	Abstract	Load	Failure Mode	Cause
		each special lifting device be subjected to either a load test or dimensional testing, visual inspection, and non-destructive testing of major load carrying welds and critical areas. The NRC inspectors identified that the licensee did not perform dimensional testing of the RPV head strongback and steam dryer and steam separator lifting device, non-destructive testing of major load carrying welds and critical areas of the steam dryer and steam separator lifting device, or a load test on either. Licensee corrective actions included performing, prior to each use, dimensional testing, visual inspection, and non-destructive testing of major load carrying welds and critical areas of the RPV head strongback and steam dryer/steam separator lifting device.			
99	Refuelling machine stopped by interlocks action due to the rupture of control cables in the system of power supply to refuelling machine bridge	Unit 3 was in the planned maintenance outage. Efforts were in progress to load the new fuel assemblies into the reactor core in accordance with the working schedule entitled "Reactor Core Refuelling". Refuelling machine (RM) stoppage occurred due to the actuation of Refuelling Machine Control System (RMCS) interlocks. While doing so, RM boom did not contain fuel assemblies. RM visual examination revealed the rupture of 12 control cables in the system of power supply to RM bridge. Thermal Instrumentation and Controls Shop (TICS) personnel restored the affected RM cable connections. RM was then checked out including the testing of RMCS protections and interlocks. Fuel assemblies loading into the reactor core was continued. Direct cause of the event: rupture of the cables bundle in the system of power supply to RM bridge due to the fracture of one plastic brace leading to cables being released from the bundle. Root causes: design deficiencies – lack of hold-down fixtures on the cable drums of the system of power supply to RM bridge to allow cable uniform laying; installation deficiencies – inadequate fixing of the cables bundle with plastic braces in the system of power supply to RM bridge leading to cables being released from the guiding groove of the cable drum. The corrective actions taken were aimed at: replacing the affected cables in the system of power supply to RM bridge; conducting RM check-out involving the testing of RMCS protections and interlocks after restoration of cable connections; developing, manufacturing and installing the hold-down fixture on the cable drums of the system of power supply to RM bridge; performing complete wrapping of the cable bundle with reinforced-fabric adhesive tape.	No load	Crane controls/ protections failures	Other, unknown, unspecified
100	Unauthorised movement of spent fuel assembly (SFA) gripper due to fracture of the spring of the gripper drive's brake and staff errors	The unit was operating at the rated power of 1 020 MWe. Reactor Shop personnel was involved in loading the container-car shipping cask used for transporting spent fuel assemblies (FAs) from at-reactor fuel storage pools to the Spent Fuel Storage Facility (SFSF). In Fuel Pool 1 efforts were under way to load spent FA No. 95056 into the transportation fixture (TF) container. Radiation monitoring system detectors actuated in the Central Hall 3 (CH-3) indicating hi-hi radiation level. Personnel left CH-3 room. TF visual examination revealed 95 056 spent FA end piece being thrust against the loading device cover. The affected spent FA was transported with the help of TF to the prepared cask in Fuel Pool 1 under a special programme. The results of in-cask sampling showed that the affected FA was leak-tight, and no damage to fuel rods was found. Direct causes of the event: 1) fracture of a spring in the electromagnetic brake of TF gripper drive; 2) operations personnel errors – untimely opening of TF ball /globe/ valve prior to its alignment with the loading device slot. Root causes: 1) lack of technical documentation for TF gripper drive maintenance; 2) inadequate personnel attention while monitoring the correctness of fuel-handling equipment operators actions while loading spent FA into the container-car shipping cask. Inadequate surveillance over the fuel-handling operations on the part of the foreman. The corrective actions taken were aimed at replacing the spring of electromagnetic brake of TF gripper drive, changing frequency and scope of TF maintenance and giving additional briefing to personnel.	Container with radiologic al waste	Lifting interface failure	Inadequate monitoring or co-ordination

ID	Title	Abstract	Load	Failure Mode	Cause
101		During load testing of a new runway beam within the ILW Store Crane Maintenance Area the beam trolley passed the end stops of the runway beam resulting in the beam trolley, load cell, block and tackle and the 500kg test weight dropping to the ground. The 500kg test weight was approximately 2 feet above the ground. The lifting equipment fell in close proximity to the rigger involved in the task.	Test load	Crane controls/ protections failures	Other, unknown, unspecified
102	Damage of a fuel element caused by dropping	A new core configuration was planned. Therefore for each loaded fuel element a measurement of the counting rate concerning 3 different control rod positions took place. This measurement takes about 30 minutes. During this time the personnel already prepared the transport of the next fuel element. The fuel element was slung to the hoist. After the personnel departed the loading bridge the fuel element was loosened from the hook. It dropped about 2 m and hit the concrete floor. It's not known why the connection between the hook and tool to lift the fuel element loosened.	Nuclear fuel	Lifting interface failure	Other, unknown, unspecified
103	Loosening of a fuel rod bundle from its fuel assembly upper tie plate	The relocation of a fuel element to its new position in the fuel pool was planned. The fuel element was lowered to its new position when the fuel rod bundle detached and dropped to its new position. The fuel assembly upper tie plate and the fuel channel remained in the gripper. The event was caused by the rupturing of the fuel element's central-water channel beneath the first spacer.	Nuclear fuel	Load structural failure	Other, unknown, unspecified
104	Control rod cluster hanged on the upper internals during lifting	11/02/2016 at 22:00: beginning the rod disconnection operation. The activity consists of many steps and any error made during one or more may result in a hanged control rod cluster. An error was made during the achievement of Technical Checking (TC) of the cluster K10. Poor activity of disconnection of the control rod cluster K10, led the control rod cluster to be stuck to upper internals. Technical checks on the activity did not allow to detect this situation. We keep therefore 2 errors, one on the phase of disconnection of the control rod cluster concerned and another mistake in the technical inspections conducted on this cluster. The 12/02/2016 at 01h56: beginning of the activity of the lifting of upper internals. The 12/02/2016 at 02h15: during the phase of CCTV inspection of the upper internals at a distance of 400 mm from the vessel mating surface under the appropriate procedure, it is found that a cluster remained hanged to the control rod. The 12/02/2016 at 03:00: Cell for a team to deal with the problem. The 12/02/2016 at 14h: reading of the CCTV and achievement of additional expertise allowing to confirm that the cluster K10 is really involved. The 12/02/2016 at 18h: validation of a scenario to unhook the cluster from the rod lowering the upper internals of 2 m, installation of the handler of the control rods, vibration of the control rods to obtain rod dropping. The 12/02/2016 at 21h: Setting up of a first scenario. On 13/02/2016 at 8h: validation of a 2^{nd} scenario to disconnect the cluster of the rod involving the following actions: - lifting of the rod K10; - re installation of the upper internals in the vessel and the rod cluster K10; - removal of the internals handling tool that prevents disconnection of the control rods, while it is still hanged to the crane on the vessel internal side; - disconnection of the control rod clusters and lifting of EIS;	Control rods (or parts)	Collision during handling	Inadequate monitoring or co-ordination

ID	Title	Abstract	Load	Failure Mode	Cause
		- monitoring by CCTV of absence of control rod cluster hanging. Immediate corrective action: Insertion of the cluster in its fuel assembly and disconnection of the cluster from the rod in order to restore a situation complying with the OTS. Origin: the control rod cluster K10 sticks to the upper internals. Organisation for the management of work interruptions not implemented. Reversal of 2 phases of the work file while the activity consisting in disconnecting the cluster K10 is going on. Misuse or distortion of the tool COUSSEAU ensuring this phase of the activity.			
105		The main 150 Te Thorp Receipt and Storage building crane is used to lift flasks containing spent nuclear fuel from the rail bay up into the building, to permit onward processing within the plant. The crane hoist has an emergency braking system whose purpose is to i) prevent uncontrolled lowering of a flask and ii) to arrest the load on detection of an overspeed condition. While carrying out a proof test on the 150 Te crane overspeed switch (safety mechanism), the trip setting was found to be out of the allowed tolerance permitted in the proof test by a small margin. The actual setting was 138% over speed compared to 120% by design. This was an unrevealed failure of a safety mechanism. In the worst case, in which the overspeed switch was not functioning at all, an uncontrolled lowering of a laden fuel flask could occur from full height into the rail bay, resulting in potential radiological release. There are a number of barriers to prevent this outcome; the overspeed switch was available and functional, there are normal and emergency brakes on the crane which is under operator surveillance with emergency stop control. The mechanical resistance within the crane system will limit the speed of an uncontrolled lowering event. All flasks handled within the building are substantiated for a full height dropping. There were no safety consequences as a result of this condition.	Test load	Hoist emergency brakes failure	Other, unknown, unspecified
106	Tilting of a transport container for new fuel elements	A transport container (containing 2 new fuel elements) should be transported into the reactor building. The transport container was hoisted on top of another container. During the dismounting of the lifting beam one side of the transport container was hoisted a few centimetres which led to the overturning of the container. The dropping height was about 80 cm. The lifting beam was deformed. The event's cause is not yet determined. Further investigations are still ongoing.	Nuclear fuel	Other	Other, unknown, unspecified
107		During normal operations the Flask Maintenance Facility (FMF) main hall crane was being used to transfer an empty flask undergoing maintenance to the lower park area of the building. Using the main hoist, the crane operator moved the flask on the cross travel while still at transport height and then began lowering the flask into the designated position. At this point it was observed that the crane was still moving on cross travel for a distance of approximately 2 metres. This forced the crane operator to deploy the emergency stop button to halt the movement. There were no operators at risk of contact with the flask during this period. The worst case scenario would have been a continued uncontrolled movement of the load. The remaining functional barriers included the training provided to the crane operator and the emergency stop button.	Container with radiologic al waste	Unauthorised crane operations	Other, unknown, unspecified

ID	Title	Abstract	Load	Failure Mode	Cause
108		The Skip Handler Machine (SHM) had been parked at grid position A34 at the start of the afternoon shift prior to the operator's pre-shift brief. It was left in this configuration for around 20 minutes. During this period, due to the windy conditions, the SHM drifted down the pond from grid position A34 to A30, a distance of approximately 8.0 metres. This was due to a failure of the long travel brake while in mast mode. The brakes have no safety designation. The brake had seized in the off position causing the skip handler to have no long travel (East/West) braking capacity. Throughout this uncontrolled movement, the mast did not make contact with any pond structure or its contents although there was the potential for the mast to do so. There was no impact on other systems. However the crane operators were required to re-enter the cab of the SHM with no effective long travel brakes available. Buffers are installed to prevent the SHM leaving the crane tracks. The cross travel brakes were fully functional and prevented SHM from moving North/South.	No load	Other	Other, unknown, unspecified
109	Fuel rod lost in spent fuel	During reconstruction of a fuel bundle, the fuel rod was being transferred to a cassette before it was supposed to be mounted into a new fuel assembly. An event occurred when one fuel rod slipped out of the gripping tool and landed on the bottom of the spent fuel pool, without damage. All work was stopped and analysis showed that the event was caused by using the wrong gripping tool. Erroneous information from the contractor in addition to missing documentation resulted in using the wrong gripping tool. The gripping tool was not closed correctly during the handling because the tool used was not compatible with the fuel rod. If the correct gripping tool had been used, the operator would have been forced to close the tool before lifting the fuel rod. Construction of the workplace and ongoing conversation between operators during the event are judged to be contributing causes. The event could have resulted in damage to the fuel rod and a possible release of contaminated gases in the building. The event had no effect on the operation of the reactor.	Nuclear fuel	Lifting interface failure	Other, unknown, unspecified
110	Proper operational actions not taken before heavy lift (> 4.5 tonnes) in the reactor building	During heavy lifting in the reactor building, certain operational actions should be performed to limit the consequences following a possible event if the heavy load were dropped. For example, the pumps and the valves for the emergency containment cooling system should be blocked. If a heavy load were dropped on the pipes in this system, the condensation pool could be drained. The work supervisor contacted the operator in the control room with information about a certain sequence of a work order related to heavy lifting. The control room operator confirmed that the work supervisor could call back again when the sequence had been performed. The work supervisor understood that message as a "green light" to perform the whole lifting sequence of the work order, which was also performed. However, what the control room operator actually meant was that the supervisor could perform the sequence of the work order related to preparation before performing the heavy lift and that the supervisor should contact the control room again before performing the heavy lift in order to give the control room operators time to perform their actions before the actual lifting part. Due to the misunderstanding between the work supervisor and control room operator, the heavy lift was performed without having performed the proper preventive operational actions.	Other loads	Unauthorised crane operations	Inadequate monitoring or co-ordination

ID	Title	Abstract	Load	Failure Mode	Cause
		After the event, all operational shifts were informed about the importance of two-way communication.			
111	Irradiated control rod dropped in shipping container during handling in spent fuel pool	A part of an irradiated control rod was being lifted into a shipping container in the spent fuel pool. The spent fuel pools at the facility are not very deep and fuel rods are handled using lead protection. The lead protection obstructs visibility when the fuel charging machine is used. Therefore, handling of control rods is performed by using a loose gripping device and lifting rods, instead of using the fuel charging machine. The verification of the gripping position failed and the grip on the control rod was incorrectly placed in the hook of the gripping device. When the control rod was transferred into the shipping container, the movement got stuck and the grip opened. The control rod fell 2 meters down into the shipping container. The work was halted. The control rod was undamaged during the fall, though the cassette in the shipping container was affected. The safety significance of the event was of a minor impact. However, it might have been serious if the control rod had been dropped on a fuel assembly. The gripping function has been changed to simulate the same method used for gripping fuel assemblies. The visual verification of the control rod position was also enhanced. Documentation relating to handling of control rods was also verified and updated.	Control rods (or parts)	Lifting interface failure	Inadequate monitoring or co-ordination
112	Defect in gripping device in the fuel charging machine	The gripping device for the fuel charging machine consists of 2 gripping claws working in the same principle as a pair of scissors. The grip is electrically locked and can only be opened if it is in the right position and unloaded. If it is bearing a load, the grip is mechanically locked and the load is secured by the 5 tines in the jaw of the grip. During handling of the control rods, the grip was locked and an alarm signal followed. During the overhaul of the gripping device, it was discovered that one of the 5 tines was missing. The missing tine is 15*15*3 mm. A search for the missing part was performed in the shipping container and fuel pool, but it was not found. The cause of the defect is judged to be overload in combination with skew load. This is because of the possibility that the grip can end up in a skew position over the handle. One corrective action due to this event is to perform an extended inspection on the fuel charging machine during the annual overhaul, in addition to liquid penetrant testing of the grip.	Control rods (or parts)	Lifting interface failure	Other, unknown, unspecified
113	Heavy lifting performed during power operation	With unit 4 operating at 50% power and one turbine in shutdown state, a heavy lift was made over a lift shaft in the turbine building. According to technical specifications, heavy lifts with loads heavier than 4.5 tonnes are only allowed during cold shutdown. During this plant condition, an engine weighing 7.9 tonnes was blocking the way and causing problems for maintenance workers. The engine was lifted down into a lift shaft in the turbine building and placed on a wagon. In the morning the following day, the engine was moved once again, this time from the wagon onto a pallet in the same lift shaft. The cooling pipes for the component cooling system are located below the floor in the lift shaft. If the cooling pipes for heat sink to the component cooling system are damaged, the heat sink to the reactor cooling system for vital safety functions and fuel pools would be lost. During the event, residual heat through steam generators and feed water were available. The heavy lift of the engine was made during power operation, and the central control room was not informed about the lift, and consequently without following instructions for maintenance staff. The probabilistic safety analysis (PSA) analysis performed deems the situation as having a small risk increase factor. The safety significance of the event is estimated to be of marginal impact.	Other loads	Unauthorised crane operations	Human error

ID	Title	Abstract	Load	Failure Mode	Cause
		When the event involving the heavy lift was identified, all lifting activities in the turbine hall were stopped by collecting all keys to the gantry crane. Before any lifting activity was allowed, a meeting with all affected staff was held about established routines and instructions to prevent reoccurrence. An information sign was placed on the railing to the lifting shaft to alert personnel in the area to the requirement for heavy lifting. This action was also carried out on Unit 3. A contributing factor was work planning including synchronised shift schedules for personnel to facilitate co-operation between different professional groups.			
114	Overhead crane declared out of operation	During preparations before fuel transport, an empty shipping container was being transported up to the fuel pool. The gantry crane was tripped due to an unintended release of the overload protection, which resulted in the gantry crane being declared out of operation. A printed circuit board was identified as the source of error. No spare part was available and the estimated time to obtain a spare part was on the scale of months. The maintenance and operations department made the decision to interlock the overload protection and perform compensatory measures to be able to go on with transporting the empty shipping container. The shipping container weighs 80 tonnes, which is well below the accepted criteria for the gantry crane (165 tonnes). According to technical specifications, the overload protection must be available during transport, and the compensatory measures were considered unfulfilled. Moreover, the analysis after the event showed that there is a redundant connection on the circuit board that could have been used.	Other loads	Unauthorised crane operations	Human error