5. OTHER HANDLING SYSTEMS

5.1. PIT HANDLING SYSTEM FOR IRRADIATED FUEL CASKS (DMK)

5.1.0. Safety requirements

5.1.0.1. Safety functions

The main functions of the pit handling system for irradiated fuel casks are the transport of irradiated fuel casks from the cask lifting crane to the penetration located at the bottom of the fuel loading pit, the placing of the cask in the loading pit and the preparation and conditioning of the cask. It does not play a direct part in fulfilling any safety functions. However, it must contribute to the following safety functions:

5.1.0.1.1. Control of reactivity

The pit handling system for irradiated fuel casks must prevent a criticality accident following the dropping of a cask.

5.1.0.1.2. Decay heat removal

The pit handling system for irradiated fuel casks must be designed to remove the decay heat of the fuel assemblies.

5.1.0.1.3. Radioactive substance containment

The pit handling system for irradiated fuel casks must be designed to preserve the integrity of the fuel cladding.

5.1.0.2. Functional criteria

5.1.0.2.1. Decay heat removal

The pit handling system for irradiated fuel casks must be designed to cool the fuel in the cask before conditioning.

The pit handling system for irradiated fuel casks must ensure no uncovering of fuel casks before complete closure of the casks.

5.1.0.2.2. Controlling reactivity and containing radioactive products

The pit handling system for irradiated fuel casks must be designed to prevent a fuel cask from falling during handling.

The pit handling system for irradiated fuel casks must be designed to prevent an unconditioned fuel cask from falling in the event of an earthquake or the shaking following an aircraft crash.
5.1.0.3. Design-related requirements

5.1.0.3.1. Requirements resulting from safety classifications

5.1.0.3.1.1. Safety classifications

The pit handling system for irradiated fuel casks must be classified according to the principles given in Chapter C.2.

5.1.0.3.1.2. Single failure criterion (active and passive)

Not applicable

5.1.0.3.1.3. Uninterruptible power supplies

The temperature and water level sensors of the fuel cask must be backed up.

5.1.0.3.1.4. Qualification to operating conditions

Not applicable

5.1.0.3.1.5. Mechanical, electrical and instrumentation and control classifications

The mechanical, electrical and instrumentation and control classification of safety elements must comply with the requirements of Chapter C.2.

5.1.0.3.1.6. Seismic classification

The pit handling system for irradiated fuel casks must be seismically classified in accordance with the principles given in Chapter C.2.

5.1.0.3.1.7. Periodic tests

The pit handling system for irradiated fuel casks is subject to periodic tests to ensure its ability to fulfil its function and to check the state of components which are essential from a safety point of view.

5.1.0.3.2. Other regulatory requirements

5.1.0.3.2.1. Official texts, laws, orders and decrees

To follow.

5.1.0.3.2.2. Basic Safety Rules

To follow.
5.1.0.3.2.3. Technical Directives

To follow.

5.1.0.3.2.4. Specific EPR texts

Not applicable

5.1.0.3.3. Hazards

Hazards other than earthquake and aircraft crash have no specific impact on the pit handling system for irradiated fuel casks given that the system is installed in the fuel building.

5.1.0.3.3.1. Internal hazards

Not applicable

5.1.0.3.3.2. External hazards

Seismic hazard

The pit handling system for irradiated fuel casks must be designed so that its integrity will be preserved when the fuel cask is inside the fuel building, following the design basis earthquake.

Aircraft crash

The pit handling system for irradiated fuel casks must be designed so that its integrity will be preserved when the fuel cask is inside the fuel building, following vibrations caused by an aircraft crash.

5.1.1. Design bases

The design complies with the following requirements:

a) the pit handling system for irradiated fuel casks is designed to limit the risk of dropping or damaging the fuel casks during transfer from one location to another. The equipment is fail-safe in the event of loss of power

b) the pit handling system for irradiated fuel casks may be stopped on demand

c) the pit handling system for irradiated fuel casks is designed to maintain the load during loading operations following a design basis earthquake or following shaking caused by an aircraft crash.

d) all operations relating to fuel cask handling are designed to ensure protection of staff against radiation and to prevent heating of the fuel

e) the evaluation of the radiological consequences of a fuel handling accident takes account of the general installation of the equipment (structures, systems and components) to ensure the safety and protection of the general public
f) the transfer machine, the closure head hoist at the bottom of the pit, the fuel cask plug handling station and the line-up device under the penetration are designed either according to the requirements of the KTA 3902 code “Design of nuclear plant hoisting equipment” or the requirements of the CST 60.C.007.03 “High-security hoisting and handling equipment.”

g) The safety classification of the components of the irradiated fuel cask handling system is presented in Chapter C.2.

5.1.2. Description, characteristics of equipment

The irradiated fuel cask handling system comprises mainly the fuel cask transfer machine and the various pieces of equipment installed on the unit.

The irradiated fuel cask transfer machine is used to transport the cask from the irradiated fuel cask lifting crane to the loading bay of the fuel building.

In addition, the irradiated fuel cask transfer machine allows access to the cask and to the penetration during the cask preparation and conditioning phases. It supports a part of the fluid systems needed for removal of spent fuel.

The irradiated fuel cask transfer machine travels on rails and is guided sideways into the fuel building.

The following equipment is installed on the unit:

- the penetration used for connecting the spent fuel loading pit to the cask
- the biological plug handling station allowing removal and replacement of the biological plug on the cask
- the closure head at the bottom of the loading pit manoeuvred using a hoist
- the control room for the irradiated fuel cask transfer machine from which most automatic tasks are controlled and monitored remotely

The irradiated fuel cask handling operations are as follows for fuel removal:

- the irradiated fuel cask arrives on site in the horizontal position on a trailer or a wagon. After removal of shock absorbers and radiological checks, it is lifted and placed in the vertical position using an irradiated fuel cask lifting crane before being placed on the irradiated fuel cask transfer machine
- the irradiated fuel cask transfer machine containing the cask positioned vertically is transferred in the loading bay of the fuel building to the hopper (?) station
- the irradiated fuel cask transfer machine is secured in relation to the building structure using seismic restraints.
- the fluid, electrical and instrumentation and control systems of the transfer machine are connected to the unit
- the following operations are performed:
  - cask airtightness checks
cask closure head removal
placement on the cask of the blocking/centring ring of the penetration flange
loosening of the biological plug
filling the cask with water

- the seismic restraints are unlocked and the irradiated fuel cask transfer machine is moved beneath the biological plug handling station
- the irradiated fuel cask transfer machine is secured in relation to the building structure using seismic restraints
- the biological plug is removed
- the seismic restraints are unlocked and the irradiated fuel cask transfer machine is positioned beneath the penetration, at the lower part of the loading pit
- the irradiated fuel cask transfer machine is secured in relation to the building structure using seismic restraints
- the penetration is placed in contact with the cask at the cask sealing surface using a sealing device. This device consists of a sealing flange, a bellows seal with two walls and a connection flange between the bellows seal and the sealing flange
- the penetration is filled
- the loading pit is filled
- the closure head at the bottom of the loading pit is opened
- the sluice gate between the spent fuel pool and the loading pit is opened
- the spent fuel assemblies are loaded under water into the cask using the overhead crane
- the sluice gate between the two compartments of the pool is closed
- the closure head at the bottom of the loading pit is closed
- the penetration is emptied
- the cask is partially drained
- the penetration is dried
- the sealing flange is disconnected from the cask sealing surface
- the seismic restraints are unlocked and the irradiated fuel cask transfer machine is positioned beneath the biological plug handling station
- the irradiated fuel cask transfer machine is secured in relation to the building structure using seismic restraints
• the biological plug is put in place
• the seismic restraints are unlocked and the irradiated fuel cask transfer machine is finally positioned beneath the handling hopper
• the irradiated fuel cask transfer machine is secured in relation to the building structure using seismic restraints
• the final cask conditioning operations are performed:
  
  locking of the cask biological plug
  complete drainage of the cask
  drying of the cask if necessary
  closing of the cask closure head
  checks for airtightness and radioactivity of the cask
• the fluid, electrical and instrumentation and control systems of the transfer machine are disconnected from the unit
• the seismic restraints are unlocked and the irradiated fuel cask transfer machine is removed from the building and taken to the irradiated fuel cask lifting crane
• the cask is lifted vertically using the irradiated fuel cask lifting crane and is placed in the horizontal position on the wagon or the trailer
• after the final preparations, the cask is ready to leave the site

N.B.: the equipment of the irradiated fuel cask handling system may also be used to hold new MOX fuel casks, using a process similar to the one described above.

5.1.3. Preliminary safety analysis

5.1.3.1. Satisfying the functional criteria

5.1.3.1.1. Decay heat removal

The spent fuel casks and/or their inserts are handled under water deep enough to ensure adequate biological protection and cooling.

The seals are double-barrier type seals (valve, check valve, dashpot, seal or full plug). When the double isolation comprises two valves, at least one of them is motor-driven.

Incorrect movements are prevented by electrical interlocks. The motor-driven valves have a closed safety position. All the mechanical components and valves feature a manual emergency control for completion of operations.

All measures are taken to prevent accidental emptying of the cask or the loading pit, particularly in the event of hose breakage. The layout of the systems prohibits complete emptying of the cask before the plug has been replaced on it.
Accidental leaks from the cask or the loading pit are detected by measuring sensors with threshold alarms.

When the cask is filled with water in the fuel building and loaded with irradiated assemblies, the system ensures back-up cooling of the cask in any position, in the event of abnormal heating due to being in a prolonged stationary position.

The penetration between the loading pit and the cask is designed to maintain its seals during a design basis earthquake or under the effects of vibrations caused by an aircraft crash.

The piping is designed to maintain its integrity in the event of a design basis earthquake or under the effects of vibrations caused by an aircraft crash.

Interlocks are provided to ensure the airtightness of the penetration during the various operations (see Chapter I.5.1.3).

5.1.3.1.2. Controlling reactivity and containing radioactive products

The design of the cask/loading pit rules out the risk of dropping or damage to the cask during handling operations in the fuel building: the cask is not lifted; it is attached to the transfer machine which sits directly on the floor.

The irradiated fuel cask remains on the irradiated fuel cask transfer machine, which is designed to hold it and not tip over, even in the event of an earthquake or shaking caused by an aircraft crash. This statement is valid when the transfer machine is in the fuel building with the assumption that the cask is loaded, positioned and stowed on the handling system, which in turn is connected to the civil engineering structure by seismic restraints. The transfer machine holding the conditioned irradiated fuel cask may tip over in the event of an earthquake with the EPR loading spectrum, if it is located outside the fuel building. This type of situation does not damage the integrity of the irradiated fuel cask.

The design rules out any collision between fuel casks or against columns or other structures during handling operations.

The parts of the irradiated fuel cask handling equipment, or parts linked to it, are designed to preclude the risk of their falling into a pool or onto a service floor in the fuel building.

In the event of a design basis earthquake or shaking caused by an aircraft crash, the cask is secured in all directions by the irradiated fuel cask transfer machine which is held in place by seismic restraints when it is in the fuel building.

The transfer machine is equipped with a dropped voltage electrical brake and a service brake.

The transfer machine is equipped with buffers which absorb the kinetic energy at the end of the track.

The transfer machine is equipped with anti-slip pads close to the wheels with minimal interplay above the tracks, so that breakage of a roller, unit or axis has no impact on the integrity of the cask or of the fuel.

Following operational feedback from the P'4 and N4 units, the transfer machine is designed to limit dispersion of contaminated water. The transfer machine is equipped with piping connections with low leakage, a modified overflow tank to avoid overflows at closure of the cask and devices to recover any drip-off.
The transfer machine is also designed to limit the exposure of staff to radiation by limiting the accumulation of contamination as well as the operation times on the cask. The transfer machine is equipped with simplified fluid systems which promote flow, ability to decontaminate equipment, motor-driven valves, a blocking/centring ring at the level of the penetration and a horizontally adjustable plug lifting device.

The following interlocks are provided:

<table>
<thead>
<tr>
<th>Operation</th>
<th>Prior condition</th>
</tr>
</thead>
</table>
| Positioning of the transfer machine for removing the plug | - lobby door and handling hopper closed  
- iodine ventilation extraction in operation  
- plug gripper in the top position        |
| Grasping of the plug                           | - seismic restraints locks closed                                                  |
| Lifting of the plug                            | - gripper claw closed                                                            |
| Positioning of the transfer machine beneath the penetration | - plug locked in the top position  
- electrical power of the plug station cut off  
- penetration in top position  
seismic restraints locks open          |
| Lowering of the penetration                    | - transfer machine positioned with translation supply cut off  
- seismic restraint locks closed           |
| Opening of the vent and filling of the penetration with water | - seal of the penetration locked  
- all electrical power supplies cut off except that of the closure head at the bottom of the pit |
| Pressure balancing each side of the closure head at the bottom of the pit | - penetration filled with water  
- condition of all seals checked          |
| Opening of the closure head at the bottom of the pit | - balanced pressure on both sides of the closure head |
| Opening of the sluice gate between the pool and loading pit | - all electrical supplies are cut off |
| Emptying of the penetration                    | - closure head at the bottom of the pit closed  
- pool sluice gate closed  
- pressure balancing pipes closed             |
| Unlocking and lifting of the penetration seal. | - penetration empty of water  
- checking the condition of the closure head seal at the bottom of the pit |
| Movement of the transfer machine to the plug lifting station | - seismic restraints locks open  
- penetration in top position |

5.1.3.2. Compliance with design requirements

5.1.3.2.1. Safety classifications

The classification of the components of the irradiated fuel cask handling system is presented in Chapter C.2.

5.1.3.2.2. Uninterruptible power supplies

The temperature and water level sensors of the cask are backed up by batteries ensuring autonomous supply for 24 hours.
5.1.3.2.3. **Hazards**

5.1.3.2.3.1. *Internal hazards*

<table>
<thead>
<tr>
<th>Internal hazards</th>
<th>Protection required in principle</th>
<th>General protection</th>
<th>Specific protection introduced in the design of the system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipe breaks</td>
<td>Not applicable</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Breaks of tanks, pumps and valves</td>
<td>Not applicable</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Internal missile</td>
<td>Not applicable</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Dropped loads</td>
<td>Yes</td>
<td>Design of handling equipment</td>
<td>-</td>
</tr>
<tr>
<td>Internal explosion</td>
<td>Yes</td>
<td>Prevention</td>
<td>-</td>
</tr>
<tr>
<td>Fire</td>
<td>Yes</td>
<td>BK (fuel building) fire protection</td>
<td>-</td>
</tr>
<tr>
<td>Internal flooding</td>
<td>Yes</td>
<td>BK (fuel building) installation</td>
<td>-</td>
</tr>
</tbody>
</table>

5.1.3.2.3.2. **External hazards**

**Earthquake**

The pit handling system for irradiated fuel casks is designed to maintain its integrity under the effects of a design basis earthquake with the assumption that the cask is loaded, positioned and stowed on the transfer machine, which in turn is connected to the civil engineering structure by seismic restraints.

The connecting piping is designed to maintain its integrity in the event of a design basis earthquake.

The seal between the penetration and the cask is required in the event of an earthquake.

Operation of the electrical equipment is not guaranteed during or after an earthquake but the manual controls of the mechanical units enable all functions to be performed.

When it transports the conditioned cask out of the BK (fuel building), the transfer machine may tip over in the event of an earthquake with the EPR loading spectrum. This situation does not damage the integrity of the irradiated fuel cask.

**Aircraft crash**

The pit handling system for irradiated fuel casks is designed so its integrity will be maintained under the effects of vibrations caused by an aircraft crash, with the assumption that the cask is loaded, positioned and stowed on the transfer machine, which in turn is connected to the civil engineering structure by seismic restraints.

The connecting piping is designed so its integrity will be maintained under the effects of the vibrations potentially caused by an aircraft crash.
The tightness between the penetration and the cask is required to withstand the effects of vibrations caused by an aircraft crash.

Operation of the electrical equipment is not guaranteed during or after an aircraft crash but the manual controls of the mechanical units enable all functions to be performed.

<table>
<thead>
<tr>
<th>External hazards</th>
<th>Protection required in principle</th>
<th>General protection</th>
<th>Specific protection introduced in the design of the system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earthquake</td>
<td>Yes</td>
<td>Location in BK (fuel building)</td>
<td>Seismic design</td>
</tr>
<tr>
<td>Aircraft crash</td>
<td>Yes</td>
<td>Location in BK (fuel building)</td>
<td>Seismic design</td>
</tr>
<tr>
<td>External explosion</td>
<td>Yes</td>
<td>Location in BK (fuel building)</td>
<td>-</td>
</tr>
<tr>
<td>External flooding</td>
<td>Yes</td>
<td>Location in BK (fuel building)</td>
<td>-</td>
</tr>
<tr>
<td>Snow and wind</td>
<td>Yes</td>
<td>Location in BK (fuel building)</td>
<td>-</td>
</tr>
<tr>
<td>Extreme cold</td>
<td>Yes</td>
<td>Location in BK (fuel building)</td>
<td>-</td>
</tr>
<tr>
<td>Electromagnetic interference</td>
<td>Yes</td>
<td>Location in BK (fuel building)</td>
<td>-</td>
</tr>
</tbody>
</table>

5.1.4. Testing, inspection and maintenance

5.1.4.1. Pre-operational testing

The irradiated fuel cask pit handling system must undergo a range of pre-operational tests. The tests required will be defined in a test procedure and will include handling sequence tests, electrical circuit tests, leak resistance tests and load tests. Tests will be performed on the plant at the manufacturer’s premises and on site.

At acceptance on site, the components must be inspected to check that no damage has been caused by transport and storage. In on-site testing, the equipment must satisfy a set of checks to ensure smooth operation of the pit fuel handling system following assembly.

5.1.4.2. Surveillance in operation

Before each usage campaign, the irradiated fuel cask pit handling system must undergo a series of intrinsic and functional re-qualification tests. The tests are designed to confirm the availability of the system, and involve surveillance and maintenance operations. Surveillance involves mainly visual inspections. The maintenance operations comprise maintenance of mobile parts and periodic replacement of worn parts.

5.1.4.3. Periodic tests

The system must be designed to enable periodic tests to be carried out, particularly to check the state of the components which are essential from a safety point of view.
5.2. POLAR CRANE (DMR)

5.2.0. Safety requirements

5.2.0.1. Safety functions
The polar crane, whose main role is to carry out heavy handling in the reactor building, does not directly fulfil any safety functions.

However, the machine is designed to prevent, during normal or accident operation, any accidental criticality, unjustified exposure to ionizing radiation or unacceptable discharge of radioactive substances (in particular with respect to the risk of drop or collision).

The polar crane and the load it handles must not pose hazards to systems and equipment that carry out safety functions, specifically:

- the fuel assemblies (during shutdown/unloading and reloading/start-up phases, during handling of the vessel cover and the upper internals)
- the reactor cavity and the internals (ditto)
- the airtight liner in the reactor building pool
- the containment
- the parts of the back-up circuit fixed at the level of the polar crane on the containment
- systems with a safety function located vertically to the crane or handled loads

5.2.0.2. Functional criteria
The polar crane must be designed to avoid any load drop or any impact during load handling.

The polar crane must be designed to avoid the dropping of parts from the crane.

The polar crane must be designed to avoid any interference with the Reactor Building and the EVU [CHRS] piping.

5.2.0.3. Design-related requirements

5.2.0.3.1. Requirements issued by safety classifications

5.2.0.3.1.1. Safety classifications
The polar crane has no safety function and is thus not safety classified. However, the consequences of hypothetical failure leads to classification of the crane elements as explained in Chapter C.2.

5.2.0.3.1.2. Single failure criterion (active and passive)
Not applicable for the polar crane in its entirety.
Although the single failure criterion does not apply to the polar crane, certain components of the polar crane are designed with redundancy in order to prevent a load drop if one of the components fails.

5.2.0.3.1.3. **Uninterruptible power supplies**
Not applicable

5.2.0.3.1.4. **Qualification to operating conditions**
The polar crane box girders, and if applicable the other box structures, are equipped with orifices to allow pressure balancing during containment tests and in the event of LOCA.

5.2.0.3.1.5. **Mechanical, electrical and instrumentation and control classifications**
The mechanical, electrical and instrumentation and control classification of safety elements must comply with the requirements in Chapter C.2.

5.2.0.3.1.6. **Seismic classification**
The polar crane must be seismically classified in accordance with the principles given in Chapter C.2.

5.2.0.3.1.7. **Periodic tests**
The polar crane is subjected to periodic tests.

A maintenance schedule is developed, which is used to check the condition of safety significant crane components, and also to ensure its ability to fulfil its function.

The polar crane is subjected to periodic tests which may be required by the national regulatory regime.

5.2.0.3.2. **Other regulatory requirements**

5.2.0.3.2.1. **Official texts, laws, orders and decrees**
later

5.2.0.3.2.2. **Basic safety rules**
Not applicable to UK EPR.

5.2.0.3.2.3. **Technical Directives**
No specific Technical Guidelines are applicable to the polar crane.

5.2.0.3.2.4. **Specific EPR texts**
Not applicable
5.2.0.3.3. Hazards

Hazards other than earthquake, aircraft crash, fire and breaks in pipes, tanks, pumps and valves, have no impact on the polar crane given the protective role of the reactor building containment and the elevated position of the polar crane in the reactor building.

5.2.0.3.3.1. Internal hazards

Fire

Only fire on the crane is taken into account, and in particular fire in the electrical equipment.

Operability of the crane is not required during or after the fire. Control of the load and integrity of the crane must be maintained during a fire on the crane.

Breaks of pipes, tanks, pumps or valves

The support arrangements for high-energy pipes, and the relative position of the crane in relation to the pipes, tanks, pumps and valves, ensure that the mechanical effects of breaks of these components can be withstood.

Following a break of any pipe, tank, pump or valve, the over-pressurisation and temperature increase in the reactor building must not cause structural failure of the polar crane.

5.2.0.3.3.2. External hazards

Earthquake

The polar crane must be designed to withstand a design basis earthquake.

Control of the transported load, and integrity of the crane, must be maintained during and after an earthquake.

Operability of the crane without need for maintenance or repair is not required during or after an earthquake.

The load must be able to be placed safely after an earthquake.

The crane must not generate any non-allowable stresses on its runway track and on the Reactor building in an earthquake.

The crane must not damage the EVU [CHRS] pipes for final heat removal from the containment in an earthquake.

Aircraft crash

The polar crane must be designed to withstand vibrations caused by an aircraft crash.

Control of the transported load, and integrity of the crane, must be maintained after shaking caused by an aircraft crash.

The load must be able to be placed safely after shaking caused by an aircraft crash.
The crane must not generate any non-allowable stresses on its runway track and on the enclosure during shaking caused by an aircraft crash.

The crane must not damage the EVU [CHRS] pipes used for decay heat removal from the containment during shaking caused by an aircraft crash.

5.2.1. Design basis

The design complies with the following requirements:

a) The polar crane is designed to minimise the risk of load dropping. The equipment is fail safe in the event of loss of power. Any internal failure of an essential element or loss of electrical power causes the movement to be stopped.

b) The polar crane may be stopped on demand.

c) The polar crane is designed to withstand a design basis earthquake and shaking following an aircraft crash, with and without handled load.

d) The polar crane is designed either according to the requirements of the KTA 3902 code “Design of nuclear plant hoisting equipment” or the requirements of the CST 60.C.007.03 “High-security hoisting and handling equipment.”

e) The safety classification of the polar crane is given in Chapter C.2.

5.2.2. Description, characteristics of equipment

5.2.2.1. Description of the system

The polar crane is used during the construction phase to install the main components in the reactor building (the reactor cavity, the steam generators, the pressuriser, etc.) and during fuel reloading operations for handling the vessel cover and other equipment and tools.

5.2.2.2. Description of components

The polar crane in the reactor building travels on a runway track consisting of a circular metallic frame sitting on metal brackets attached to the containment.

The crane has three trolleys:

- A main trolley equipped with a 320 tonne main hoist
- A secondary trolley equipped with a 35 tonne secondary hoist
- An auxiliary trolley equipped with a 5 tonne auxiliary hoist

The 5 tonne hoist also enables back-up handling of fuel assemblies, using the spent fuel handling tool, in the event of refuelling machine failure.
5.2.3. Preliminary safety analysis

5.2.3.1. Achievement of functional criteria

The rules of the KTA 3902 code or the specifications of the CST 60.C.007.03 contain provisions for load restart (redundant brakes and cables, drop-prevention mechanisms) in the event of failure of certain components of the polar crane.

The polar crane is designed to maintain its structural integrity in all accident conditions, including the design basis earthquake, shaking caused by an aircraft crash, and a loss of primary coolant accident.

The polar crane is designed to prevent inadvertent movement following loss of electrical energy.

The brakes engage automatically as soon as the control for the movement concerned is released. They are designed to ensure a jerk-free stop. The hoist control devices are designed to avoid any uncontrolled acceleration of the load during the lowering operation.

The brakes are designed to operate on power under-voltage. They operate as soon as a malfunction in the hoisting chain is detected.

Each lift is equipped with a system for measuring the load handled. For the auxiliary hoisting system, a system compares the value displayed with the value recorded, for each operation. If a defect is noted, the movement is stopped.

All movements are made safe by devices which lock in extreme situations of speed and position.

The polar crane is designed to enable the load to be placed in a safe position, during a degraded situation.

Main hoist (320 tonne)

The polar crane main hoist is equipped with a closed sequence chain featuring the following:

- Two operational brakes
- Two emergency brakes

The sequence chain is equipped with a device for surveillance in operation which controls the lost synchronisation between the two speed reducers.

The main hoist is equipped with a block and tackle with 16-strands installed symmetrically to allow the hook to be lowered along a vertical axis.

Secondary hoist (35 tonne)

The polar crane secondary hoist is equipped with a double open sequence chain in the case of design according to KTA 3902 or a closed sequence chain in the case of design according to CST 60.C.007.03. In both cases, the sequence chain features the following:

- Two operational brakes
- Two emergency brakes
Auxiliary hoist (5 tonne)

The polar crane auxiliary hoist is equipped with an open sequence chain featuring the following:

- a service brake
- an emergency brake
- a safety brake

The auxiliary hoist is equipped with a specific limit switch to prevent handling of fuel assemblies above a water level required during emergency handling of assemblies.

N.B.: The sequence chain may consist of a service brake and a secure motorised movement system.

5.2.3.2. Compliance with design requirements

5.2.3.2.1. Safety classifications

The classification of the polar crane is given in Chapter C.2.

5.2.3.2.2. Hazards

5.2.3.2.2.1. Internal hazards

Pipe breaks

The polar crane box girders and other box structures are equipped with orifices to allow pressure balancing if the building is subjected to excess pressure.

The crane structural behaviour is confirmed to be acceptable, taking into account temperature increases resulting from pipe break accidents, for the most pessimistic accident conditions.

Fire

The crane electrical beam is equipped with a fire detector consisting of smoke detectors located above the risk areas in a position that takes into account the partitioning of the beams. The detectors trigger an alarm with a horn.

The polar crane is equipped with either an automatic extinguishing system or visible and accessible extinguishers located in the electrical service room and at the access to the crane.

In the latter case, the electrical beam will be equipped with ventilation for renewal of the air in the beam after a fire.
### Internal hazards

<table>
<thead>
<tr>
<th>Internal hazards</th>
<th>Protection required in principle</th>
<th>General protection</th>
<th>Specific protection introduced in the design of the system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipe breaks</td>
<td>Yes</td>
<td>Elevated position in the BR (fuel building)</td>
<td>Pressure balancing orifices. Verification of the structure at high temperatures.</td>
</tr>
<tr>
<td>breaks of tanks, pumps and valves</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal missile</td>
<td>Yes</td>
<td>BR (fuel building) compartment</td>
<td></td>
</tr>
<tr>
<td>Dropped loads</td>
<td>Not applicable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal explosion</td>
<td>Yes</td>
<td>Prevention and BR (fuel building) compartment</td>
<td></td>
</tr>
<tr>
<td>Internal flooding</td>
<td>Not applicable</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5.2.3.2.2.2. **External hazards**

### Seismic hazard

The polar crane is designed so its integrity will be maintained and it will not drop its load under the effects of the design basis earthquake. The polar crane is designed without the load in the parked position and with the maximum operating load suspended in the centre of the crane. The calculation for earthquake is a non-linear dynamic calculation (time-history method).

### Aircraft crash

The polar crane is designed to maintain its integrity and not to drop its load under the effects of shaking caused by an aircraft crash. The polar crane is designed without the load in the parked position and with the maximum operating load suspended in the centre of the crane.

<table>
<thead>
<tr>
<th>External hazards</th>
<th>Protection required in principle</th>
<th>General protection</th>
<th>Specific protection introduced in the design of the system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earthquake</td>
<td>Yes</td>
<td>Located in BR (fuel building)</td>
<td>Seismic design</td>
</tr>
<tr>
<td>Aircraft crash</td>
<td>Yes</td>
<td>Located in BR (fuel building)</td>
<td>Seismic design</td>
</tr>
<tr>
<td>External explosion</td>
<td>Yes</td>
<td>Located in BR (fuel building)</td>
<td></td>
</tr>
<tr>
<td>External flooding</td>
<td>Yes</td>
<td>Located in BR (fuel building)</td>
<td></td>
</tr>
<tr>
<td>Snow and wind</td>
<td>Yes</td>
<td>Located in BR (fuel building)</td>
<td></td>
</tr>
<tr>
<td>Extreme cold</td>
<td>Yes</td>
<td>Located in BR (fuel building)</td>
<td></td>
</tr>
<tr>
<td>Electromagnetic interference</td>
<td>Yes</td>
<td>Located in BR (fuel building)</td>
<td></td>
</tr>
</tbody>
</table>
5.2.4. Testing, inspection and maintenance

Measures must be taken to enable access for inspection and testing to components which help hold and deposit the load.

Individual tests must be implemented to replace global tests which may involve significant restrictions or risks of damage (e.g.: tests for operation of safety brake on breakage of sequence chain).

5.2.4.1. Tests before commissioning

The polar crane must undergo full acceptance tests prior to commissioning:

- operating tests empty and full
- regulatory static and dynamic tests (coefficients, increased in relation to the regulatory coefficients, to be applied to the nominal design load are 1.5 and 1.2 respectively).

5.2.4.2. Surveillance in operation

In compliance with applicable national regulations, the polar crane will undergo regular tests of safety units and other periodic checks as appropriate. These tests may be conducted with the unit in operation.

Given the considerable size of the test load needed to test the crane to its maximum capacity, and the consequences on the facility in the event of a dropped load, the crane tests will be carried out with a reduced load in accordance with the method commonly used on the French fleet.

In the event that the regulatory test frequency is not met due to the duration of the reactor operating cycle, regulatory tests will be carried out before the crane is used again.

Before use of the crane, an inspection of the state of the crane is performed, consisting of the following controls:

- visual inspection to check for the absence of unattached parts or for the presence of parts not belonging to the crane, absence of dust or grease
- inspection of lifting cables (worn or broken strands)
- visual inspection of all travel limit switches and switch activators to ensure that no part is damaged or broken
- checking of correct operation of the equipment

5.2.4.3. Periodic tests

The polar crane must undergo periodic safety tests, the aim of which is complementary to the tests to check the smooth operation of components which assist in holding and depositing the load.