Shielded cells design and periodic safety review

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The periodic safety review consists in a systematic reassessment of the safety of a facility carried out at regular intervals to deal with the cumulative effects of ageing, modifications, operating experience, technical developments, new regulation and guidelines comparison and siting aspects, and is aimed at ensuring a high level of safety throughout the operating lifetime of the plant. In Belgium, the periodic safety review is mandatory for waste facilities, interim storage facilities, radiopharmaceutical producers, etc. In such a facility the number of shielded cells that have to be reassessed is consequent. It could also be highlighted that some facilities have been built in the 70's under legislation, regulation and guidance very different from the present one. The comparison of the design of the shielded cell, with a series of more recent guidelines and practices, makes it possible to highlight design defects, poorly controlled modifications, wear and tear of certain parts, etc. The corrective actions proposed by the operators make it possible to reduce the possible gap between up to date references and an old design.

Regulation

In Belgium, the safety authority is the Federal Agency for Nuclear Control (FANC). Some of its tasks have been delegated to Bel V (www.belv.be), its subsidiary. Bel V inspects class I facilities (2001) and a subcategory of class II facilities (called class IIa) mainly consisting of cyclotrons and irradiators. Every ten years, class I facilities are asked to perform a periodic safety review (IAEA SSG25). In Belgium this exercise is not only mandatory for NPP but also for radioactive waste facilities, radioactive interim storage facilities, fuel fabrication facilities, radiopharmaceutical producers… In such a facility the number of shielded cells that has to be reassessed is consequent. It could be also highlighted that some facilities have been built in the 70's under legislation, regulation and guidance very different from the present ones. According to IAEA definition, the periodic safety review consists in a systematic reassessment of the safety of a nuclear power plant carried out at regular intervals to deal with the cumulative effects of ageing, modifications, operating experience, technical developments and siting aspects, and is aimed at ensuring a high level of safety throughout the operating lifetime of the plant.

Safety function

Two safety functions are mainly reviewed and reassessed during the periodic safety review of a shielded cell: the integrity of the static confinement and the dynamic confinement, i.e. mainly the underpressure cascade of the shielded cells in their environment. A third safety function of the shielded cell is the shielding in itself. Usually no problem is highlighted on this third safety function. A reassessment concerns also the processes hosted by the hot cell and the equipment annexed like the fire extinguisher system.

Static confinement

To review the static confinement, the methodology followed by most of the licensees consists usually in retrieving the plans “as built” of the shielded cell (sometimes from the 70’s), identifying the modifications that have been set up by the licensees on the installation (especially on the alpha box) often to ease the process inside the hot cells. An identification of the weak points, subsystem by subsystem compared to guidelines (ISO 11933 - 1, 2, 3 & 5) is done by the licensees and a proposal to correct them is submitted to the regulatory body that will also perform an independent review and possibly add extra remarks and corrective actions. This may lead, in the worst case to a foreseen and programmed stop of the activity, a full decontamination and a full refurbishment of the shielded cells. Most of the time after this heavy work, a leak test following a well-known methodology described in a guideline (ISO 10648 - 1 & 2) agreed with the licensee is asked before the re-start of the activity. This test is necessary to demonstrate the efficiency of the shielded cell’s refurbishment and improvement.

Dynamic confinement

The dynamic containment of the cell in relation to the immediate environment is also subject to periodic safety reassessments. The methodology used essentially consists of first reassessing the physico-chemical characteristics of the source term in order to determine and classify the shielded cells in relation to a risk level. In a second step, the depression cascade, the redundancies of some systems and the renewal rates implemented in the alpha box of the shielded cells are compared to guide documents (ISO 17873). A re-evaluation of the filtration means (ISO 11933: 4; ISO 2889; ISO 16170; NFEN 779; NFEN 1822) in direct contact with the cell’s atmosphere is also carried out by taking into account the type of gaseous effluents that can be generated by the process located in the shielded cells.

Process

Shielded cells usually house a very wide variety of processes. During the periodic safety review, the operator determines the physico-chemical constraints generated by its process. In this way temperature, pressure, dose rate ranges as well as compatibility with the chemicals used are determined. The suitability of the materials used in the process (tubing, joints, materials, etc.) is then estimated in relation to the constraints and compared with guide documents (NFEN 10204; ASME - IX; NBNEN 287 – 1; ISO 15614 – 1; ISO 9712; ISO 3585; ISO 7619; ISO 10380; EN 1779). The impact of the process on the filters is also evaluated. This may concern, for example, the means of liquid retention or the fire detection and suppression system.

Discussion

Typically a series of weaknesses are identified during periodic safety reviews. The list of the weaknesses is discussed between the regulator and the licensee. These affect both the safety functions assigned to the shielded cells and also the process. Concerning the static confinement, weaknesses are usually identified at the interfaces between the alpha box and ancillary equipment such as remote manipulators, doors, sample transfer connections, rotating parts passing through the alpha box, connections for liquid transfers, etc. One of the points of attention concerns in particular inflatable joints whose poor condition, wear over time or inadequate design can have an impact on both static and dynamic confinement via uncontrolled introduction of compressed air into the shielded cell. Feedback on the operation of fire suppression systems using inert gas and studies to re-evaluate their effectiveness may lead to their replacement or to the adoption of new

extinguishing techniques. The absence of redundant equipment, for example at the level of the filtration of the atmosphere of the cells, can lead to important modifications of the shielded cells.

During this reassessment work, the modifications made to the shielded cells are traced and documented if this had not been the case. After the weaknesses identification, corrective actions are proposed by the licensee. These corrective actions have also been discussed between the regulator and the licensee, implemented and at the end of the process, approved by the regulator.

Conclusion

The periodic safety review of the shielded cells design verifies that the condition of the shielded cells reaches at least the same level of safety as when they were installed. The comparison of the design of the shielded cells, sometimes installed more than 40 years ago with a series of more recent guidelines, makes it possible to highlight design defects, poorly controlled modifications, wear and tear of certain parts, etc. The list of the weaknesses is discussed between the regulator and the licensee. Corrective actions are discussed between the regulator and the licensee, implemented and at the end of the process, approved by the regulator. The corrective actions proposed by the operators make it possible to reduce the gap between current references and guidelines and an old design.

References

Federal Agency for Nuclear Control (FANC) www.fanc-fgov.be

Royal Decree of 20 July 2001.

IAEA SSG25, Periodic Safety Review of Nuclear Power Plant.

ISO 11933-1 : Components for containment enclosures-Part 1: Glove/bag ports, bungs for glove/bag ports, enclosure rings and interchangeable units.

ISO 11933-2 : Components for containment enclosures-Part 2: Gloves, welded bags, gaiters for remote handling tongs and for manipulators.

ISO 11933-3 : Components for containment enclosures-Part 3: Transfer systems such as plain doors, airlock chambers, double door transfer systems, leaktight connections for waste drums.

ISO 11933-5 : Components for containment enclosures-Part 5: Penetrations for electrical and fluid circuits.

ISO 10648-1 : Containment enclosures-Design Principles.

ISO 10648-2 : Containment enclosures-Classification according to leak tightness and associated checking methods.

ISO 17873 : Nuclear facilities - Criteria for the design and operation of ventilation systems for nuclear installations other than nuclear reactors.

ISO 11933-4 : Components for containment enclosures-Part 4: Ventilation and gas-cleaning systems such as filters, traps, safety and regulation valves, control and protection devices.

ISO 2889 : Sampling airborne radioactive materials from the stacks and ducts of nuclear facilities.

ISO 16170 : In situ test methods for high efficiency filter systems in industrial facilities.

NF EN 779 : Particulate air filters for general ventilation - Determination of the filtration performance.

NF EN 1822 : High efficiency air filters (EPA, HEPA et ULPA).

NF EN 10204 : Metallic products – Types of inspection documents.

ASME section IX : Welding, brazing and fusing qualifications.

NBN EN 287-1 : Welder qualification test - Fusion welding - Part 1: Steels.

ISO 15614-1 : Specification and qualification of welding procedures for metallic materials - Welding procedure test - Part 1 : Arc and gas welding of steels and arc welding of nickel and nickel alloy.

ISO 9712 : Non-destructive testing - Personnel training and examination.

ISO 3585 : Borosilicate glass 3.3 - Properties.

ISO 7619 : Rubber, vulcanized or thermoplastic - Determination of indentation hardness - Part 1: Durometer method (shore hardness.).

ISO 10380 : Pipes and hoses - corrugated metal hoses and hose assemblies.

EN 1779 : Non destructive testing – Leak testing – Criteria for method and technique selection.