LICENSING UNCONVENTIONAL ACCELERATOR PROJECTS: A QUEST FOR THE SAFEST COMPROMISE.

F. SCHMITZ
Bel V
Brussels, Belgium
Email: frederic.schmitz@belv.be

S. VERMOTE
Bel V
Brussels, Belgium

N. NOTERMAN
Bel V
Brussels, Belgium

C. KENNES
Bel V
Brussels, Belgium

Abstract

Recently, exchanges have taken place between operators and the Belgian regulator, FANC (Federal Agency for Nuclear Control) and its technical subsidiary Bel V, concerning unusual applications of accelerators. These new projects presented to the Belgian regulator are not standard and are rather difficult to compare with other installations. They have been designed for various reasons, including an insufficient production capacity for critical radioisotopes used in nuclear medicine for therapy or an alternative production of well-established production routes of radioisotopes used for diagnostic. These special projects represent a regulatory challenge for the regulator to define the appropriate requirements to authorize them making use of the existing legislative corpus.

1. INTRODUCTION

In recent years, technical and administrative exchanges have taken place between operators and the Belgian regulator, FANC[1] (Federal Agency for Nuclear Control) and its technical subsidiary Bel V[2], concerning unusual applications of accelerators[3,4,5]. These projects imply the use of a powerful accelerator as an alternative to classical radioisotopes production routes, or the use of an accelerator as a way to control the amount of the neutrons produced by nuclear fission.

They have been designed for various reasons, including an insufficient production capacity for critical radioisotopes used in medicine for therapy or an alternative production of well-established production routes for radioisotopes used for diagnostic in aging installations.

These special projects represent a regulatory challenge for the regulator to define the appropriate requirements to authorise them making use of the existing legislative corpus. This is particularly relevant for hybrid systems such as accelerator driven systems (ADS) where equipment classified in different categories (according to the regulation) are connected.

2. REGULATORY FRAMEWORK

The Royal Decree of 20 July 2001[6] has established the regulatory framework dealing with the radiation protection of the population, the workers and the environment. The Royal Decree defines four classifications of licensees:

— Class 1 corresponds to facilities where quantities of fissile substances in excess of half a critical mass are used or held. In summary it mainly concerns nuclear power plants, research reactors, fuel factories, waste storage plants and medical radioisotopes facilities handling fissile material;

- Class II corresponds to facilities producing or conditioning radionuclides from irradiated fissile substances, particle accelerators, facilities containing high activity sealed sources, nuclear medicine departments, some types of electronic microscopes, CT scans, X-rays generators with nominal peak voltage higher than 200, … In summary, the type of Class II establishment is very broad, covering very different fields of activity and consequently leading to very different risks for the population, workers and the environment;
- Class III corresponds to facilities that are not covered by Classes I and II, facilities where one or more of the following installations are located: facilities where radioactive substances, including waste, are used or held under conditions that do not give rise to an exemption in accordance with Article 3.1.d. of the Royal Decree of 20 July 2001, installations in which X-ray generating equipment not covered by Article 3.1.b. of the Royal Decree of 20 July 2001 is used;
- Class IV is a class exempt from declaration or authorization. For example: a device that does not create, at any point within 0.1m of its accessible surface and under normal operating conditions, a dose rate greater than 1μSv per hour.

According to the Royal Decree of 20 July 2001, Class III and Class IV are the lowest categories of installations and out of scope of this paper.

3. EVOLUTION OF THE REGULATORY FRAMEWORK

The Belgian Parliament underlined the extreme heterogeneity of Class II installations as defined in the Royal Decree of 20 July 2001 and the lawsuit of an irradiation accident[7,8] speeded up the need to reassess the safety within some installations. Consequently, the Federal Agency for Nuclear Control decided to reform the facility classification by creating a subgroup including the heavy Class II installations, the so called Class IIa facilities[9,10]. The following types of facilities were included in this new classification:

- Facilities producing and conditioning radioisotopes from irradiated fissile substances;
- Particles accelerators used in research or in the frame of radioisotopes production;
- Facilities building accelerators;
- Irradiators used for sterilization purposes.

For all installations falling under classification IIa, additional constraints, having their origin in Class I installations, have been imposed by the regulator:

- A reporting procedure of events and accidents to the regulator must be established and approved by the regulatory body;
- The management of modifications to the installation has to be described in a procedure[11]. The modifications are classified according to their importance in three categories. The smallest ones have to be approved by the internal health physics control, while the most important ones require a modification of the operating license by the regulatory body. For middle modifications, an adaptation of the safety report approved by the regulator is requested;
- The organization of an internal health physics control has to be set-up;
- The drafting of a safety report is mandatory. This safety report is attached to the operating license and must be updated annually or after a modification to the installation. The safety report content has been defined:
  - Chapter I : Introduction;
  - Chapter II : Site characteristics;
  - Chapter III : Description of the installation and the process;
  - Chapter IV : Radiological impact;
  - Chapter V : Safety functions;
  - Chapter VI : Waste management;
  - Chapter VII : Radioprotection;
  - Chapter VIII : Organization;
  - Chapter IX : Technical specification;
  - Chapter X : Dismantling;

- Chapter XI : Internal emergency planning.

— For facilities releasing radioactive gases and/or radioactive liquids, an annual declaration of releases is required;

— New Class IIa operators willing to set up a new facility in Belgium are required to provide a provisional safety report incorporating the latest technical developments as part of the annex of a license application. By this way, the regulatory body ensures that latest improvements in, for example, decommissioning are taken into account by the new operators.

4. FUTURE EVOLUTION OF THE REGULATORY FRAMEWORK

Recently, some new projects presented to the Belgian regulator are not standard and are rather difficult to compare with other "classical" accelerator installations. They have been designed and justified for various reasons, including an insufficient production capacity of critical radioisotopes used in nuclear medicine for therapy or an alternative production of well-established production routes of radioisotopes used for diagnostic, some of them being produced in aging installations. These special projects represent a challenge for the regulator who must find in the existing legislative corpus the best way to license them. This is for instance an issue on hybrid systems like Accelerator Driven Systems (ADS). According to Belgian legislation, the nuclear reactor part must be granted with a Class I license, while the accelerator is supposed to be granted with a Class IIa license. Decoupling the accelerator license from the nuclear reactor one does not make sense from a safety point of view and the regulator will have to take into account, at some points of the process, the interactions resulting from the coupling of these two subsystems.

From a purely technical point of view, the regulator and his technical subsidiary also has to overcome several challenging issues:

— The concepts and designs presented to the regulator are new and essentially based on small-scale research and development (R&D) projects. The scaling up of the results from this research to an industrial level has been done with calculation codes and models sometimes poorly benchmarked. Hence, the validation and verification of these models, sometimes developed internally by the operator, is a challenge for the regulatory body.

— On the other hand, since the project is still in the design phase when the first discussions with the regulator take place, it is not uncommon that as the project evolves, major revisions of the basic design are proposed by the operator, rendering obsolete the safety option selected by the licensee as well as the safety analyses already performed.

— One of the difficulties encountered is also related to the diversity of applications that an accelerator will have to perform. The more scientific objectives the accelerator is designed to achieve, the more complex the machine and its infrastructure become and the more difficult the safety analyses in support of a license application become. It is also assumed that reliability of the operation and the performances of the system are likely to be lower compared to a simpler system.

— The intensive irradiation of targets of unusual design also raised many questions regarding their cooling and the final management of the radioactive waste that will be generated, including in the cooling circuitry. A thorough characterization of the irradiation parameters as well as the introduction of many appropriate interlocks in the machine control system must be evaluated to avoid unacceptable direct damage to the accelerator and possible indirect damage to the environment resulting from failure of the machine and containment barriers.

— Also, many questions are raised about the definition of reference accidents. This is especially the case with ADS, where accidents considered minor or with a certain frequency on an accelerator alone like a flooding of a vacuum chamber can become major once this accelerator is coupled to a reactor.

— A range of external hazards such as earthquakes, aircraft crash accidents, extreme weather conditions are usually not considered in accelerator safety analyses, based on the assumption that stopping the power supply from any cause will stop the beam. However, it would be useful to extend this analysis of external risks to equipment peripheral to the accelerators, such as the cooling circuits, as soon as non-conventional means of cooling are used.

— The acceptance of waste by Ondraf/Niras[12] (the national agency for radioactive waste and enriched fissile materials) and its industrial subsidiary Belgoprocess[13], from these projects may itself be a source of technical problems that must be proactively addressed in the safety analysis of the dossier.
— In terms of dismantling, the legislator wants these unusual accelerator applications to incorporate, wherever possible, the last improvements that have been made and described in the scientific literature in order to facilitate the dismantling:
  - Use of low activation concrete;
  - Reduce the beam loss;
  - Use of fiber glass rebar if it is possible;
  - Remove unnecessary material and peripheral equipment from the bunker;
  - …

There exists a series of guidelines[14] that have been drafted by the regulator and that apply to Class I facilities. These guidelines, for the moment, are not mandatory for class IIa installations. It is therefore regrettable that the monitoring of the installation of an accelerator is, with some exceptions, the sole responsibility of the licensee.

Finally, the external feedback (return of experience = REX) from accelerators similar to the project that has to be licensed is often weak and poorly documented. It may be useful to establish relations with regulators in foreign countries that have already licensed similar facilities.

5. CONCLUSION

Almost 10 years ago, after a reassessment of the safety of accelerator sites following a radiation accident, the legislation was adapted to reinforce the safety of sites holding accelerators. This adaptation was triggered by an awareness of the heterogeneity of accelerators and their applications.

The new projects currently presented to the regulator would again merit a reflection on an adaptation of the legislation taking into account new challenging technical developments.

However, because of the presented administrative and technical issues and the uncertainties that characterize the future of this new projects, the regulator needs to develop a flexible and graded approach to licensing.

This approach implies frequent exchanges and adjustments with the licensee but without compromising the nuclear safety.

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[14] 27/05/21 Règlement technique déclinant en termes pratiques l'objectif de sûreté nucléaire conformément à l'article 3/1 de l'AR du 30/11/11 portant prescriptions de sûreté des installations nucléaires. Règlement technique du 27 mai 2021 déclinant en termes pratiques l'objectif de sûreté nucléaire conformément à l'article 3/1 de l'arrêté royal du 30 novembre 2011 portant prescriptions de sûreté des installations nucléaires