Regulatory Aspects of Criticality Control in Australia

Sergei ZIMIN
Australian Radiation Protection and Nuclear Safety Agency,
PO Box 655 Miranda NSW 1490 Australia
sergei.zimin@health.gov.au

With the creation of Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) the Australian approach to criticality safety was revisited. Consistency with international best practices is required by the Act that created ARPANSA and this was applied to practices in criticality safety adopted in other countries. This required extensive regulatory efforts both in auditing the major Australian Nuclear Operator, Australian Nuclear Science and Technology Organisation (ANSTO), and assessing the existing in Australia criticality safety practices and implementing the required changes using the new legislative power of ARPANSA. The adopted regulatory approach is formulated through both the issued by ARPANSA licenses for nuclear installations (including reactors, fuel stores and radioactive waste stores) and the string of new regulatory documents, including the Regulatory Assessment Principles and the Regulatory Assessment Guidelines for criticality safety. The main features of the adopted regulation include the requirements of independent peer-review, ongoing refresher training coupled with annual accreditation and the reliance on the safe design rather than on an administrative control.

KEYWORDS: criticality safety, nuclear installations, regulatory approach, audit, regulatory assessment, accreditation, training, safe design

1. Introduction

Independent regulation of criticality safety in Australia started with the creation of Nuclear Safety Bureau (NSB) in 1987. Initially the NSB was set up as a part of Australian Nuclear Science and Technology Organisation (ANSTO).

The NSB was established by the ANSTO Amendment Act 1992 as an independent Corporate Body, reporting to the Parliament through the Minister for Health. The following NSB functions were set by the act:

- Monitor and review the safety of nuclear plant owned or operated by ANSTO
- Advise the Commonwealth on nuclear safety matters

Soon after the NSB became an independent Corporate Body an independent criticality audit of ANSTO was conducted [1] and a number of useful recommendations were proposed as a result of the audit.

A Federal Government regulatory agency, Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), was established in 1999 to regulate radiation and nuclear activities of Commonwealth Entities. This important development in nuclear area in Australia coincided with the announcement by the Australian Government of a grant to ANSTO to build a new replacement research reactor (RRR) at the ANSTO site in Sydney by the year 2005. These events contributed to the strengthening of the mechanisms for criticality safety control through licensing of ANSTO facilities. The goal is to achieve a control level that is comparable with the best international regulatory practices in criticality safety.

This paper discusses basic principles of our national approach to regulation of criticality arrangements in Australia. It also includes main result of a criticality review of ANSTO held in October 2000. A number of recommendations for criticality safety improvement were produced as a result of the review. These recommendations are the part of the approach to regulation of criticality safety arrangements adopted by Australia. The implementation of these recommendations is being reinforced through the licensing process for ANSTO facilities.

2. Regulatory principles

ARPANSA issued the three major regulatory documents prepared by ARPANSA and related to regulation of criticality safety:

- Regulatory Assessment Principles for Controlled Facilities [2];
- Regulatory Assessment Criteria for the Design of New Controlled Facilities and Modification to Existing Facilities [3];
- Regulatory Assessment Principles for Criticality Safety [4].

Refs. 2 and 3 are the major regulatory documents that are used by ARPANSA for assessing the safety of Controlled Facilities. They address criticality safety only in general terms. Refs. 2 and 3 require maintaining safe operation both in subcritical facilities, where criticality is not expected, and nuclear reactors, where criticality is planned and must be controlled.

Ref. 4 is the major regulatory document related to criticality safety. This document is used by ARPANSA for assessment of criticality safety documentation submitted to ARPANSA for authorisation. It defines criticality safety as relevant to those controlled facilities where the criticality is not expected. The control of criticality in nuclear reactors is covered by Refs. 2 and 3.

Further details of ARPANSA approach to the regulation of criticality safety are listed in the report dealing with the review of criticality safety arrangement at Australian Nuclear Science and Technology Organisation (ANSTO) [5]. This report lists 13 general recommendations, outlining the major Australian regulatory requirements for criticality safety control, and 17 specific recommendations, dealing with specific arrangements of some facilities at ANSTO.

We do not have our own criticality standards in Australia. Therefore we rely at present on the standards ISO 1709 [6]. We also use extensively different ANS standards [7-9]. Other international best practices in criticality safety have been taken into account in our recent review of criticality safety arrangements in Australia, eg. Refs. 10-12.

Major regulatory requirements listed in Ref. 4 and discussed in more details in Ref. 5 are summarised below.

2.1 Safe design

The major requirement of ARPANSA to criticality safety arrangements in Australia is the safe and robust design of the Controlled Facility. Our regulatory guidelines [4] require Operators to rely on the operational control as a last and supplement measure enhancing criticality safety. The criticality safety must be guarantied by the safe design, eg. through using geometrically subcritical containers, etc.

The design shall incorporate sufficient safety features to ensure that two independent concurrent changes must occur in the conditions originally specified as essential to nuclear ciriticality safety before the system may become critical. Our regulatory guidelines [4] lists number of abnormal conditions which we require our Operators to consider. It is up to Operators to justify the cases of independence of abnormal conditions through a safety case submitted to ARPANSA.

An important example is the flooding and the fire in the fissile material storage. These events are not always independent abnormal conditions since the fire fighters could use water in the event of the fire, even if a special non-water sprinkling system is installed in the fissile material storage. Similar logic could be said about the fire and the earthquake. That said, the appropriate risk assessment should be done in the safety assessment report submitted to ARPANSA for review and, if accepted, authorisation.

2.2 Independent review of criticality calculations

A requirement of ARPANSA for criticality safety arrangements in Australia is the need for independent review of criticality calculations. Such a review must be done independently from the principal assessor. The review must include both criticality calculations and a risk assessment.

Independent calculations of criticality assessments should be done using an independent computer code and using independently acquired data. Such checks are needed to make sure that there are no significant errors in the criticality assessment. This requirement follows from the different situation in practice with regard to criticality calculations compared with reactor calculations:

- In general, fewer different groups of people are engaged in the criticality calculations and there is therefore less automatic and independent checking of data, etc.
- The assumed geometrical arrangement of the fuel is often unlike any reactor situation and there is some difficulty therefore for the physicist to judge the credibility of his results.
- The code may not have been checked against experiments for the conditions being studied.

The independent evaluation of risk assessment is equally important, as the risk assessment shows what scenarios are credible and type of criticality calculations should be done.

2.3 Importance of supporting documentation

The major supporting documentation is the document of nuclear criticality safety assessment. Such a document is not required for all cases. Where the total amount of fissile material is below the set up limit [5], ARPANSA does not require any assessment. However, even in this case a criticality certificate must be issued to maintain good nuclear accounting practice.

The criticality safety assessment should be issued with sufficient clarity and lack of ambiguity. We require that an assessor issue the document with sufficient details to permit an independent judgement of results by an independent reviewer. The document must include the following information:

- A description of the theory of the methodology in sufficient detail, clarity, and lack of ambiguity that allows understanding of the methodology, including validity of assumptions and independent duplication of results;

- A description of the area of applicability that identifies the range of values for which valid results have been obtained for the parameters used in the methodology;
- A description of the use of pertinent computer codes, assumptions, and techniques in the methodology;
- A description of the benchmark experiments and data derived there from that were used for validation the methodology;
- A description of the bias, uncertainty in this bias, uncertainty in the methodology (e.g. from statistics, computational convergence, and nuclear cross section data), uncertainty in the data, uncertainty in the benchmark experiment, and margin of subcriticality for safety, as well as the bias for these items, as used in the methodology;
- A brief description of the software that will use the methodology.

We also believe that the criticality safety certificates and working procedures are of operational importance. Therefore, we required our Operators to clearly issue and review these documents and send the reviewed copies of the documents to ARPANSA. The maximum time of validity of criticality safety certificate is five years. However, where the criticality assessment is needed, the criticality certificate may be issued for a maximum two years or until any changes or modification of the controlled facility occurs over that two-year term.

2.4 Training and accreditation

Training and accreditation in criticality safety is considered by ARPANSA as a key regulatory requirement aimed to make sure that Operators are well trained and competencies confirmed through a formal and rigorous accreditation process. ARPANSA Inspectors will attend the criticality safety accreditations on a regular basis to make sure that the process is rigorous.

The training is important at all levels of the operating organisation and should be commensurate with the level of criticality hazards and responsibility. Managers need to understand the risks associated with different criticality arrangements. Supervisors and operators must be trained in general policies and the specific safety-related aspects of their duties. More details on our current specific to criticality safety training requirements may be found in Ref. 5.

The training program must be conducted on a periodic basis. In practical terms, it means a requirement of regular refresher training every year. The accreditation may be valid for two to three years.

The training program must not be limited to general understanding of criticality theory and practices. It must include:

- Criticality control requirements;
- Limits;
- Operational conditions and practices;
- Analysis of incidents and accidents that could happen in the facility;
- Analysis of accidents that took place in similar facilities.

The training program must be submitted to ARPANSA for a review.

2.5 Criticality alarms.

It is worth to remember that although criticality accidents did not take place in Australia, in some countries criticality accidents have happened [11], and criticality alarms have at least twice initiated life saving evacuation of areas in which accidents occurred. The value of such systems is therefore clear, and their installation is desirable in areas processing potentially critical quantities of fissile materials.

The need for criticality accident alarms shall be considered for arrangements where criticality can not be ruled out either for normal or accidental conditions. Criticality safety alarms have not been installed installed in Australia as license holders claim operations are safe from unplanned criticality both for normal and credible abnormal conditions. This is being reviewed by ARPANSA.

3. Concluding remarks.

The major area of criticality safety regulation in Australia is criticality arrangements where criticality is not expected. The major controlled areas are:

- Dry and wet storages of spent nuclear fuel (SNF);
- Decommissioned reactors;
- Dry storages of fresh nuclear fuel;
- Transportation casks;
- Storages of other fissile and fertile materials;
- Liquid waste arising from fission production of molybdenum.

ARPANSA attention now is centred around the construction of new 20-MW replacement research reactor (RRR), the criticality safety is not a major issue for RRR safety as the criticality both is expected in the reactor and is well controlled by modern automatic systems. The two independent shutdown systems of the RRR further increase our confidence in the RRR safe operation without any criticality excursion.

All major criticality arrangements in Australia are associated with ANSTO facilities. ANSTO has operated more than 40 years without any criticality accident due to the stringent and thorough criticality control at ANSTO and the professionalism of ANSTO staff. The independent regulation of ANSTO criticality arrangements by ARPANSA together with the criticality accident free history of ANSTO operation make us confident that both our national criticality arrangements and their regulation are consistent with the best international practices.

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