Postulate 18.4107: Dose limit values for nuclear installations, radioactive radiation and radiation protection – Begleitbericht			
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1. Introduction

With the aim of fulfilling Postulate 18.4107 a panel of three independent experts has been formed. The 3 authors of the present review form that panel and ensure a balanced composition from the fields of radiation protection and nuclear safety. This panel of experts has first defined the framework conditions concerning the audit report required by the postulate and has then selected the French technical support organization IRSN, judged to be a suitable independent body to draw up the audit report. The panel has prepared a call for tender comprising the three following main questions:

1. How does Swiss legislation on radiological protection compare with international best practices?
2. How can we compare the levels of acceptable risk of a nuclear power plant with other sources of radioactivity dissemination and external irradiations?
3. What are the current discussions in science and research regarding low dose of ionizing radiations?

The panel of experts followed the IRSN work, checked the plausibility of their report and prepared the present review.

2. How does Swiss legislation on radiological protection compare with international best practices?

The question is mostly addressed in chapter 5 of the IRSN report. IRSN has made a survey of different international regulations and recommendations and compares them with the Swiss regulatory framework.

IRSN is insisting that the safety of a nuclear installation is not solely checked by the adherence to a dose limit resulting from the normal operation or an accidental situation but is based on the application of safety principles (defense-in-depth) that are included in the regulative framework (ENSI-Guideline and Swiss regulation). The dose limits are used for checking the application of these prescriptions. In other words, the dose limit must be assessed with the underneath conservatism included in its evaluation or calculation.

Comparing the Swiss regulation to international practices, IRSN points out the following:

- The Swiss frequency of occurrence defined in the Swiss regulation (10^{-4} to 10^{-2}; 10^{-6} to 10^{-4}) for design basis accident are in accordance with the IAEA recommendations.
- The concept of risk constraint associated with potential exposure is used, based on ICRP, in different countries for the design of final waste storage facilities but not directly for the assessment of the safety of nuclear installations.
- The dose constraint defined in the Swiss regulation are conservative (by a factor 10) compared to the recommendation of the ICPR (Chapter 5.2.1 / Table 4).
- IAEA states that the radiation doses resulting from the operation or accidental situation must remain below acceptable limits but does not give specific numerical values. Alike, EURATOM does not set quantitative limits for the radiological consequences in term of estimated frequency of event.
- The 1 mSv criterion for accident with a frequency between 10^{-2} and 10^{-4} is among the lowest value of the dose criteria in the countries considered; the 100 mSv for accident frequency

between 10^{-4} to 10^{-6} is at the upper limit, but in agreement with international standard practice.
As repeatedly written in the IRSN-report, the dose constraints defined in a regulation must always be evaluated / compared by considering the conservatism of their determination, the integration time, the group of people to whom they apply and the location of this group (distance to the accident site). It makes a direct comparison of the applied dose constraint in different countries very difficult due to the sometimes very different approach (as showed by the presentation of the French regulation in chapter 3 of the IRSN report).
For example, in Switzerland the dose must be evaluated for the most affected population group living at the boundary of the nuclear site and eating local food, which is very conservative.

- Switzerland is the only country with a strict application of dose criteria requesting the (temporary) shutdown of the installation in case of noncompliance.
- Swiss regulation applies to all nuclear installations (not only the nuclear power plants); this point is further commented in the next chapter of this review.

IRSN concludes that, in view of the conservatism included in the regulatory guideline and the prescriptive approach using cut-off value in a strict way, the Swiss framework is in good agreement with the international best safety practices for nuclear installations.

3. How can we compare the levels of acceptable risk of a nuclear power plant with other sources of radioactivity dissemination and external irradiations?

The Swiss approach to apply the same criteria (occurrences and consequences) regardless of the type of installation is quite unique. International practice is rather to use probabilistic assessments exclusively on NPPs and, in some cases, other installations of the nuclear fuel cycle. For smaller radiation facilities, deterministic approaches are applied, e.g. eliminate dangerous situations. As illustrated on page 37 of the IRSN report, it is indeed difficult to apply an analogous approach to safety for all types of radiation installations, mainly because of the large variety of such installations with sometimes unique or very specific characteristics.

Having the same approach in the legislation may suggest that a comparison of different radiological risks is easy and straightforward. The IRSN report does not provide a comparison to radon exposure, neither to medical exposures. Radon is for example responsible in average for a yearly exposure in the orders of 1 to 3 mSv/person across Europe. Those values are very similar when looking at medical exposures. Both exposure types thus sum up to several tens and not so seldomly to several hundreds of mSv over a lifespan of any European citizen. However, it is important to note the difference between existing “real” exposures and a potential exposure that may occur within a certain probability and that is calculated with assumptions on a conservative basis. Thus, it is not meaningful to compare values in a simplistic approach given their very different contexts.

While the health risk of a real exposure situation of 100 mSv can be indicated, there is no straightforward link between a legally binding dose criteria used for safety purposes and the risk of any person living in the vicinity of the nuclear installation. If we look above at the perception of risks, an emotional dimension is added to the scientific evidence. Most people perceive the risks from nuclear installations as very high, while other exposure situation, including medical and radon are considered to be of little risk, even though the sanitary impact of the two latter is higher.

With regard to nuclear and radiological accidents, the ICRP recommends adopting a reference level for the protection of the population between 20 and 100 mSv for the first year following the accident. It should be added that reference levels form the basis to define the response strategy. Based on the strategy, protective measures are defined to aim at protecting the population from exposures above those levels. However, it is not a limit that may not be exceeded. Doses calculated in the context of a safety assessment do not consider the effects of protective measures.

Taking into account the difference of how the dose is expressed, how the exposure is calculated and how the criterion itself is defined, it is difficult and mostly not meaningful to simply compare a single calculated dose in order to conclude on the robustness of nuclear safety.

4. What are the current discussions in science and research regarding low dose of ionizing radiations?

This question of the effects of low doses of ionizing radiation was part of a previous postulate[1], for which a report from the Federal Council was published on March 2, 2018. It was also addressed in another recent National Council postulate[2], indirectly asking the Federal Council to update the 2018 report. This demonstrates that the question posed to IRSN in this section is still relevant.

Chapter 6 of the IRSN report addresses this issue with a short discussion of the relevance of the 2018 report, before reviewing recent epidemiological studies related to the risk of developing cancer, developing non-cancerous diseases, and ending with studies currently in progress.

IRSN considers the 2018 report to be of good quality, not exhaustive but comprehensive and well-balanced. It provides a good synthesis of the state of epidemiological knowledge on the effects of low doses in 2018. The conclusions are consistent with the state-of-the-art. Their relevance to the radiological protection system is clearly explained and correct.

Chapter 6 of the IRSN report provides an excellent synthesis of epidemiological studies on Hiroshima and Nagasaki survivors, patients, workers, the environment, as well as the latest syntheses and meta-analyses. These studies clearly strengthen the scientific understanding of the effects of low doses of radiation on cancer risk. It is now shown that excess cancer risk is possible at dose levels of the order of 100 mSv or less, at least for all cancers taken together and for some specific types of cancer. This dose level typically corresponds to what a person living in Switzerland receives on average over a period of about 20 years. Given that in the absence of radiation, the risk of developing any cancer is about 50 %, such an epidemiological result is a demonstration of the quality of recent studies. Several international organizations (ICRP, NCRP, UNSCEAR, NCI) conclude that the evidence for carcinogenic effects of low dose ionizing radiation is increasing and that the assumption of no threshold for radiological protection appears relevant and reasonable.

Several recent studies were published on non-cancer diseases induced by ionizing radiations, namely diseases of the circulatory system, diseases of the central nervous system, lens opacities and hereditary effects. Although a growing number of results tend to show an excess of risk at low doses, the uncertainties remain very large, and the heterogeneity of the results strongly limits the ability to characterize these risks. Within the framework of UNSCEAR, several groups of experts should enable the consolidation of our knowledge in the years to come.

It should also be mentioned that the ICRP has recently begun a process of updating the radiological protection system in which several working groups have been set up, and in which members of Swiss institutions are involved. For example, on the improvement of the classification of the health effects of radiation, on the factors of variation in the individual response to radiation exposure, or on the risks of diseases of the circulatory system. These working groups should also provide new syntheses on the effects of low doses in the years to come.

The main conclusions of IRSN are therefore that the 2018 report remains relevant. It is even strengthened in the sense that the most recent epidemiological studies support the relevance of the linear-non-threshold model as a basis for radiological protection. For non-cancerous diseases, although the trend of an excess risk is increasingly likely, there is not sufficient evidence to currently support it.

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[1] Postulate 08.3475 led to the publication of a detailed report (in French and in German) on the effects of low doses on humans and risk assessment.

[2] Postulate 23.3415, titled "Low-dose ionizing radiation, adapting the recommendations to the current state of knowledge", was submitted on 17.03.2023.

5. Conclusions of the IRSN report

The Swiss legislation is in line with international recommendations and with the legal framework of countries of similar development level. The use of strict limits to require the shutdown of a power plant is a Swiss peculiarity that cannot be found elsewhere, even though the analysis of the relationship between the probability of occurrence of an event and the dose to the population is widely used in our neighboring countries. This difference in approach makes international comparison difficult, and IRSN has refused to do it explicitly. When one attempts to do so, one finds that the limit value adopted by Switzerland is among the highest. However, this is counterbalanced by the conservative scenario of a child living near the power plant and eating local food.

The comparison of the risk from the nuclear industry with other sources of radiation, such as medicine or the environment, has been little discussed in the IRSN report. This is probably because it has long been clear that the tolerability and acceptability of a risk do not depend only on objective and quantifiable factors such as dose, but also on factors such as familiarity with the vector, ethics, affectivity, the nature of the effects, the trust one may have in those in charge, etc. A task group of the ICRP, in which a Swiss representative is involved, is currently working on this subject.

It is also important to point out the difference between an existing exposure, including medical, occupational or natural exposures and a dose limit value, calculated on the basis of assumptions and in relation to more or less probable circumstances.

The main conclusions of the 2018 Federal Council report on risk assessment remain valid. Among other things, the most recent studies support the application of the linear-non-threshold model as a conservative basis for radiological protection in Switzerland, and compliance with the dose limits set in the legislation ensures that this risk is tolerable for the population. This justifies the continued application of the principle of optimization in radiological protection, which consists in reducing doses to the lowest level reasonably achievable.

In conclusion, the IRSN report does not challenge the Swiss legislation and its associated limits.

The three independent experts, and authors of this review, agree with this conclusion.