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Chapter Pilot: P. AUCLAIR *Name/Initials* *Date 25-09-2012*	
Approved for EDF by: A. MARECHAL *Name/Initials* A.Je.Maréchal *Date 26-09-2012*	Approved for AREVA by: G. CRAIG *Name/Initials* G Craig *Date 27-09-2012*

REVISION HISTORY

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00	First issue for INSA review	14.01.08
01	Integration of technical, co-applicant and INSA review comments	26.04.08
02	PCSR June 2009 update: - inclusion of references, - clarification of text - the maximum dose to an individual off-site is set in accordance with Sub-chapter 12.0.	23.06.09
03	Consolidated Step 4 PCSR update: - Minor editorial changes - Update of references	27.03.11
04	Consolidated PCSR update: - References listed under each numbered section or sub-section heading numbered [Ref-1], [Ref-2], [Ref-3], etc - Additional bullet point covering "Zinc injection programme" added to list of optimisation studies (§2)	27.09.12

For information address:

AREVA NP SAS
Tour AREVA
92084 Paris La Défense Cedex
France

EDF
Division Ingéniérie Nucléaire
Centre National d'Equipement Nucléaire
165-173, avenue Pierre Brossolette
BP900
92542 Montrouge
France

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SUB-CHAPTER 12.1 - RADIATION PROTECTION APPROACH

1. PRINCIPLES OF RADIATION PROTECTION

ICRP 60 [Ref-1] proposes recommendations defining the three basic principles applying to Radiation Protection:

The principle of justification

A nuclear activity or operation may be undertaken or carried out only if it is justified by the advantages it produces, notably in health, social, economic or scientific matters, in comparison with the inherent risks of exposure to ionising radiation to which it may subject people.

The principle of optimisation

A person's activities or undertakings must be held at the lowest level of exposure reasonably achievable, taking into account technological, economic and social factors. This is the ALARA (As Low As Reasonably Achievable) principle, which has been applied in the EPR design.

The principle of limitation

The sum of the doses received individually by a single worker exposed to ionising radiations cannot exceed the limits set by the regulations.

The principles mentioned above were expanded on by the European Community in Euratom Directive 96/29 of the 13th of May 1996 [Ref-2]. This directive defines the basic safety norms for protecting the health of workers and of the public at large against the dangers produced by ionising radiation.

The first principle of "justification" states that any exposure to radiation must be justified from an economic and social standpoint.

The second principle of "optimisation" is applied from the design stage to ensure that more design effort is devoted to operational activities identified as high risk in terms of individual and collective doses.

The third principle of "limitation" sets worker and public radiation exposure limits. The UK EPR Safety Design Objectives fix the individual limit for a worker at 10 mSv per year and the limit for the public at 0.3 mSv/year from the EPR unit and 0.5 mSv/yr from the site on which an EPR is located. Employees working on site but who are not likely to be exposed to ionising radiation are considered in the same way as the public.

The following sections and Sub-chapters of Chapter 12 outline the radiation protection strategy which is being implemented on the EPR.

2. SOURCE TERM REDUCTION

The minimisation of radiations exposure and plant activity levels is achieved by optimising the plant radioactive inventory and shielding provisions.

The composition of the primary component materials has a direct impact on the radioactive inventory in the primary coolant, especially on the activation of corrosion products. Therefore, chemistry and radiochemistry are optimised in the EPR design to reduce the primary circuit radioactive inventory and lower the dose rate levels. The optimisation studies [Ref-1] being carried out for the EPR primary circuit chemistry and related material considerations are:

- Material selection: the main requirements are to reduce the amount of Stellite™ based hard facing components in the primary circuit components (e.g. valves, internal reactor vessel components) and to lower the cobalt contents in alloys;
- Design optimisation of the purification systems in compliance with the source terms (RCV [CVCS], PTR [FPC(P)S]);
- Identification of pre-conditioning measures to be implemented prior to the initial start up to passivate the primary circuit;
- Establishing a constant pH value of 7.2 at 300ºC during power operation using enriched boric acid and lithium hydroxide, then controlling the production and transport of corrosion products in the primary coolant;
- Optimisation of chemistry control during cold shutdown phases (e.g. oxygenation of the primary coolant) and reactor start-up phases (nickel monitoring), to limit the release of corrosion products. Then the release of fission products during transients is also controlled;
- Definition of a zinc injection programme, to limit general corrosion of primary circuit material and reduce the length of time that crud resides on the external surface of the fuel cladding rods.

The design and operational improvements which have already been selected to optimise the primary circuit chemistry for the EPR, and hence the primary circuit inventory, are discussed in more detail in section 3 of Sub-chapter 12.2 and Sub-chapter 12.4. Further improvements are being considered and will be reported on during the detailed design assessment phase.

The basis for the design of shielding provisions for the EPR is outlined in detail in section 2 of Sub-chapter 12.3.

3. COMPLIANCE WITH THE INDIVIDUAL DOSE LIMIT

The UK EPR Safety Design Objectives require that radiation doses are ALARP and set an individual dose limit of 10 mSv over 12 consecutive months.

The general arrangements aim, however, at maintaining low dose rates in working areas and satisfactory ergonomics, thus enabling the reduction of individual worker dose.

The actions to optimise the collective doses also enable individual doses to be reduced proportionally (activities carried out by insulators, welders and service staff or mechanics).

4. COLLECTIVE DOSE TARGET

Although no collective dose limit is imposed by regulations, a target value has been defined. This value has to be observed during the various design phases. To this end, detailed studies have been carried out on radiation protection during high-risk activities.

The collective dose objective for the EPR is **0.35 man Sievert per year per unit**, averaged over 10 years, divided into: 0.20 man Sievert on average for a Refuelling Only Outage (ROO), 0.40 man Sievert on average for a Normal Refuelling Outage (NRO), 0.99 man Sievert on average for 10 year outage (in-Service Inspection Outage – ISIO) and 0.09 man Sievert on average during normal reactor operation**.** The methodology applied to achieve this objective is defined in Sub-chapter 12.4. The EPR collective dose target is based on current operational feedback from French NPPs [Ref-1] and takes into consideration the improvements implemented on the EPR. The methodology applied to establish this value is defined in Sub-chapter 12.4.

The main measures taken to comply with the collective dose objective and reduce the individual dose of the most exposed workers are:

- Taking into account the feedback and best practice from the best operational nuclear power plants;
- Reducing the equipment maintenance requirements based on the choice of reliable and suitable materials, taking into account conventional safety and Human Factors;
- Choosing materials which favour a reduction of activated corrosion products (mainly cobalt isotopes);
- Improvements in fuel assembly technology leading to fewer cladding defects (leading to reduced release of fission products).

However, the relationship between collective dose and the parameters which influence it (design, layout, source term, dose rate, exposed work area, operating practices ...) leaves a very wide scope for optimising the organisation of maintenance work and the highest dose activities.

First, basic engineering documents that describe the general principles of dose and source term optimisation and which justify the collective dose target, taking into account the best French nuclear power plants feedback, are produced.

Further studies are then carried out to identify improvements which could be implemented at the project detailed design assessment stage, for example accessibility taking into account Human Factors and conventional safety, measures to isolate radioactive materials within the facility, improvements in ease of fuel handling, possibility of carrying out in-service inspections, use of robotics or automation.

The activities which give the highest doses of radiation are identified and are the subject of detailed studies.

SUB-CHAPTER 12.1 – REFERENCES

External references are identified within this sub-chapter by the text [Ref-1], [Ref-2], etc at the appropriate point within the sub-chapter. These references are listed here under the heading of the section or sub-section in which they are quoted.

1. PRINCIPLES OF RADIATION PROTECTION

[Ref-1] 1990 Recommendations of the International Commission on Radiological Protection. ICRP Publication 60. Ann. ICRP 21 (1-3). 1991. (E)

[Ref-2] Council Directive 96/29/EURATOM of 13 May 1996 laying down basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionizing radiation. Official Journal of the European Communities, L159, Vol. 39. June 1996. (E)

2. SOURCE TERM REDUCTION

[Ref-1] EPR – Source term. Letter ECEP081158. EDF. October 2009. (E)

4. COLLECTIVE DOSE TARGET

[Ref-1] EPR – Establishment of the reference dose, taking into account the statistics from the best French nuclear plants – ECEIG040828 Revision A1. EDF. April 2009. (E)

ECEIG040828 Revision A1 is the English translation of ECEIG040828 Revision A.