A CORPORATE ALARA ENGINEERING SUPPORT FOR ALL EDF SITES
A major improvement: the generic work areas optimisation studies

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Summary
ALARA studies performed by EDF plants are quite simple and empirical. Most often, feedback experience and common sense, with the help of simple calculations allow reaching useful and efficient decisions. This is particularly the case when the exposure situations are not complex, within a simple environment and with a single source, or one major source. However, in more complex cases this is not enough to guarantee that actual ALARA solutions are implemented. EDF has then decided to use its national corporate engineering as a support for its sites. That engineering support is in charge of using very efficient tools such as PANTHER-RP. The objective of the presentation is to describe the engineering process and tools now available at EDF, to illustrate them with a few case studies and to describe the goals and procedures set up by EDF.

1. A strong EDF commitment to facilitating ALARA implementation on sites: the corporate engineering support

1.1 Initial situation

ALARA studies performed by EDF plants are quite simple and empirical. Most often, feedback experience and common sense, with the help of simple calculations allow reaching useful and efficient decisions. This is particularly the case when the exposure situations are not complex, within a simple environment and with a single source, or one major source.

However, in some cases this is not enough to guarantee that actual ALARA solutions are implemented. Common sense is not able to handle complex situations when many sources contribute to the dose rate at the workplace, when the workloads at the same workplace are very different from one outage to the other and when some old materials may be removed or new ones installed during an operation, modifying then the radiological context. Furthermore the single use of feedback experience may lead to maintain practices without taking care of progresses due to technological and knowledge improvements. Therefore, it is then necessary to perform more complex analysis relying on the use of quite sophisticated radiological protection software's and codes. Such codes are not available at the site level, where there are no resources (specialists and time) to use them.

1.2 Objectives and Resources

Since 1991, EDF has established a national ALARA programme with a very effective result in terms of dose reduction. Of course, EDF management has decided to further improve occupational exposure management and dose reduction (both collective and individuals). One key element allowing reaching the new goals is the set up of a national corporate engineering as a support for EDF sites for quite usual interventions.

That engineering support consists of a growing up team comprising at the moment about ten engineers, including CAD specialists and health physicists. It is in charge of using very efficient tools such as PANTHER-RP to perform national modelling studies concerning the reactor and auxiliary buildings areas, which are the most costly in terms of doses. That tool has been developed initially for the first steam generator replacements by EDF SEPTEN engineering department. It uses up to date and friendly user 3D software's to create a geometrical model of the concerned area with all existing materials (pipes, valves, concrete walls…) allowing visualising on personal computers, each area from all perspectives.

Other important inputs for PANTHER RP are the quantities of radioisotopes present in each material. The code allows then estimating the dose rates at each location in the area, calculating the contribution of each equipment (i.e. sources) in the area to the dose rate in each point; calculating also the contribution of each radio element to the dose rates.

With the help of these models, the engineering is then able to perform in depth generic work areas optimisation studies, taking into account the workload in each workstation. Up to recently these studies were performed only for huge operations such as steam generator replacements, they are now proposed to EDF sites for more usual interventions. The selection of these interventions takes care of - the dosimetric cost of the operation(s) performed at the workstation(s); - the complexity of the environment (multiple sources); - the repetitiveness of the jobs (either on a single unit or on several ones). One may estimate that there are about ten such situations per type of reactor: operations performed in the vicinity of the reactor coolant valves, operations performed in the reactor pool, operations performed in the vicinity of the secondary side of the steam generators, maintenance interventions on the DHRS and CVCS heat exchangers…

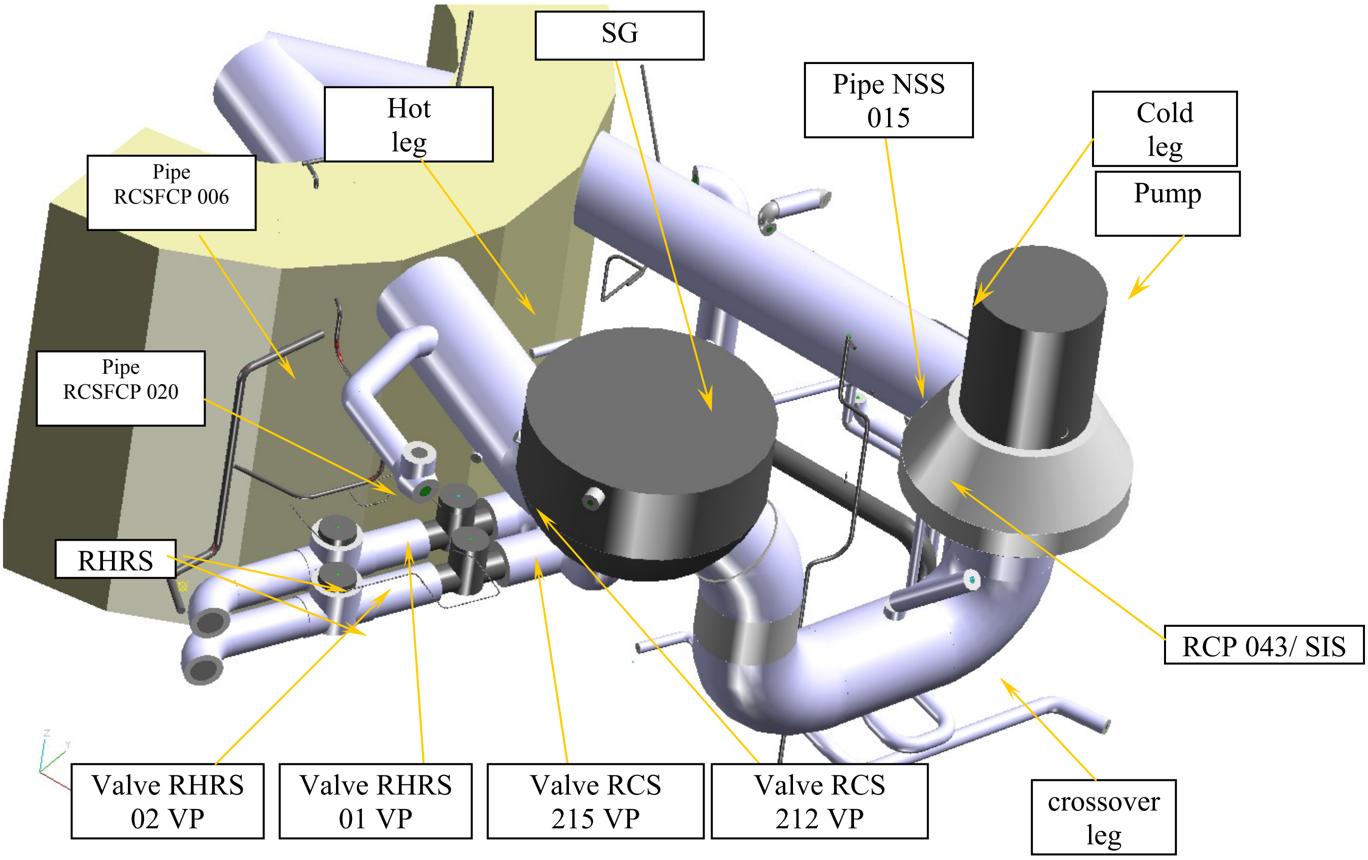
2. The generic work stations optimisation studies: example of the work areas in the vicinity of the primary coolant valves.

One example has been selected here. It concerns the possible reduction of occupational exposure at the workstations situated nearby the primary coolant valves (between 30 and 150 man-mSv before optimisation according to the contamination level of the circuits for the 900 MW units).

As regards the three criteria already mentioned:

- The dosimetric stake is important not only in terms of collective dose but also for individual doses, as only 15 workers are concerned.
- Secondly, more than ten materials (or parts of) are contributing-sources to the dose rates at the workstation (primary pipe hot leg, primary pipe cold leg, U primary pipe, RCS / DHRS valves, Reactor cavity and spent fuel pit cooling and treatment system pipes…) as may be seen on the Figure one, which is the result of the geometric analysis with the 3D software.
- Finally, at each outage, some inspections are performed on these valves.

Figure 1: Location of sources in the surrounding area



The number and type of inspections depends on the type of outage. Three main work scenarios are possible:

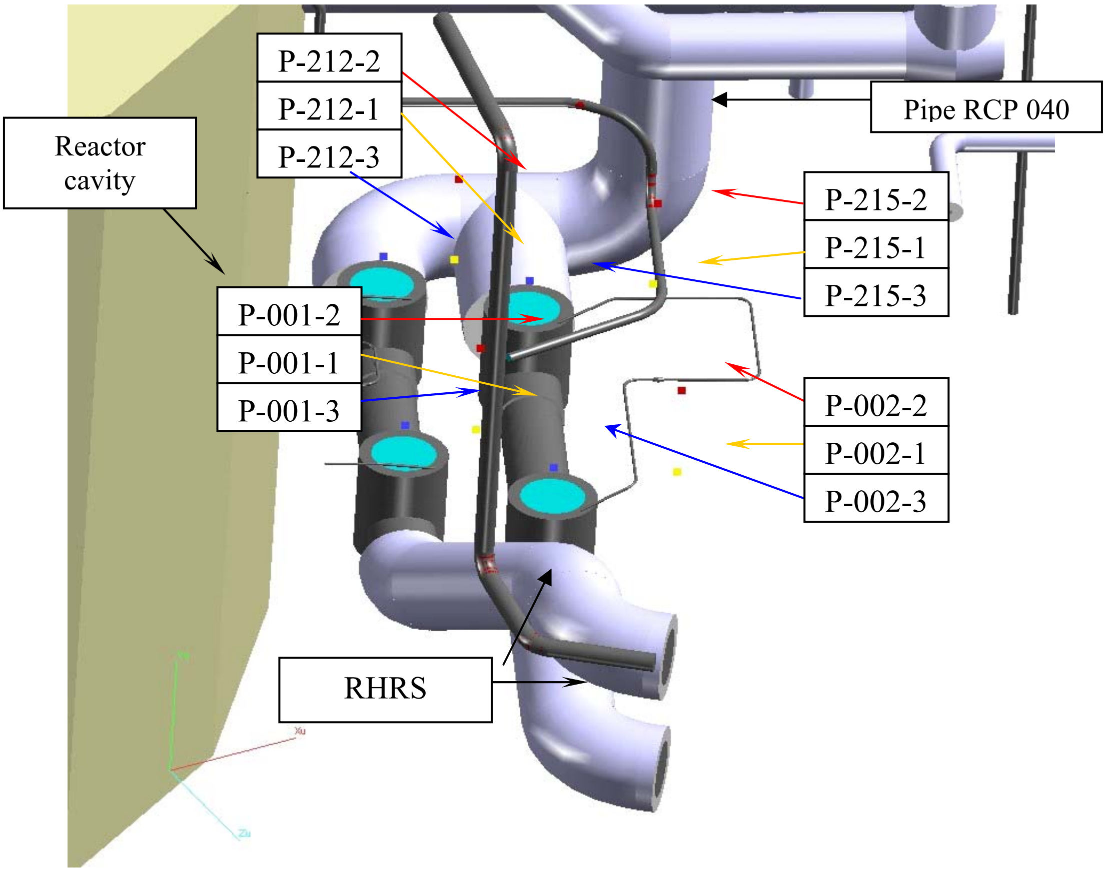
- Scenario 1: simplified inspection of one Reactor Coolant System/Decay Heat Removal System valve.
- Scenario 2: one complete inspection and one simplified inspection of one Reactor Coolant System/Decay Heat Removal System valve.
- Scenario 3: one complete inspection of two Reactor Coolant System/Decay Heat Removal System valves and one simplified inspection of one Reactor Coolant System/Decay Heat Removal System valve.

The possible options are the installation of biological shielding (different thickness), optimisation of water movements, chemical decontamination of the RCS and DHRS valves and nearby pipes with different processes, flushing, and removal of active materials…

The study is first performed using radiological data such as the contact dose rates and the sources spectrum for each material (or part of) from a representative unit (here Tricastin 1) with no specific pollution or hot spot.

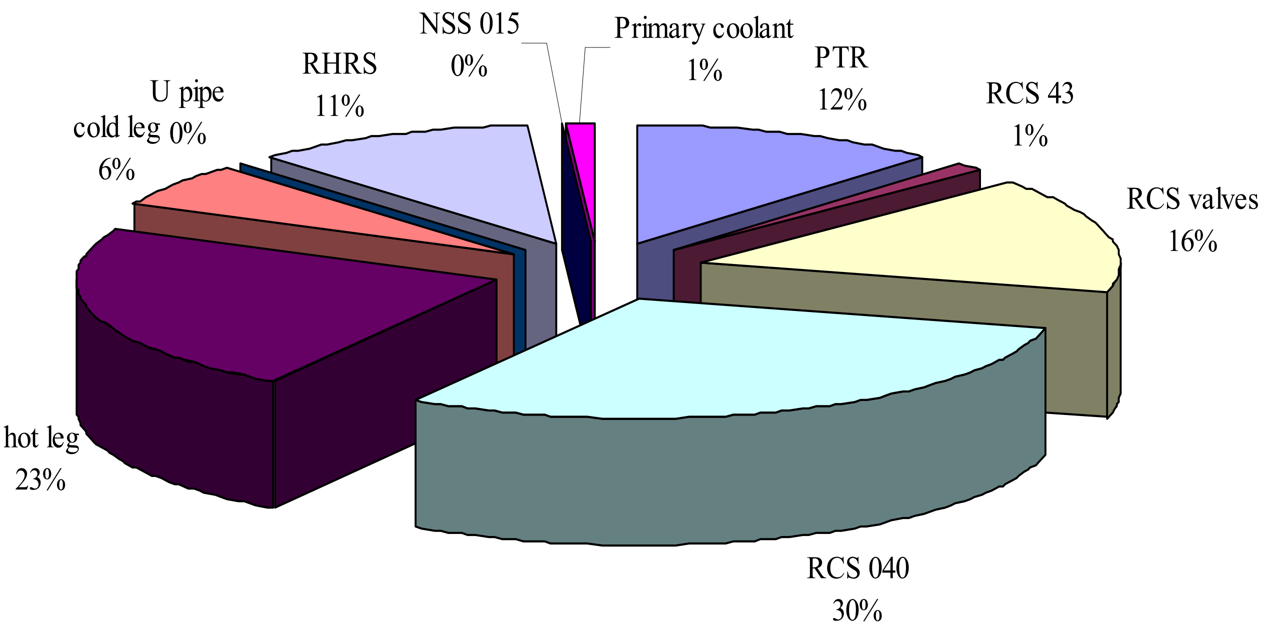
It is then possible to locate all precise positions of the workstations with regards to the different materials as may be seen on Figure 2.

Figure 2: Location of the workstations



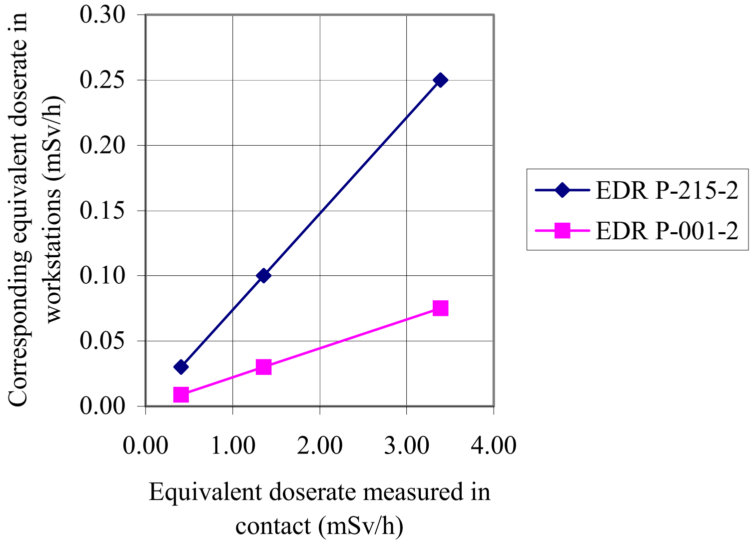
Knowing the location of the workstation and the radiological environment data, PANTHERE-RP allows providing the contribution to the dose rate at each workstation from each source, as illustrated for the workstation RCP 215 VP in Figure 3.

Figure 3: Contribution to the dose rate at the workstation RCP 215 VP from each source



It is then possible to provide an abacus providing the relationship between a contact dose rate (for a specific material) and its contribution in terms of dose rate at a workstation. This is illustrated on Figure 4 for the impact of the source “pipe RCP040” on the dose rate at the workstation RCP 215 VP. Taking into account the time spent at the workstation, and the measured dose rate on the pipe RCP 040 in a specific plant, the dose due to that specific material (i.e. source) is now easily estimated at the workstation RCP 215 VP. It is also therefore quite simple for that Plant to test the efficiency in terms of dose reduction of protection actions such as biological shielding installation between the source and the workstation. EDF has set up a pragmatic decision making rule: the installation of a biological shielding is worthwhile any time the dosimetric cost of its installation is overcompensated by more than 20%. In the case of the pipe RCP 040, it has been envisaged to install 1500 x 300 mm lead blankets (6mm thick) in two thickness at the workstation side (option 2.1), or the same in two layers, i.e. four thickness at the workstation side (option 2.2).

Figure 4 -



The combination of the three above mentioned scenarios with the two options and the decision-making rule lead to the following selection of option as a function of the contact dose rate on the pipe RCP 040.

Table 1: Selection of biological shielding option at the workstation RCP 215 side as a function of the contact dose rate on RCP 040

	0.2 mSv/h $\leq$ d < 1 mSv/h	1 mSv/h $\leq$ d < 2 mSv/h	2 mSv/h $\leq$ d
Scenario 1	Option 2.1		
Scenario 2	Option 2.1		Option 2.2
Scenario 3	Option 2.1	Option 2.2	

The previous table shows that a simple decision tool is now provided to all 900 MW units as an output from the use of more sophisticated tools by the national engineering support.

Another output from PANTHERE-RP is to providing the influence of each radio element, from all sources (and each source) on the dose rate at any workstation. This is of particular interest when analysing the efficiency of decontamination. In the previous example, it is foreseeable to decontaminate part of the circuit as shown on Figure 5 with the chemical EMMAC process.

Figure 5: Part of the circuit to be decontaminated

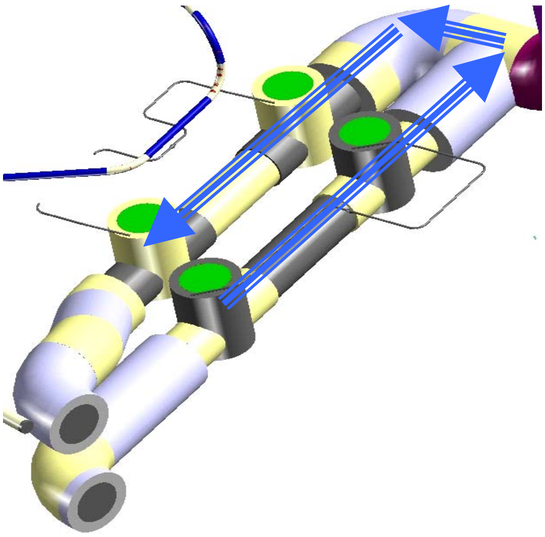
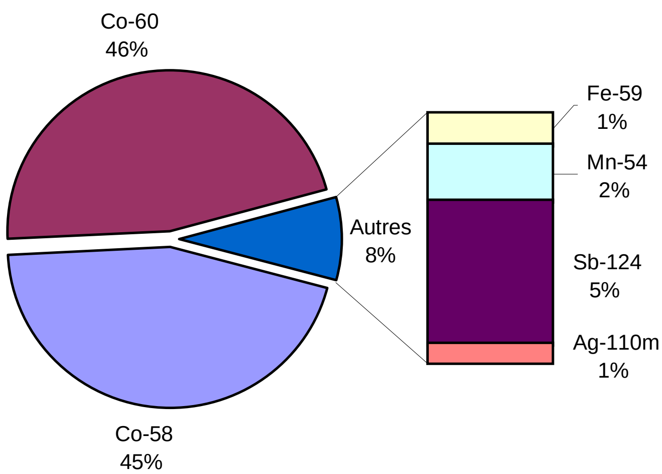


Figure 6: Contribution of the different radio elements to the doserate at the workstation



On Figure 6, one may notice that Cobalt 58 and 60 generate nearly all (92%) the dose rate at the workstation, in the same proportion (about 46% each). Having in mind that recontamination from Co_{58} will reach the same level after only one operating cycle, while the level from Co_{60} will only be reached after seven cycles, it may be estimated that, even if the decontamination factor is 100%, at the end of the next cycle already 46% of the previous contamination will be present again in the circuit due to Cobalt 58.

When decontamination is implemented, it will be performed after the installation of shielding and opening of the valves, but before the maintenance itself. The software allows then estimating a reduction by 45% of the collective dose for the jobs during that outage. The later years the decontamination will impact all the doses (including installation of shielding) but with a reduced efficiency. Therefore the percentage of reduction of collective dose after one year will only be 22.5% and after two years 20%.

The decision to do or not to do decontamination is not as trivial as the one for installing the shielding as the estimated cost of the decontamination is 100 k€. In that case a reference monetary value of the avoided man milli Sievert of 1800 € is used. A cost benefit analysis is performed. It shows the importance of the sensitivity analysis, particularly when the ratio Cobalt 58 /Cobalt 60 varies, which is the case when going from one plant to another.

It is then very important for each unit to be able to have quite a good knowledge of its sources spectrum. This will be more and more easy to do with the new portable spectrometer in test at EDF. It is then interesting to note that the tools developed for modelling are totally complementary to those developed for measuring dosimetric data.

3. Relationships between the site and the national engineering support

As illustrated in the previous example, the studies performed by the engineering support will allow:

- Determining the contribution of each source and radio element on each dose rate at a workstation
- Characterising exposure situations by answering to where?, when?, and how are doses undertaken?
- Identifying radiological protection options for reducing the exposures
- Quantifying the efficiency of these options
- Selecting the most pertinent options within an associated validity domain

Of course this will only be achieved with a good co-operation between the plant teams and the national support. Most often, a plant originates the demand of a study after a first analysis by a local multi-disciplinary team, including health physicists, technical specialists and when necessary operators, planners… After a study of the demand by the national support, a kick off meeting between the plant and the national engineering support allows discussing and freezing the maintenance scenarios presented by the plant, checking the exposed workload data provided by the plant for each scenario, defining precisely the position of each workstation, and discussing all available feedback experience information both on dose-rates and radiological protection actions performed in the same area at different occasions (in the plant or in other similar plants).
As of necessity, the national corporate engineering makes then complementary spectrometry measurements to have a better knowledge of the spectrum of each source.

All the data being made available the national engineering support proceeds to the study and issues several documents (radiological context presentation document, geometrical context presentation document by the CAD team, document on optimisation of radiological protection for each maintenance scenario, validation feedback document after implementation…).

In the optimisation of radiological protection document the French sites are provided, as often as possible, with abacuses or synthetic tables allowing them to select the most adapted solution corresponding to their own situation.

4. Conclusion 2004 2007

During the next four years, most of the models corresponding to all interesting situations will be created both for 900 MW units and 1300 MW units. It is a very important industrial investment but there will be soon a return on investment by allowing quick answers to questions from the sites. In fact, the national support studies may take a few man-hours to a few man-months depending on the complexity of the situation. The modelling of more and more areas in the reactor building being available, the new demands from the plants will be quicker to be answered to.