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DOSE INDEX: A FACTOR TO ESTABLISH THE RADIATION SOURCE TERM IN NPP OUTAGES.

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Introduction

It is known that 90% of the collective dose an a LWR NPP is received during the outage period. The Ascó NPP Radiation Protection Service has established a simple parameter that makes it possible to accurately know the source term during NPP outages. This index is obtained by dividing the collective dose (man·µSv) by the work load (man·hours); both are obtained from the operational dosimeter control system. This factor, in µSv/hour, represents the average dose rate received by workers performing tasks in the controlled area.

This document shows a presentation methodology of the different parameters; all of them related with the dose index in order to take out valuations and conclusions on the global or specific radiation source term of each activity or task during the outage period, in addition to the work load associated and therefore the collective dose reached. All of this allows us to have a broader scope of information to assess the results from an ALARA point of view.

Development

The proposal of different forms of presentation in relation with dose index parameters are:

- Global evolution of the daily and accumulated work loads throughout every outage day.
- Global evolution of the accumulated dose index in the lapse of the outage.
- Same nuclear power plant intercomparison of the different work loads and dose index reached at the end of their respective outages.
- Final outage dose index intercomparison of different Spanish nuclear power plants.
- Daily work loads and accumulated dose index evolution throughout outage days when referring to outstanding outage activities.
- Work loads and dose index intercomparison of the different outages for a same facility.

The daily work load in three different sites is shown in figure 1 (Santa María de Garoña, Almaraz and Ascó).

For each site a similar form of the graphs is observed, consequent for a same plant and outage, of a working plan with a similar rate and scope. The periodic diminutions in the daily work loads belongs to Sundays.

The difference between pressurized water reactor and boiling water reactor work loads is easily observed.

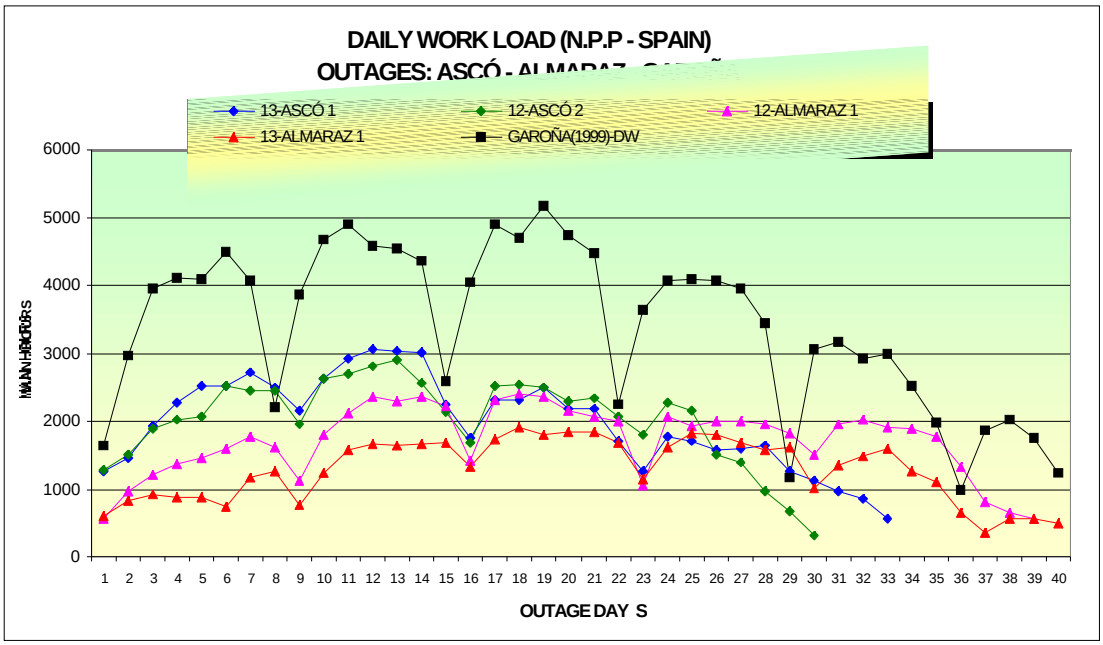

Figure 1

Accumulated work loads for different sites is shown in figure 2. This graph corroborates the information on the previous page.

The final work load between PWR plants is sensibly alike even if there are diverse work systems (curve gradients).

The similarity between Ascó I, Ascó II and Vandellós II NPPs is checked , because of a similar working organisation and also similar contractor enterprises. This approach contrasts with the different system developed by Almaraz with less daily work load and as a consequence a lower gradient in the accumulated work load representation, although with a longer outage duration than the aforementioned. This performance leads to a resembling final work load.

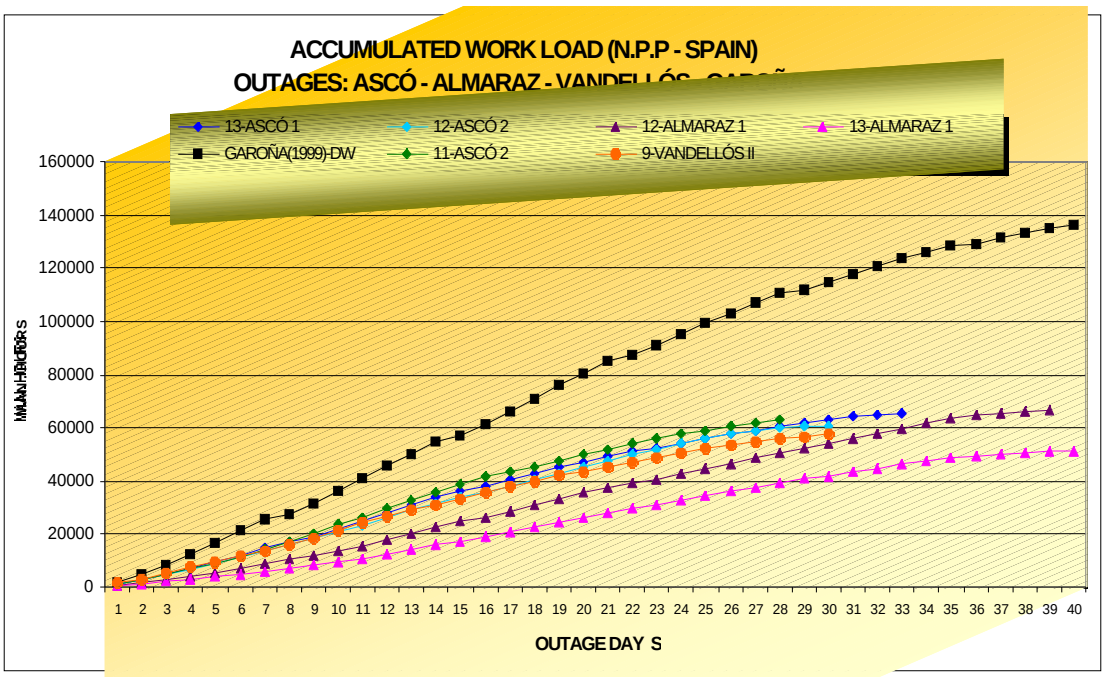

Figure 2

An interesting representation is collected in figure 3: the daily work load in man · hours and the accumulated dose index for three outages at Ascó; the 11th and 12 th of the Unit II and the 13 th of Unit I.

The coincidence, for a similar work load during the 11th and the 12 th Ascó II outages of day a day accumulated dose indexes, induce ourselves to think that this parameter for a same scope and load work has a practically constant characteristic; we will use this characteristic for outage collective dose forecasting, and at the same time during the first outage days as an indicator of the radiation source term in NPP outages.

For instance, in the graph of 13 th Ascó I outage, it is observed that this outage was subjected to a radiation source term 20% lower than the last Ascó II outages. This fact is already noticed in a very early way at the beginning of the outage. This is not always is obvious through direct measurement by the portable gamma survey meter due to the heterogeneousness of the radiation field in Controlled Area (basically in the Containment Building).

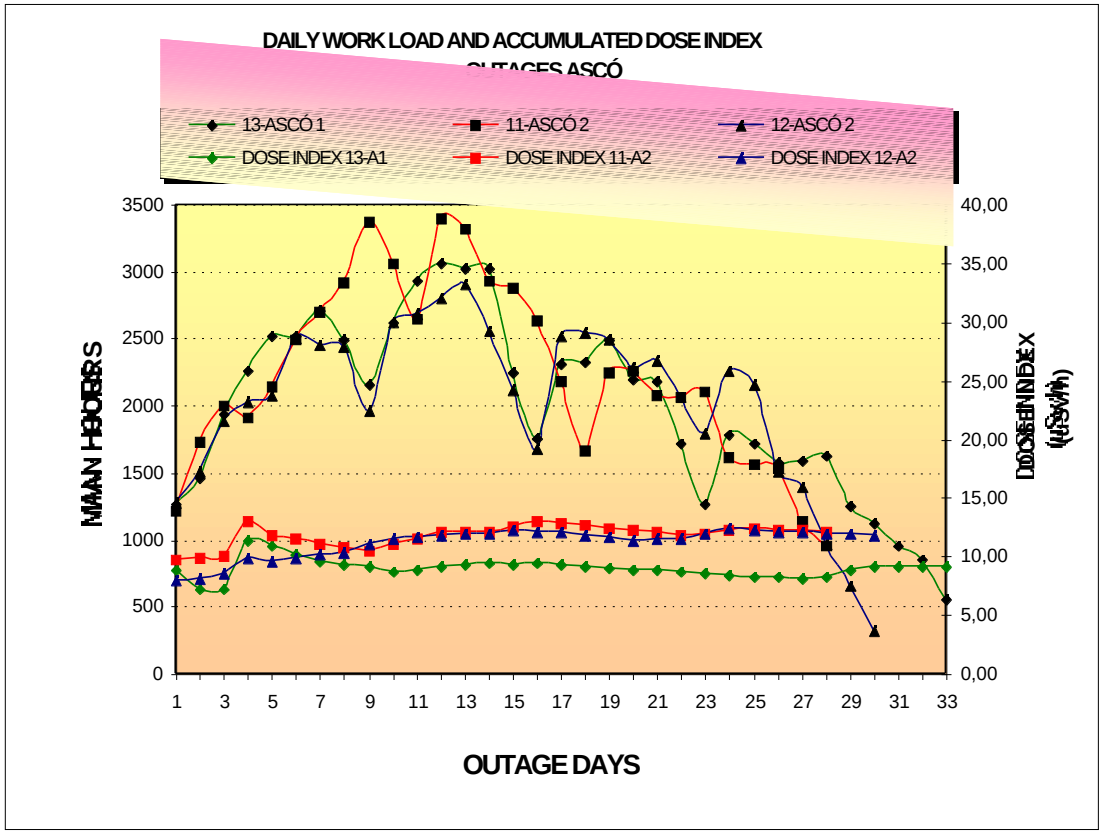

Figure 3

Particularly in Santa María de Garoña BWR, the dose index study can be separated in two indicators because there are two specific large areas: through dry well dose index and the outside dry well dose index (figure 4).

Specifically, in the dry well area, similar to inside loop areas of a PWR Containment Building, it is observed that it is the biggest radiation source term in a BWR and for this reason a radioactive decay of fission and activation products present in the zone with an equivalent half-life of 30 days is also observed through operational dosimeters.

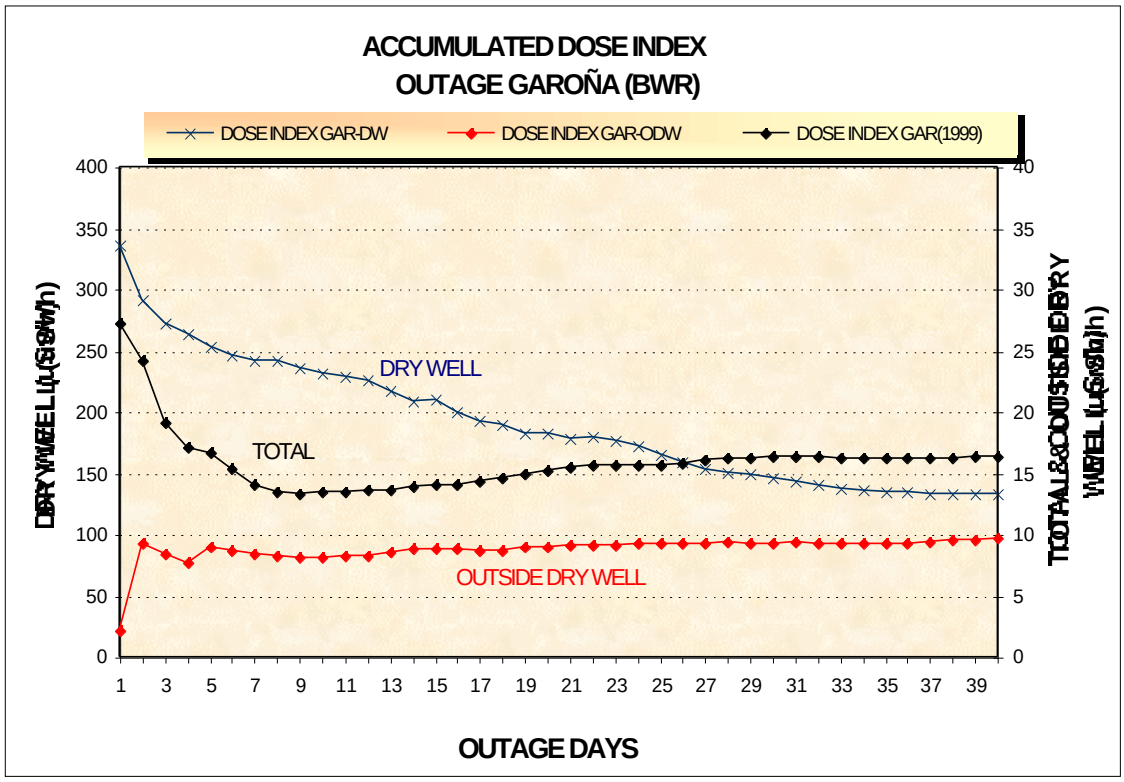

Figure 4

Dose indexes between Vandellós II, Almaraz II and Ascó I are compared in figure 5.

Vandellós II is considered a third generation PWR plant in Spain, however the dose index is higher than Almaraz and Ascó NPPs after the Steam Generator replacement at these plants. The new Steam Generators made of Incoloy 800, contain small Cobalt impurities resulting in a very important reduction in the generation of activation products (Co-58 and Co-60), which add to a diminution in Steam Generator maintenance and inspection work. These aspects give a notable radiation source term reduction during the outage period.

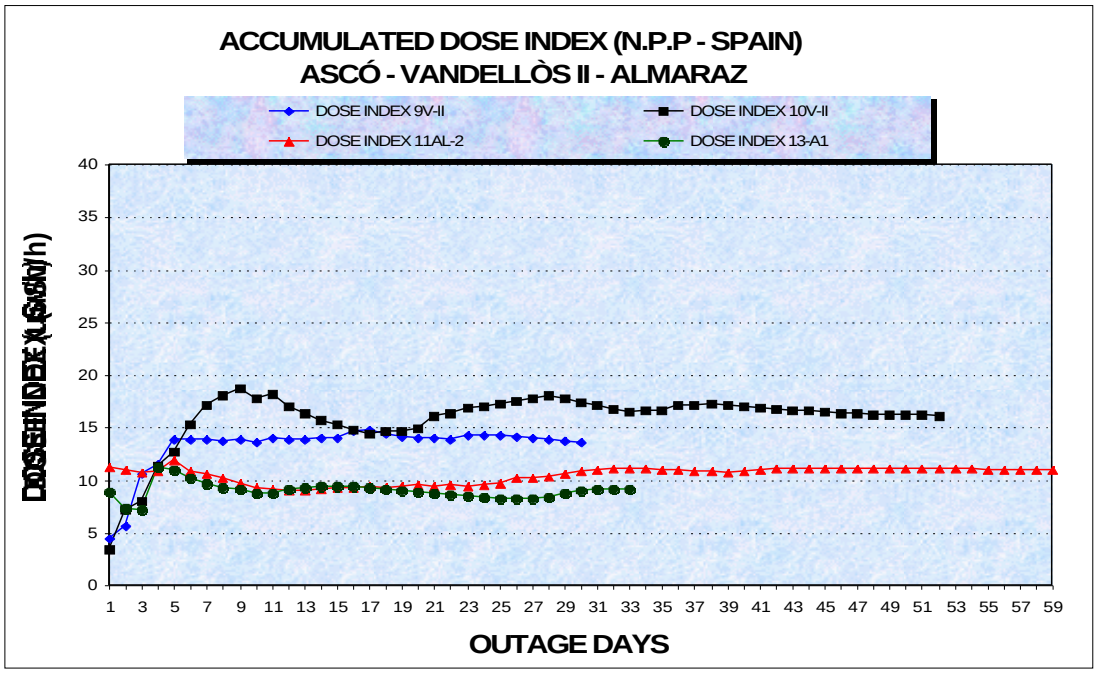

Figure 5

The final collective dose index in the last outages of Ascó I and Ascó II is offered in the figure 6.

The decrease of the dose index from the Steam Generator replacement is observed. These replacements were done during the 11th Ascó I outage and the 10th Ascó II outage, respectively.

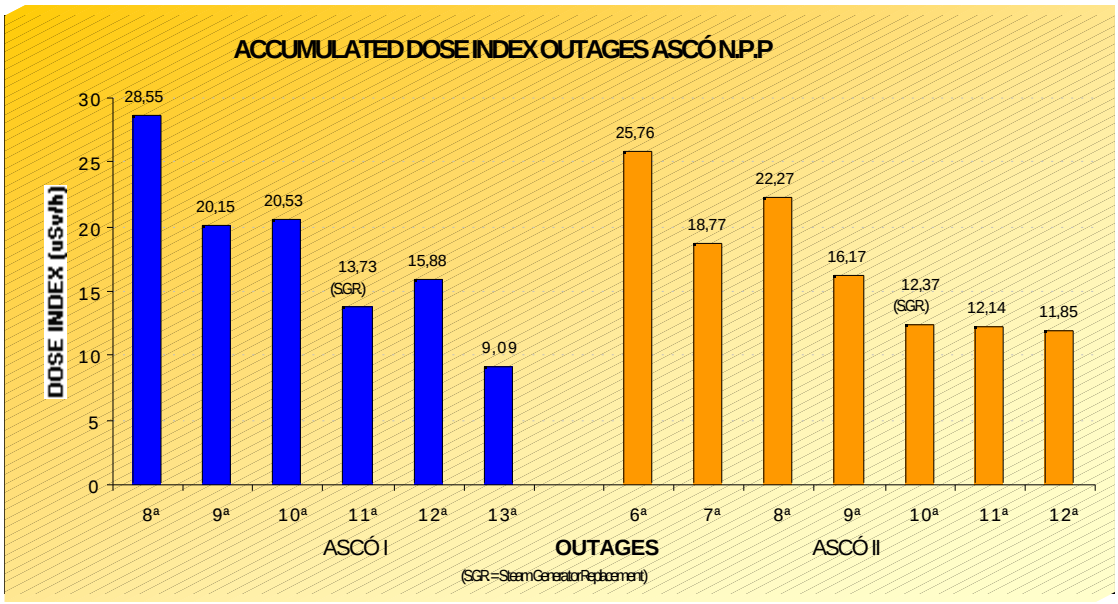

Figure 6

Subsequently, after these Ascó outages a new plan exists referring to the duration and above all the scope on maintenance work. This share diverses work loads as is illustrated in figure 7.

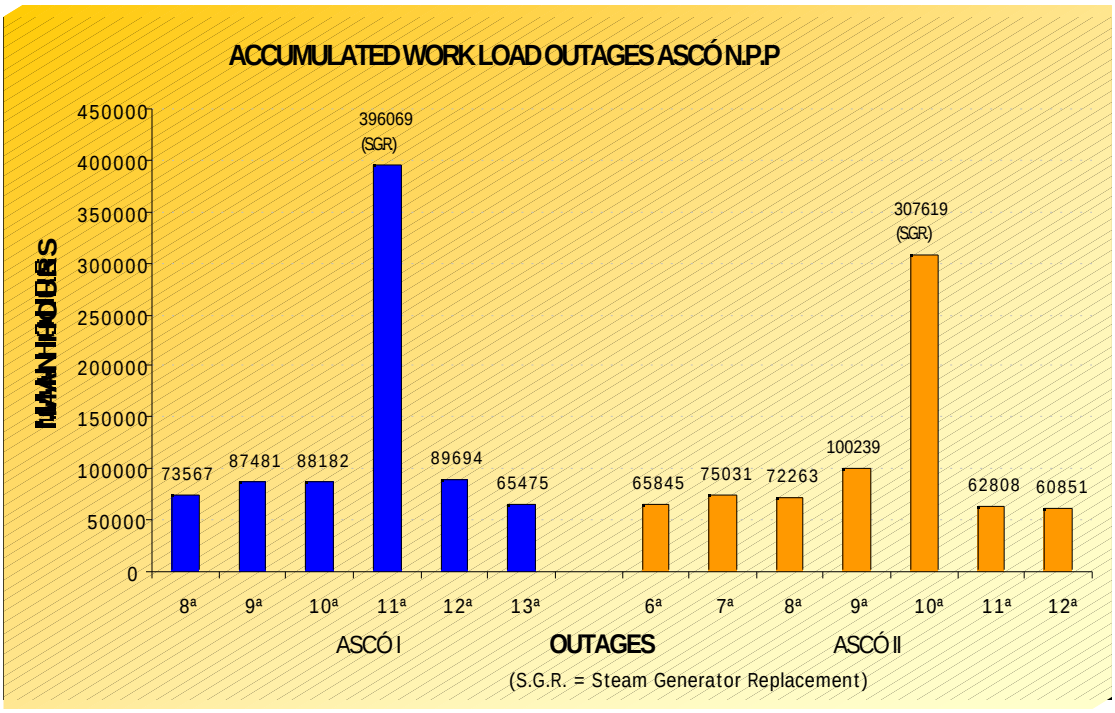

Figure 7

The dose index of the last outages of different Spanish nuclear power plants is shown in figure 8. These factors give us a comparative idea of the different radiation source terms that workers are subject to in the plants.

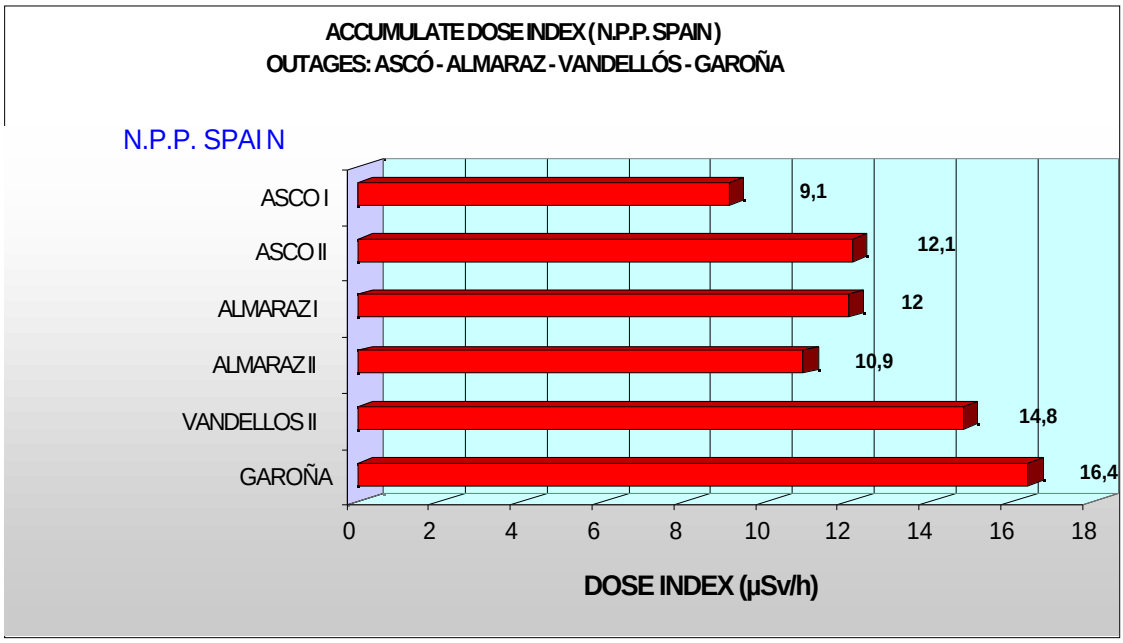

Figure 8

The daily work loads and accumulated dose index evolutions, through their appropriate representation, allow us to take out specific valuations of the radiological performance, radiation source term and ALARA of different activities during the outage period. These valuations are more obvious if we compare different outages at the same plant.

The tasks carried out for this follow up are basically developed through all outage days. These tasks will be more reliable if they last longer and if the daily work load is more similar. The plant tasks related to cleaning and decontamination are a good example.

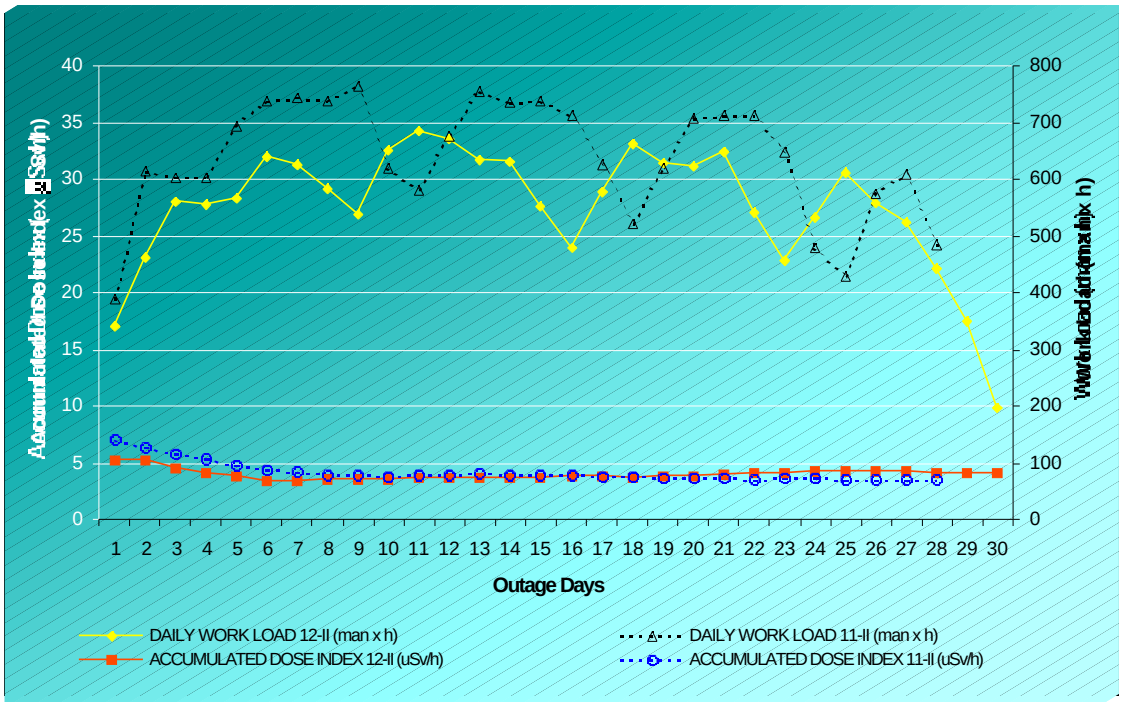

Figure 9. Ascó II outages - Cleaning and Decontamination

In the last four Ascó outages this activity has resulted as an average of 27.8 % of the total work load and 8.9 % of the total collective dose, with few discrepancies between them.

The accumulated dose index of the 11th and 12th Ascó II outages is compared in figure 9. The coincidence in the evolution can be observed, since these outages had a more global radiation source term likeness.

In the same way, the radiation monitoring tasks in the last four Ascó outages have supposed an average of 7.2 % of the total work load and 4.3 % of the total collective dose. The coincidence in the evolution of this index is recognized in figure 10, as well as the similar value obtained in the two last Ascó II outages.

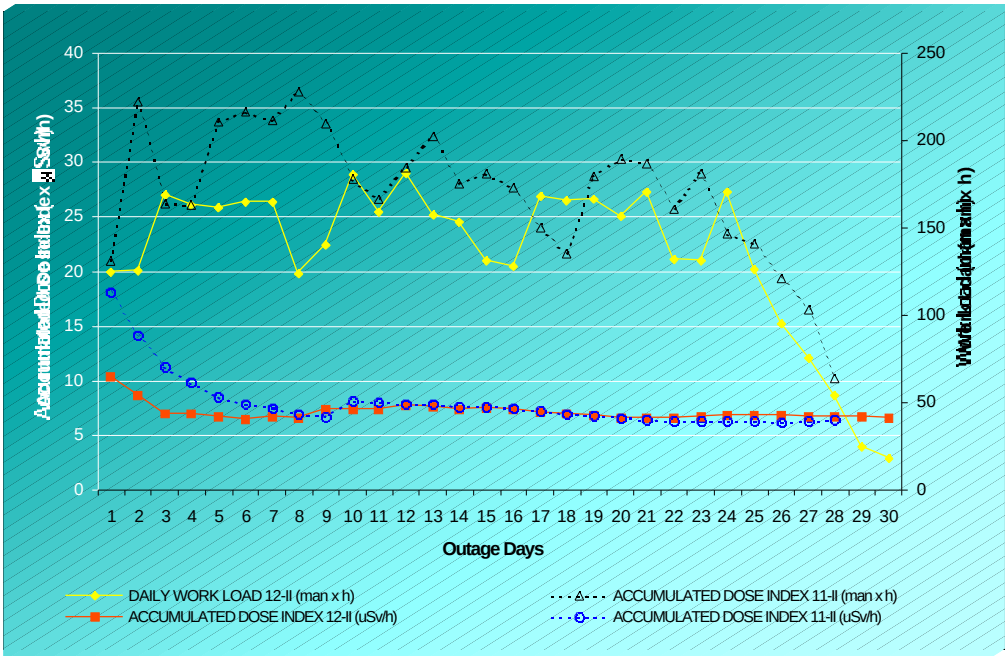

Figure 10. Ascó II outages – Radiation Monitoring

The same graph for Operation tasks is presented in figure 11.

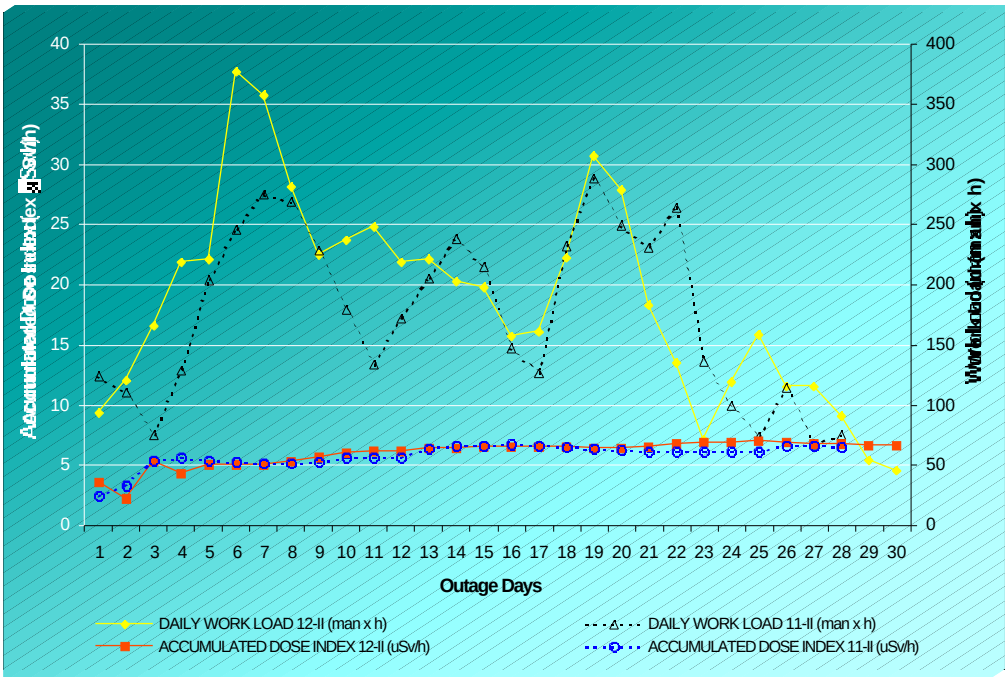

Figure 11. Ascó II outages – Operation tasks

Each task in a specific facility has a determined form of evolution. In this way the dose index due to valve work also keeps a similar style between outages (figure 12).

The differences between outages of this indicator depend on the kind of valves to check. The number of valves that will be inspected and repaired during half level primary loop (9th to 15th outage days), influence through an increment, definitively in the final index.

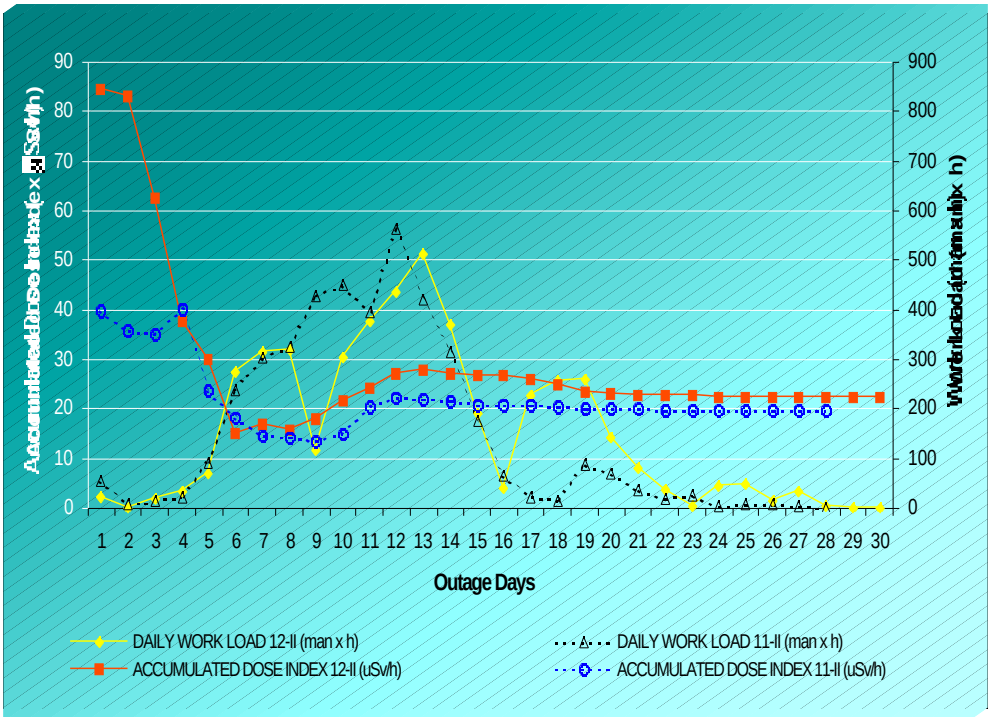

Figure 12. Ascó II outages – Valve work

The forms that present accumulated dose index curves in insulation work is offered in figure 13. The preliminary work on removal and final work on replacement of this insulation is perceived in figure 13.

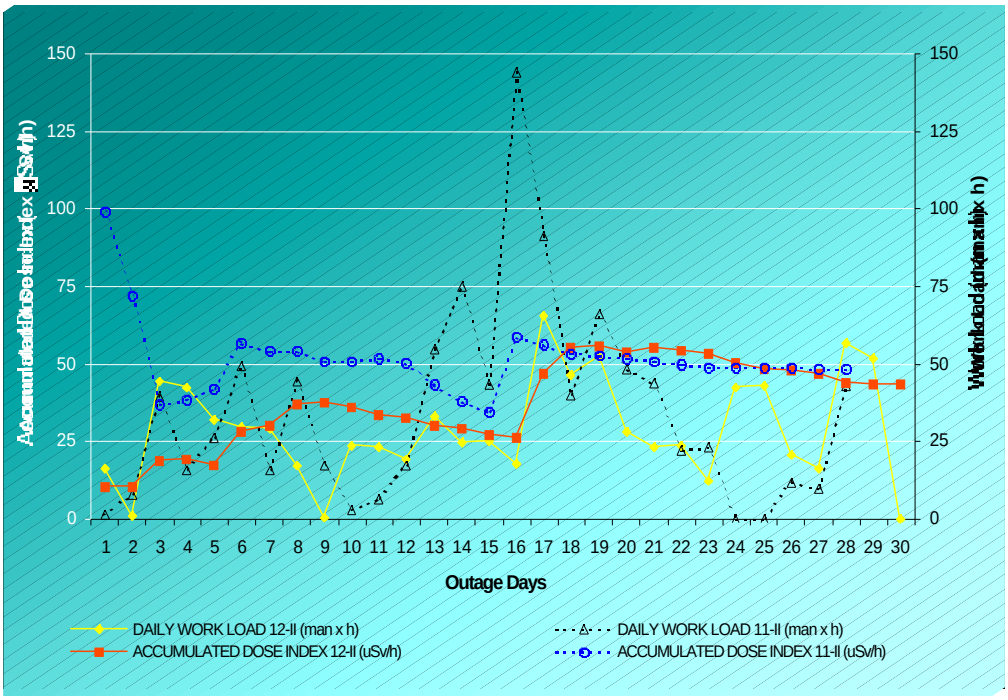

Figure 13. Ascó II outages – Insulation work

Conclusions

It has been observed that throughout a normal outage, there are few fluctuations of this Dose Index factor calculated on a daily bases. Because of this, it is possible to know, a few days after initiating the outage, if the source term is higher or lower than in other outages, due to operation of the plant, changes of RCS chemistry, modifications, etc.

A quite precise estimation of the total dose for the whole outage can be done if no additional source term reduction measures are taken. The application of this factor for specific tasks (decontamination, valve work, health physics, operation, insulation, etc.) also allows to evaluate their contribution to the global outage dose.

From the final work loads and dose index data bases of each outage activity, every one of the collective doses for the next outage can be estimated, keeping in its mind, the specific work scope.

In case of obtaining collective dose deviations with regard to estimates, the dose index allows us to know if this fact has been motivated, by for radiation source terms different to those expected, things that are not always obvious through direct measurement by the portable gamma survey meter due to the heterogeneousness of the radiation field, or by for a different forecast of the work load.

Finally, the Dose Index can also be used to compare effective source terms of different NPPs. The total result obtained (collective dose) can be separated as a product of two factors: the radiation source term (dose index) and the work load employed in the Controlled Area (man hours of operational dosimeters). This approach allows us to consider the ALARA effort of the plant.

Acknowledgements

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