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I S O E   I N F O R M A T I O N   S H E E T

OCCUPATIONAL EXPOSURE AND STEAM GENERATOR REPLACEMENTS

ISOE European Technical Center - CEPN Information Sheet No. 1

Within the framework of the ISOE system (international Information System on Occupational Exposures), five NEA 3 questionnaires concerning recent steam generator replacements have been supplied to the ISOE data base. These are supplemented by other data taken from the literature, from utilities reports and from the ELECNUC data base of French Atomic Energy Agency.

This ISOE Information Sheet presents an overview of the exposures and main characteristics of all the Steam Generator Replacements (SGR) which have been performed in the world through December, 1993. It also shows the impact of a SGR on the total collective dose after a SGR.

1. SGR Collective Exposures

The first Steam Generator Replacement took place at Surry unit 2 in 1979. Table 1 presents the collective exposures corresponding to the seventeen steam generator replacements performed (for a total of fifty steam generators) from 1979 to 1993.

Table 1. **Steam Generator Replacements (SGR) f'rom 1979 to 1993**

Country	Plant unit	Replacement year	No. of Loops replaced	Total Collective Dose (manSv)	Collective Dose per SG (manSv)
USA	Surry 2	1979	3	21,41	7,14
USA	Surry 1	1980	3	17,59	5,86
USA	Turkey Point 3	1981	3	21,51	7,17
USA	Turkey Point 4	1982	3	13,05	4,35
Germany	Obrigheim	1983	2	6,90	3,45
USA	Point beach 1	1983	2	5,90	2,95
USA	H.B. Robinson 2	1984	3	12,06	4,02
USA	D.C. Cook 2	1988	4	5,61	1,40
USA	Indian Point 3	1989	4	5,41	1,35
Sweden	Ringhals 2*	1989	3	2,90	0,97
France	Dampierre 1*	1990	3	2,13	0,71
USA	Palisades	1990	3	4,87	1,62
USA	Millstone 2	1992	3	6,70	2,23
USA	North Anna 1*	1993	3	2,40	0,80
Switzerland	Beznau 1*	1993	2	1,10	0,55
Belgium	Doel 3*	1993	3	1,96	0,65
France	Bugey 5	1993	3	1,55	0,52

**: NEA3 questionnaire existing in the ISOE database*

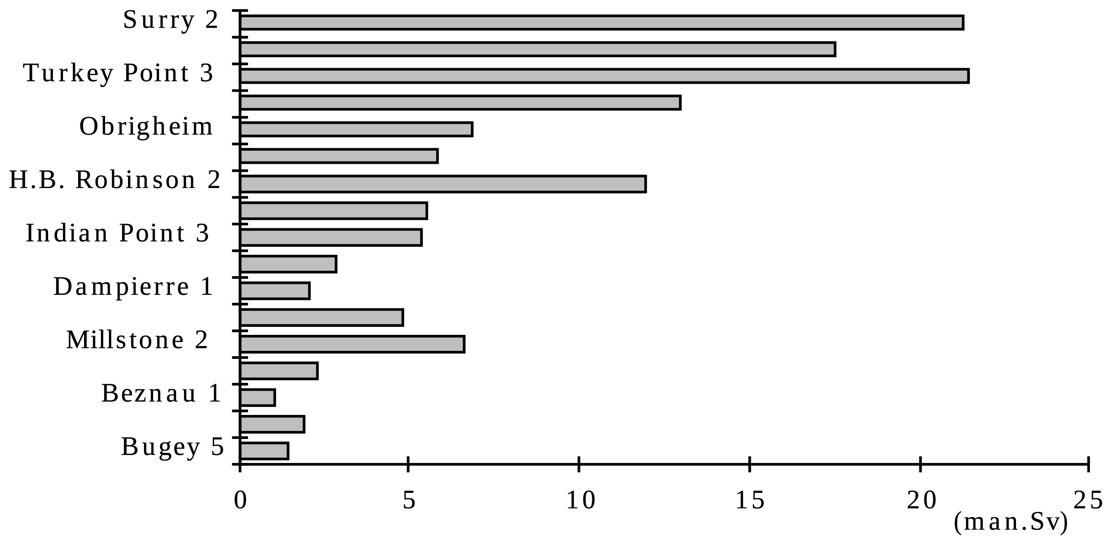

Figure 1. **Evolution of steam generator replacement collective doses**

As can be seen, the SGR collective exposure has been regularly decreasing, showing the impact of feed back experience: total and per steam generator collective doses of the last SGR in France are 14 times lower than those received du-ring the first SGR at Surry 2 in USA (Figure 1 and Table 1).

Figure 2 indicates the number of SGR performed in each country.

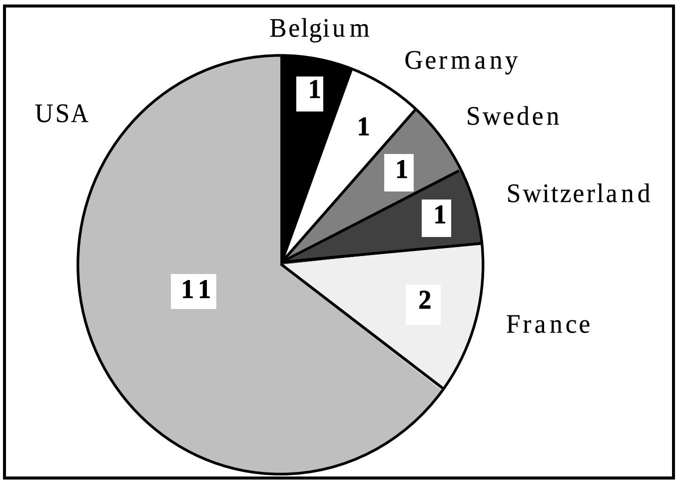

Figure 2. **Number of SGR performed per country from 1979 to 1993.**

2. Impact of SGR on Post SGR Annual Exposure

The method used to determinate the impact of SGR on post-SGR annual collective doses is presented on page 3. Based on this selection criteria, only six reactors are used in the following study. Analysis of the data shows that, on average, collective dose during the steam generators' replacement year is 70 % higher than the average collective dose during the three prior years with refuelling outages. The collective dose following replace-ment falls to approximately 50 % of the pre-replacement collective dose. Thus, from the first refuelling outage year after the SGR, the extra exposure due to the SGR has largely been recovered.

Figure 3 presents this average evo-lution assuming a normalised ave-rage collective dose, prior to SGR, of 100.

Figure 4 gives the information for each of the six reactors concerned [Robinson 2 (USA), Indian Point 3 (USA), Palisades (USA), Obrigheim (Germany), Ringhals 2 (Sweden), Dampierre 1 (France)]. Considering this figure, it is noticeable that evolutions of occupational exposures are similar for all the reactors under study.

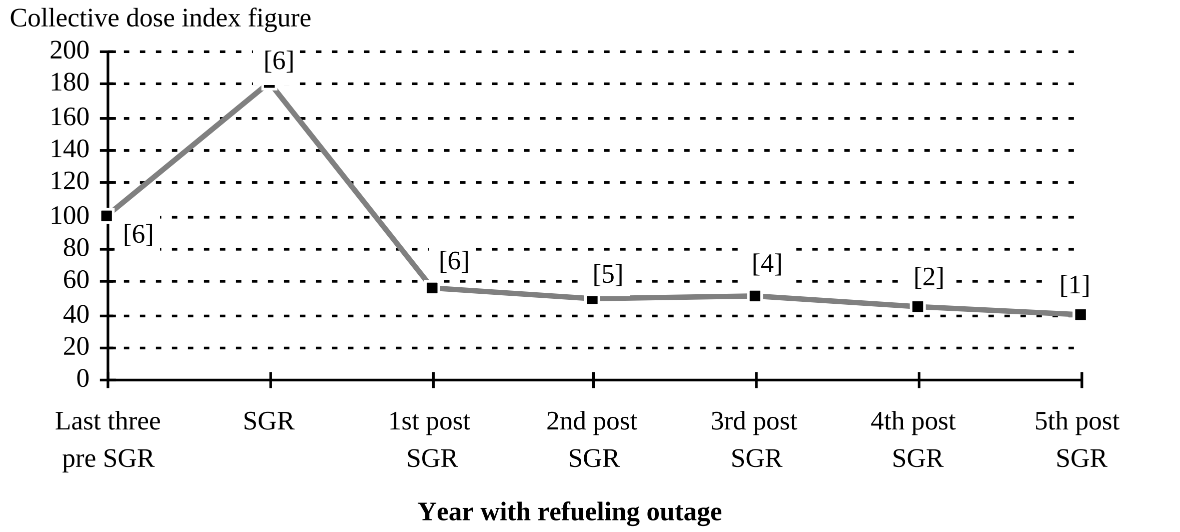

Figure 3. **Average impact of a SG replacement on the evolution of the reactor annual collective dose** [number of data considered for the average calculation]

METHOD FOR THE ANALYSIS

Recent steam generators replacements (performed in 1993) have not been taken into account in establishing Figures 3 and 4 presented in this ISOE Information Sheet, because annual collective doses concerning the post-SGR years are not available. Moreover, only the reactors for which the total annual collective exposure is given per reactor (not total exposure for the site) are kept for the analysis.

The analysis method is the following : in order to determinate if steam generator replacement has had an impact on the evolution of post-SGR annual collective exposure of a reactor, only the years with refueling outages have been considered. The reference period is composed of the last three refueling outage years before the steam generator's replacement. The average dose over these three years then represents the collective exposure received by the workers before the steam generator's replacement. For comparison with other reactors, this average collective exposure is normalized to 100. Collective exposures of the steam generator's replacement year and of the years, with refueling outages, following the SGR are also similarly normalized.

It should be noted that for the american reactors (Indian Point 3 and Palisades), only the two years before the SGR have been taken into account as the third year includes a refuelling outage of approximately one year, which is four times longer than the normal duration. Furthermore, the lower exposure level observed at Palisades during the SGR year can be partly explained by the fact that the SGR took place during two calendar years and by the fact that the considered year counted only 74 % of the collective exposure due to the SGR.

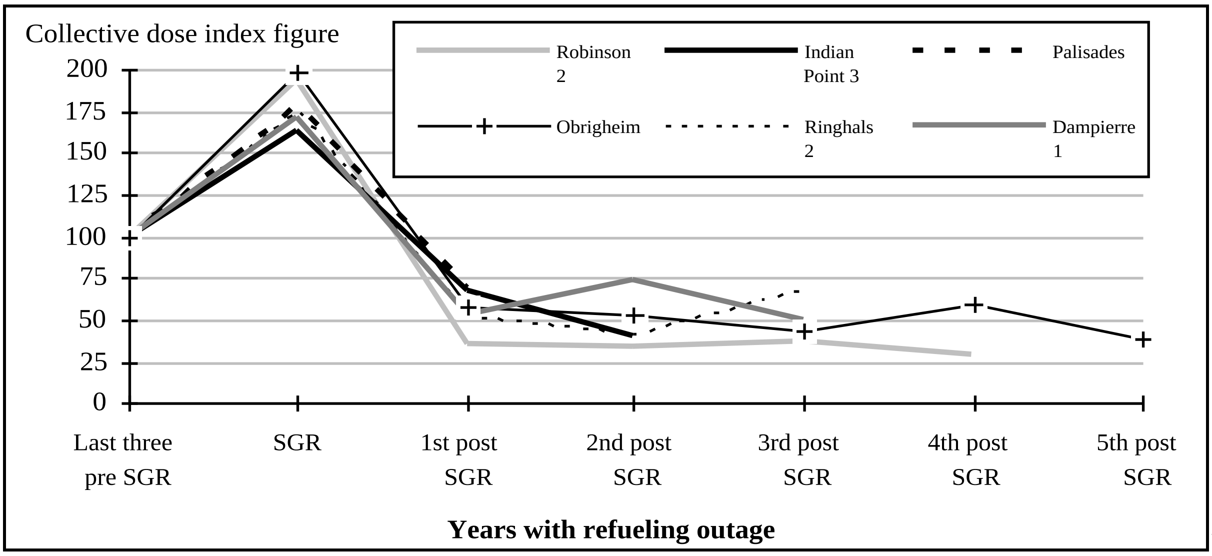

Figure 4. **SG replacements and evolutions of the annual collective doses**
(basis 100 = 3 last refuelling outage years average collective dose)

3. Some Characteristics of SGR

Some important characteristics of steam generator replacements are summarised in Table 2.

Different materials have been choosen by the plants for the steam generator tubing : since 1983, Inconel 690 TT has often been specified as a replacement for Inconel 600. Incoloy 800 is selected by Siemens, and it was used in Germany and for the Doel 3 SGR.

Table 2. **Some characteristics of Steam Generators replacements**

Plant unit	Total or partial replacement	New SG tubes material	Primary piping	
			No of cuts/SG	Cutting method
Surry 2	Lower section	Inconel 600 TT	5	Plasma
Surry 1	Lower section	Inconel 600 TT	5	Plasma
Turkey Point 3	Lower section without channel head	Inconel 600 TT	-	
Turkey Point 4	Lower section without channel head	Inconel 600 TT	-	
Obrigheim	Entire SG	Incoloy 800	4	Machining
Point beach 1	Lower section	Inconel 690 TT	2	Plasma
Robinson 2	Lower section without channel head	Inconel 690 TT	-	
D.C. Cook 2	Lower section	Inconel 690 TT	2	Plasma
Indian Point 3	Entire SG	Inconel 690 TT	2 (3)	Plasma
Ringhals 2	Entire SG	Inconel 690	4	Machining
Dampierre 1	Entire SG	Inconel 690 TT	2	Plasma
Palisades	Entire SG	Inconel 600	5*	Machining
Millstone 2	Lower section	Inconel 690 TT	2	
North Anna 1	Lower section	Inconel 690 TT	2 (3)	Machining
Beznau 1	Entire SG	Inconel 690 TT	4/5**	Machining
Doel 3	Entire SG	Incoloy 800	3	Machining
Bugey 5	Entire SG	Inconel 600 TT	2	Machining

Lower section means steam generator lower assemblies including tube bundles
TT denotes Thermally treated
**: Cold legs 2 cuts each, hot leg one cut.*
***: 4 cuts SG A, 5 cuts SG B.*

4. Some Protection Actions during last SGRs

Tables 3 gives for the last six SGRs, the type of decontamination of primary piping and the total weight of lead shielding installed for the SGR.

Through these figures, it is clear that radioprotection is a major concern during such types of operation. In order to reduce the dose rates, classical actions remain very important:

- the total amount of lead shielding installed during SGR is a as high as 80 t,
- no SGR is performed without a decontamination of parts of the primary circuit.

The most recent decontamination actions involved only the primary pipes into and out of the steam generator channel head, and were performed after the removal of the old steam generators.

Table 3. **Protective Actions during SGRs**

Plant unit	Decontamination process	Components decontaminated and length	Dose rate reduction factor range	Total weigth of lead shielding (t)
Ringhals 2	Electropolishing	0.5 m of Primary Pipe ends after Old SG removal	N.A.	25
Dampierre 1	Electropolishing in 2 SG	1,5 m of Primary Pipe ends after Old SG removal	3,5 to 4 in the steam generator cubicle	56
	Chemical decon in 1 SG (LOMI process)	Channel head & 1.5 m of Primary Pipe ends before Old SG removal	2.7 in the steam generator cubicle	
North Anna 1	Mechanical blasting with Aluminium Oxide followed by glass beads	0.5 m of Pipe ends after Old SG lower section removal	23.2 to 51.5 at the pipe end plane (post shielding)	70
Beznau 1	Mechanical process (Blasting process)	Pipes ends over 400 mm length after Old SG removal	N.A.	80
Doel 3	Sand blasting with electro-corundum	Pipe ends after Old SG removal	45 to 80 at the pipe end plane	60
Bugey 5	Chemical decontamination (EMMA process)	1.55 m Primary Pipe ends after Old SG removal	3 to 11 in the steam generator cubicle	55