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ISOE INFORMATION SHEET

OCCUPATIONAL EXPOSURE AND STEAM GENERATOR REPLACEMENTS UPDATE

ISOE European Technical Centre - CEPN Information Sheet No.30

In May 1994, the ISOE European Regional Technical Centre issued the Information Sheet on occupational exposure and steam generator replacements (SGR). An update of this data was made in December 1998 and distributed as European Technical Centre Information Sheet No. 17. On the request from the ISOE Bureau, this second update of the Information Sheet presents the Steam Generator Replacements, whose data are available, which have been performed by the end of 2000.

1. SGR Collective Exposures

Since 1979, 59 steam generator replacements (SGR) have been performed, mainly in North-America and in Europe.

Table 1 presents the collective exposures corresponding to 48 SGRs performed from 1990 to 2000 whereas Figure 1 shows the evolution of the average collective dose per steam generator replaced since 1979. Collective doses are decreasing regularly reaching about 0.5 man·Sv in average during the last six years. That average covers quite large discrepancies and the best results correspond to three SGR performed in 1996 and 1998 in Belgium and France with only 0.21 man·Sv per steam generator replaced.

Table 1. Steam Generator Replacements from 1990 to 2000

Country	Plant unit	Replacement year	No. of SG replaced	SGR duration (days)	SGR Total Collective Dose (man.Sv)	Collective Dose per SG (man.Sv)
France	Dampierre 1	1990	3	70	2.13	0.71
USA	Palisades	1990	2	121	4.87	2.44
USA	Millstone 2	1992	2	185	6.70	3.35
USA	North Anna 1	1993	3	51	2.40	0.80
Switzerland	Beznau 1	1993	2	44	1.10	0.55
Belgium	Doel 3	1993	3	44	1.96	0.65
France	Bugey 5	1993	3	70	1.54	0.52
Japan	Mihama 2	1993	2	359	1.46	0.73
France	Gravelines 1	1994	3	37	1.45	0.48
USA	V.C. Summer	1994	3	38	2.24	0.75
Japan	Takahama 2	1994	3	105	1.49	0.50
Japan	Ohi 1	1994	4	n.a.	2.93	0.73
Japan	Mihama 1	1994	2	519	1.11	0.55
Sweden	Ringhals 3	1995	3	69	1.33	0.44
USA	North Anna 2	1995	3	55	1.42	0.47
France	St. Laurent B1	1995	3	34	0.91	0.30
France	Dampierre 3	1995	3	39	1.25	0.42
Spain	Asco 1	1995	3	60	2.44	0.81
Belgium	Tihange 1	1995	3	38	1.64	0.55
Spain	Asco 2	1996	3	53	1.68	0.56
USA	Ginna	1996	2	n.a.	1.04	0.52
Belgium	Doel 4	1996	3	37	0.63	0.21
France	Gravelines 2	1996	3	33	1.38	0.46
Spain	Almaraz 1	1996	3	55	1.58	0.53
Japan	Takahama 1	1996	3	n.a.	1.17	0.39
USA	Salem 1	1996	4	n.a.	2.30	0.58
USA	Catawba 1	1996	4	74	1.68	0.42
Japan	Mihama 3	1996	3	n.a.	1.27	0.42
Spain	Almaraz 2	1997	3	42	1.20	0.40
Japan	Ohi 2	1997	4	n.a.	1.98	0.49
France	Tricastin 2	1997	3	n.a.	0.85	0.28
USA	McGuire 1	1997	4	56.3	1.43	0.36
USA	McGuire 2	1997	4	59.8	1.11	0.28
USA	Byron 2	1997	4	38	2.68	0.67
USA	Point Beach 2	1997	2	75	1.87	0.94
USA	Byron 1	1998	4	50	1.99	0.50
Belgium	Tihange 3	1998	3	76	0.62	0.21
Korea	Kori 1	1998	2	92	1.53	0.76
USA	Braidwood 1	1998	4	64	1.65	0.41
France	Tricastin 1	1998	3	63	0.62	0.21
Japan	Ikata 1	1998	2	n.a.	0.92	0.46
Switzerland	Beznau 2	1999	2	42	0.64	0.32
USA	Cook 1	1999	4	300	1.31	0.33
Slovenia	Krsko	2000	2	28	1.48	0.74
USA	South Texas 1	2000	4	54	1.73	0.43
USA	Indian Point 2	2000	4	70	2.53	0.63
USA	Arkansas 2	2000	2	42	0.81	0.40
France	Gravelines 4	2000	3	n.a.	0.67	0.22
USA	Farley 1	2000	3	58.5	1.96	0.65

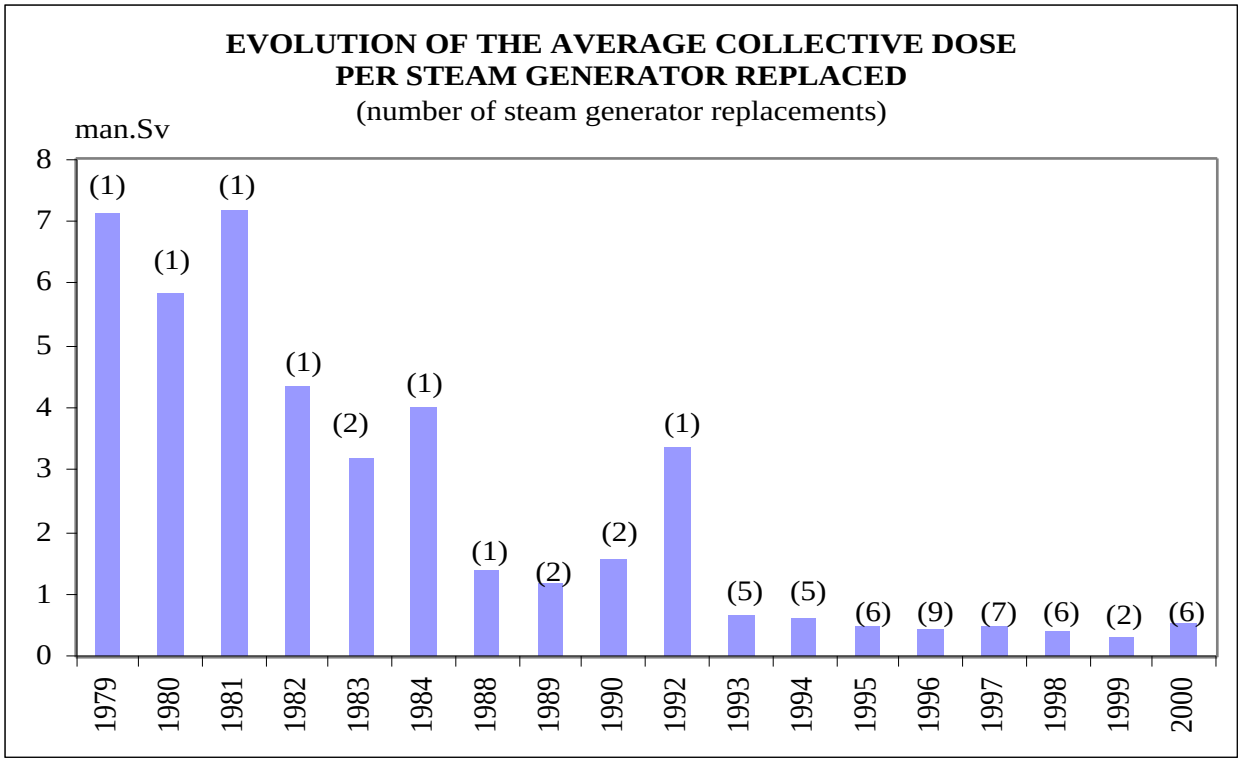

Figure 1. Evolution of the average collective dose per steam generator replaced since 1979

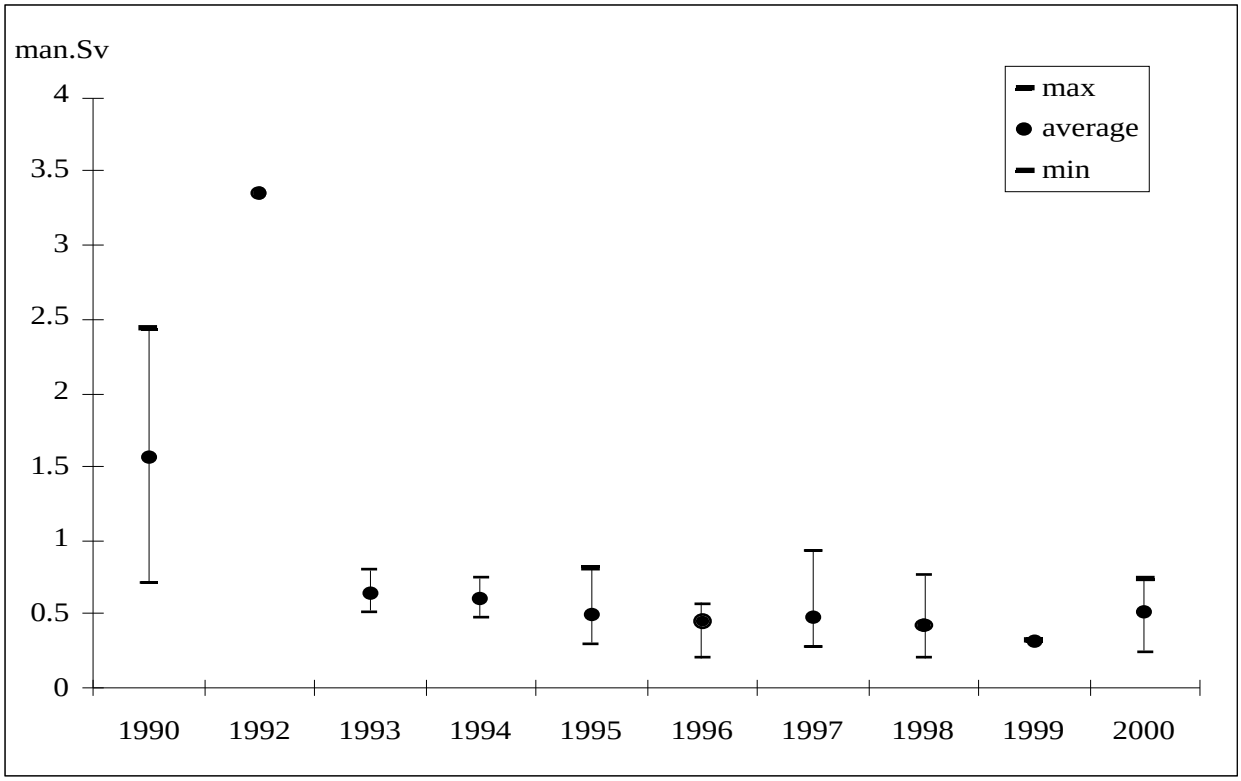

Figure 2. Recent evolution of the collective dose per steam generator replaced since 1990 (average, minimum and maximum dose)

2. Impact of SGR on Post SGR annual exposure

Based on the method described hereafter, twenty-eight reactors are used in this study, compared to twenty-one and six respectively in the previous studies. It is very impressive to see that the results observed previously have been completely confirmed:
- on average, collective dose during the steam generators' replacement year is 60% higher (as in the previous study) when compared with the average collective dose during the three prior years with refuelling outages.
- the collective dose following replacement falls to approximately 55% (50% in the previous study) of the pre-replacement collective dose, or even slightly less (40%) during the 5 post SGR years with a refuelling outage.

Figure 3 presents this average evolution assuming a normalised average collective dose of 100, prior to SGR. Figure 4 shows the standard deviation associated with the average collective dose. As one may assume that 8 to 10 years after the SGR, the decrease of outage exposure is not only the "mechanical" result from the SGR, the figures show only up to the 5th post SGR outage. Nevertheless, the correlation between that exposure decrease and the performance of a SGR remains quite obvious.

METHOD FOR THE ANALYSIS

28 reactors were used in the analysis of impact of SGR on subsequent annual collective dose. Recent steam generators replacements 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 refuelling outages have been considered. The reference period is composed of the last three refuelling 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 normalised to 100. Collective exposures of the steam generator's replacement year and of the years, with refuelling outages, following the SGR are also similarly normalised.

It should be noted that for some 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.

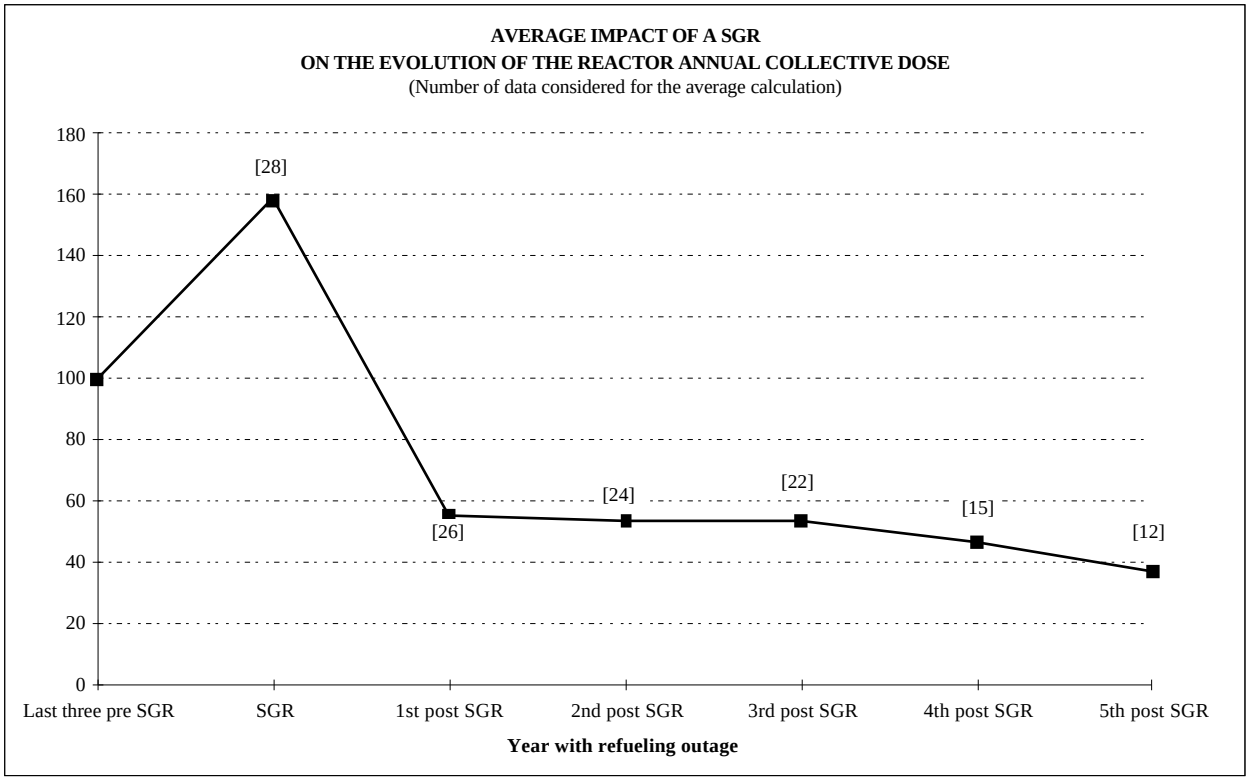

Figure 3. Average impact of a SGR on the evolution of the reactor annual collective dose [number of data considered for the average calculation]

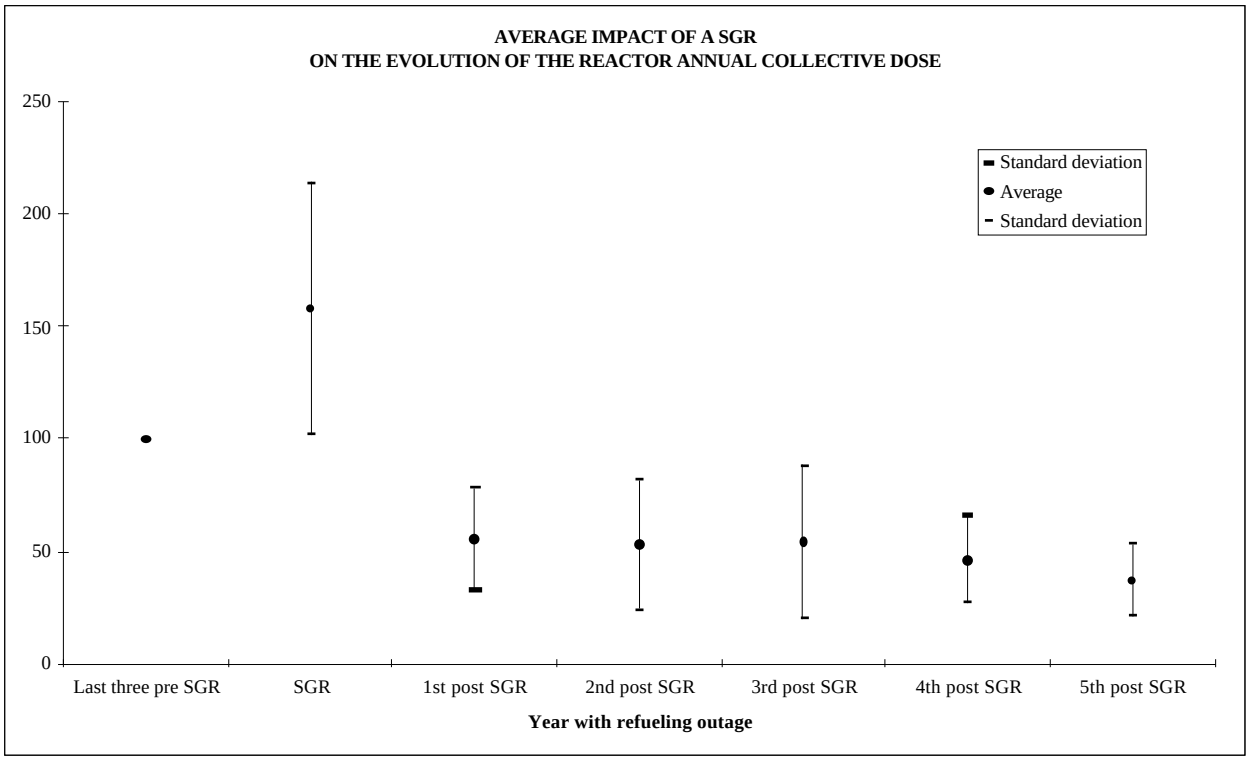

Figure 4. Impact of a SGR on the evolution of the reactor annual collective dose: standard deviation and average