NUCLEAR POWER IN SWEDEN - DOSES, RELEASES AND ACTIONS

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ABSTRACT

Some 5,000 workers at 12 units get a mean annual effective dose of 2-3 mSv corresponding to a collective dose of c. 2 man Sv per GW. Annual critical group doses from environmental releases are 0.001-0.015 mSv, public collective doses c. 5 man Sv per GW. A steam generator replacement, 1989, did not change this picture. During the 1980ies, filtered containment venting systems were installed and an organisation for local measurements of gamma dose rate established.

BACKGROUND

The Swedish nuclear programme consists of 12 light water reactors producing about half of the electric power in Sweden. Nuclear power is scheduled for phaseout by 2010, but no starting date is fixed for the phaseout.

The energy availability factor has been in the range of 75-90 %. Some years, utilisation has been about 10 % lower than availability, due to well-filled water reservoirs and low power demand in mild winters. The low annual number of scrams per reactor decreased further in 1990 to 1.7, with no trigged scram at all at 3 reactors. Most scrams originated in conventional systems, not the reactor process system.

THE SYSTEM OF DOSE LIMITATION

Current regulations are based on ICRP 26 (1). However, for workers supplementary dose limits enacted 1989 for age 30 (180 mSv) and lifetime (700 mSv) correspond to a mean of 15 mSv annually. As a level of ambition the annual collective worker dose should not exceed 2 man Sv annually per GW installed capacity. Releases must not cause annual doses exceeding 0.1 mSv to members of critical groups. The annual collective dose should not exceed 5 man Sv per GW installed.

A common centralised dose registration system is operated and used by all nuclear power plants. Internal exposure, checked at the plants by whole-body measurements, has so far been insignificant compared to external exposure.

ANNUAL OCCUPATIONAL EXPOSURES

Data on the nuclear programme and average effective doses are given in Table 1. For individual doses, utility employees have slightly but significantly lower doses than contractors. No dose since 1981 exceeds 50 mSv per year. Normalised collective doses to staff are consistently in agreement with the regulatory level of ambition, 2 man Sv per year. Internationally, the doses are low, cf. (2).

Table 1. Occupational exposure data at Swedish light water reactors, 1981 - 1990

Year	Number of re-actors	Installed capacity (GW)	Energy generated (GWa)	Number of exposed workers(a)	Annual individual mean dose (mSv) for: utility	contractors	Annual collective mean dose (man Sv) per: reactor	GWa(b)	GW(c)
1981	9	6.4	4.5	4,154	2.9	3.3	1.5	3.2	2.1
1982	9	7.3	4.3	3,766	2.3	2.6	1.1	2.3	1.5
1983	10	7.4	4.6	4,774	2.6	3.2	1.5	3.2	2.0
1984	10	7.4	5.8	4,584	2.5	2.5	1.2	2.0	1.6
1985	12	9.5	6.7	4,674	1.8	2.6	0.9	1.7	1.2
1986	12	9.5	8.0	5,688	2.1	3.4	1.4	2.1	1.8
1987	12	9.7	7.7	5,815	1.9	2.9	1.3	2.0	1.5
1988	12	9.7	7.9	5,976	2.2	3.1	1.5	2.2	1.7
1989	12	9.9	7.5	5,449	2.0	3.2	1.3	2.1	1.6
1990	12	10.0	7.4	5,138	2.1	3.1	1.2	1.9	1.4

Notes: (a) Workers with recorded doses only
(b) Energy generated
(c) Installed capacity (ambition level: annual collective dose < 2 man Sv)

The steam generators at Ringhals unit 2 were replaced in 1989. The replacement took 72 days and caused a collective dose of only 2.9 man Sv (3). All doses due to this big project are included in Table 1. As can be seen, the project has not changed dose statistics compared to other years.

ACCUMULATED OCCUPATIONAL EXPOSURES

Accumulated effective doses at age 30 are recorded, and predicted lifetime doses shown, in Table 2. Two discriminators were used for lifetime dose prediction: 1) Only workers with a current accumulated dose exceeding 100 mSv were included (their number is given in Table 2), and 2) The dose had to be distributed over 5 or more years.

Lifetime doses were calculated as E = (Dr + Dc), where Dr is the recorded dose during n years including 1990 at the latest, and Dc is the expected dose from 1991 up to age 65 calculated as Dc = (t * Dr / n) where t = years from 1991 to age 65, i.e. with the very conservative assumption of the same average annual dose all years as in past years.

Doses at age 30 have not exceeded the new 180 mSv limit since 1976 (but one foreign contractor was refused to work for this reason in 1991). A score of workers are predicted to hit the lifetime 700 mSv limit, but the prediction is not very realistic. Also, steps taken in response to the limit

Table 2. Accumulated effective dose (E) in mSv at age 30, currently and predicted for lifetime for Swedish nuclear industry workers

Occupational group	Dose at age 30: Number with E >50	E >180	E max	Current dose: Number with E >100	Predicted total lifetime effective dose: Number with E >700	E mean	E max	E median	SD E
Health physicists	33	2	222(a)	36	3	430	820	380	163
Mechanical workers	76	2	322(a)	163	17	440	1060	400	183
Service personnel	18	-	136	10	-	410	650	420	160
Insulation personnel	7	-	141	12	1	420	740	410	166
Operation personnel	9	-	148	36	-	330	670	300	124
Material testers	5	-	92	15	-	350	660	310	123
Electr & instr technicians	5	-	97	4	-	320	460	270	105
Chemists	1	-	82	5	-	310	550	240	165
Other staff	18	4	275(a)	37	-	340	660	310	143

Notes: (a) These doses were accumulated before 1976
(b) Total number of workers with recorded dose >0.1 mSv in the underlying central dose register is 27,479

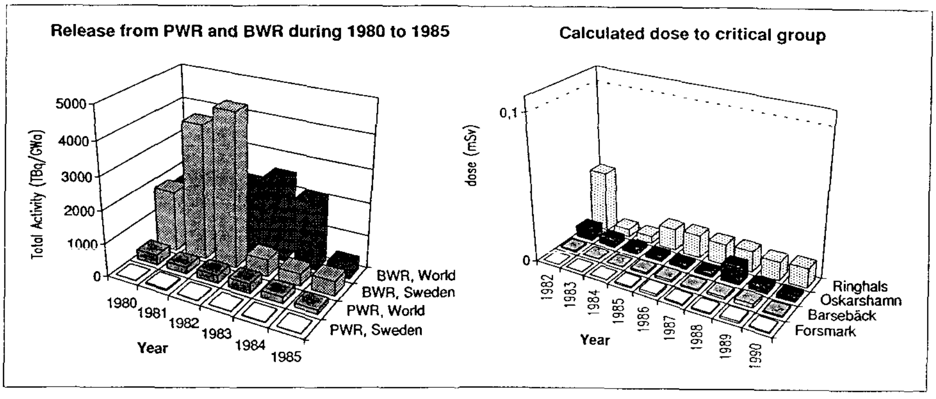
decrease doses further. Although ICRP disfavours lifetime dose limits, the new 100 mSv per 5 years limit (4) will also limit lifetime doses to 900 mSv. Few Swedish workers could accumulate 900 mSv, but several predicted mean lifetime doses exceed 400 mSv, the German lifetime dose limit (5).

EXPOSURES OF THE PUBLIC: RELEASES FROM NORMAL OPERATION

The left part of Figure 1 compares Swedish and international normalised activity releases, excluding air releases of H-3 and all C-14. On average, Swedish BWR releases are similar to other countries, while Swedish PWR releases are smaller than in other countries. The high BWR releases in 1980-1982 are mainly due to fuel damage at the Ringhals BWR unit and at Oskarshamn, causing large noble gas releases.

The right diagram shows effective doses to critical groups from Swedish plants including H-3 and C-14. All doses are far lower than the limit, 0.1 mSv. However, 3 of the 4 Ringhals units are PWRs, all other Swedish units are BWR. While PWR releases are smaller, PWR doses are higher, mainly due to lower smoke stacks causing a higher C-14 dose.

C-14 dominates the collective dose. Using a truncated 500-year time integral, the calculated C-14 collective dose is c. 48 man Sv annually, or up to c. 1.2 times the level of ambition of 5 man Sv per GW. All other releases together



give less than 0.1 man Sv.

EMERGENCY PREPAREDNESS

Since 1981, an extensive programme has introduced mitigating devices and a new severe accident handling strategy at the plants. For each reactor containment, filtered venting systems can be activated manually or automatically, in order to avoid heavy ground contamination even in severe accidents. There is a regulatory limit on accident releases through the filter of 0.1 % of the core inventory of particulate activity, normalised to an 1800 MW (thermal) reactor.

After Chernobyl, all counties and all 284 urban and rural districts in Sweden were equipped with gamma dose rate instruments with a range of 0.1 uSv/h to 10 mSv/h. Some 500 persons have been taught to use these and measurements are practiced at 7-month intervals at about 800 local reference points. Thus reference data with seasonal variations are obtained and handling proficiency retained. This supplements other means of rapid determination of radiation conditions. It would provide an important background for information to the public in accidental fallout situations.

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