SOME EXPERIENCE WITH MEASUREMENTS OF STACK RELEASES AND THEIR CORRELATION WITH ENVIRONMENTAL MEASUREMENTS.

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The first nuclear power plants (NPP) in Switzerland were built during the late 60-ties and the early 70-ties (PWR-Beznau and BWR-Mühleberg). A new generation of NPPs were built ten years later (PWR-Goesgen and BWR-Leibstadt). In all these NPP special attention was given to the sampling and measurements of the releases of radioactive materials, in particular long lived aerosols and J-131. The sampling systems at the Swiss NPP were originally installed on the basis of the "American National Standard Guide to sampling Airborne Radioactive Materials in Nuclear Facilities", (ANSI NI3,1 - 1969) or equivalent standards such as ISO 2889 and DIN 25423. Unfortunately, the sampling systems described in these guides cover only that fraction of radioactive aerosols, which is preferentially retained in various portions of the respiratory tract (0.3 to 10 μm). In a NPP one can expect during an accident a very wide range of particles with diameters as large as 100 and more μm, which can be transported away by the stack effluent and may not be properly sampled and measured. It should be taken in account that there are some non filtered rooms and that filters can fail or even break. Such particles when released cause a ground contamination in the vicinity of the plant. Such an event occurred in September 1986 in the NPP-Mühleberg.

1. THE MUEHLEBERG EVENT

Periodic measurements made in the years 1985 and 1986 in the vicinity of the plant, indicated traces of Co-60 (30 - 70 Bq/m^2). It was assumed that they were due to the routine plant releases. This nuclide was practically never found in the fallout of the atomic bomb tests.

In September 1986 [1], a further γ-spectrometric measurement in the vicinity of the plant indicated a contamination of Co-60, Cs-137 and Cs-134. This relatively high Co-60 (550 Bq/m^2) contamination indicated an unusual release of radioactivity from the plant. It was difficult to interpret the Cs-137 and Cs-134 contamination as a plant release, since the Cs-137 and Cs-134 levels were generally increased due to the Chernobyl fallout. The aerosol monitor in the stack exhaust did not indicate abnormal radioactivity releases. Spectrometric analyses of the aerosol grab sample filters of the stack have shown traces of Co-60 too, but did not indicate any abnormal aerosol releases.

The plant exhaust ventilation system was inspected downstream of the aerosol High Efficiency Particulate Filters. Massive contamination of ducts was discovered, including the exhaust stack. The contamination consisted of radioactive resin particles. The source of the contamination was identified as a centrifugal hydroextractor for resins, which was connected to the exhaust ventilation system through a prefilter. The prefilter was broken.Within the exhaust HEPA-filter system, 15 of 136 filter cells were found failed. However, the weekly records of Δp-measurements across the filters did not clearly indicate whether and when a filter had failed. If one or two cells are leaking, the local flow increases and the Δp of the filter assembly does not change significantly.

2. MISINTERPRETATION OF THE MEASUREMENT RESULTS

The γ-spectrometric measurements of the stack aerosol filters are made weekly. The highest measured weekly peaks in April and September were about $3 \cdot 10^7$ Bq, thus they did not indicate any abnormal release. The weekly limit is $3.7 \cdot 10^9$ Bq. Since the highest peaks were still 100 times smaller then the weekly limit, no attention was paid to these peaks. Particles with diameters of 50 µm and more did not reach the sample filter and were found deposited in the horizontal parts of the sample line at 120 m. A careful interpretation made after the incident has shown a direct correlation of the measured γ-peaks with the use of the centrifugal hydroextractor to dry spent resin powders.

It is very probable that if a careful analysis of the measured peaks had been made before the incident, it could have been prevented. The environmental measurements, mentioned above, were the only indicators of the incident.

3. ENVIRONMENTAL IMPACT

The total estimated amount of radioactivity released is $1.1 \cdot 10^{10}$ Bq. The corresponding release limit for aerosols is $1.8 \cdot 10^{10}$ Bq per year. The release consisted of: 40 % Cs-137, 50 % Cs-134, 7 % Co-60, 3 % Zn-65. The contamination of the ground was limited to a distance of 1 km. Milk production of nearby farmers was controlled, but no restrictions were necessary.

The dose rate measurements in the two prevailing wind directions (east-west) have shown an increase, especially in the west direction of about 45 nSv/h. Table 1 gives the quarterly net dose data for the years 1985 and 1986 measured with the existing network of the thermoluminescence dosimeters (TLD) in the vicinity of the NPP. These data were obtained with use of the method of the site specific parameters (SSP) [2]. This method gives a possibility to obtain the net doses within an error of ± 20 µSv/quarter and about ± 40 µSv/year (3 S.D.).The estimated average of the Chernobyl fallout dose for 1986 in the vicinity of the NPP-Mühleberg is about 70 µSv ± 40 µSv. The higher doses on some measurement points (*) are probably due to the Mühleberg event (Fig. 1).

4. LESSONS LEARNED

4.1 The Mühleberg event has shown that sampling systems must be designed to identify a wide range of airborne particulates. Not only particles which will be preferentially retained in various portions of the respiratory tract, but also those which can be transported away by the stack effluent flow have to be taken into account.

4.2 Any changes of the measured results from the steady state level must be interpreted and explained.

Table 1. Net dose data of the TLD-network obtained in the years 1985 and 1986 in the vicinity of NPP-Mühleberg (μSv).

Station	1985 (± 20 μSv)				Total (±40 μSv)	1986 (± 20 μSv)				Total (± 40 μSv)
	I.	II.	III.	IV.	1985	I.	II.	III.	IV.	1986
1. Niederruntigen	-7	-12	2	6	-12	-8	45	51	56	152*
2. Siedlung WKW	4	2	7	-1	12	-6	31	35	51	117*
3. Fuchsenried	-23	-17	-7	9	-37	6	24	25	22	71
4. Eiau	5	-15	-9	7	-12	5	24	18	29	11
5. Leimeren	-16	44	-18	-1	9	-15	-9	4	5	0
6. Mühleberg	-3	3	-13	-4	-17	4	23	22	23	68
7. Wileroltigen	-6	0	8	0	2	-2	18	20	18	56
8. hin. Rewag	15	11	-1	3	28	-15	15	16	18	49
9. Ufem Horn	-1	-17	0	2	-16	8	41	38	100	179*
10. Salvisberg	-4	-8	18	2	9	12	39	38	26	103*
11. Aebnitacher	10	-23	2	2	-9	8	37	22	33	92
12. Buttenried	12	3	13	7	34	-4	31	35	24	90
13. Marfeldingen	14	-14	11	9	20	4	54	32	38	124*
14. Oberruntigen	-3	40	-5	-9	24	-7	31	33	25	89
15. Talmatt	1	-17	-4	-7	-27	12	39	20	22	81
16. Frieswil	2	31	5	-12	26	3	17	4	9	30
17. Murzelen	1	-10	-9	-14	-32	-4	17	13	8	38
average net dose	--	--	--	--	--	--	28	25	30	83[1]

1) This value includes an average calculated Chernobyl contribution of about 70 μSv ±40 μSv for the year 1986. The higher doses at some measurement stations (*) are due to the NPP-Mühleberg event in September 1986.

4.3 A redundant, preferably diverse sampling and monitoring system should be installed. An example of such a system, which will be backfitted in the NPP-Mühleberg, is shown in Fig. 2. This has two isokinetic nozzle systems each with their own independent monitoring apparatus. One of the systems is installed very near to the sampling nozzles, thus having very short sample lines. Both systems have particle separators (PSep) combined with on-line monitors for particles with diameters greater then 10 μm.

In addition, on-line monitors for small particles are available in each sampling system. The filters of the particle separators and the in-series installed grab sample filters provide representative particulate samples for laboratory analysis. A special arrangement is forseen for efficiency tests of the whole sampling and monitoring systems.

4.4 The environmental impact of the Mühleberg incident is low. Nevertheless, this event has shown that sensitive environmental measurements provide a useful detection capability for such incidents.

4.5 It should be stated that NPPs with intact HEPA-filters in almost all effluent paths, can be practically free of emission of radioactive particulates. An intensified surveillance programme has been adopted for the HEPA-Filters in the Swiss NPP to guarantee this emission free situation.

References

1. Incident Reporting System No. 728, OECD Nuclear Energy Agency
2. Czarnecki J., Health Physics Vol. 45, (July), pp. 173-179, 1983

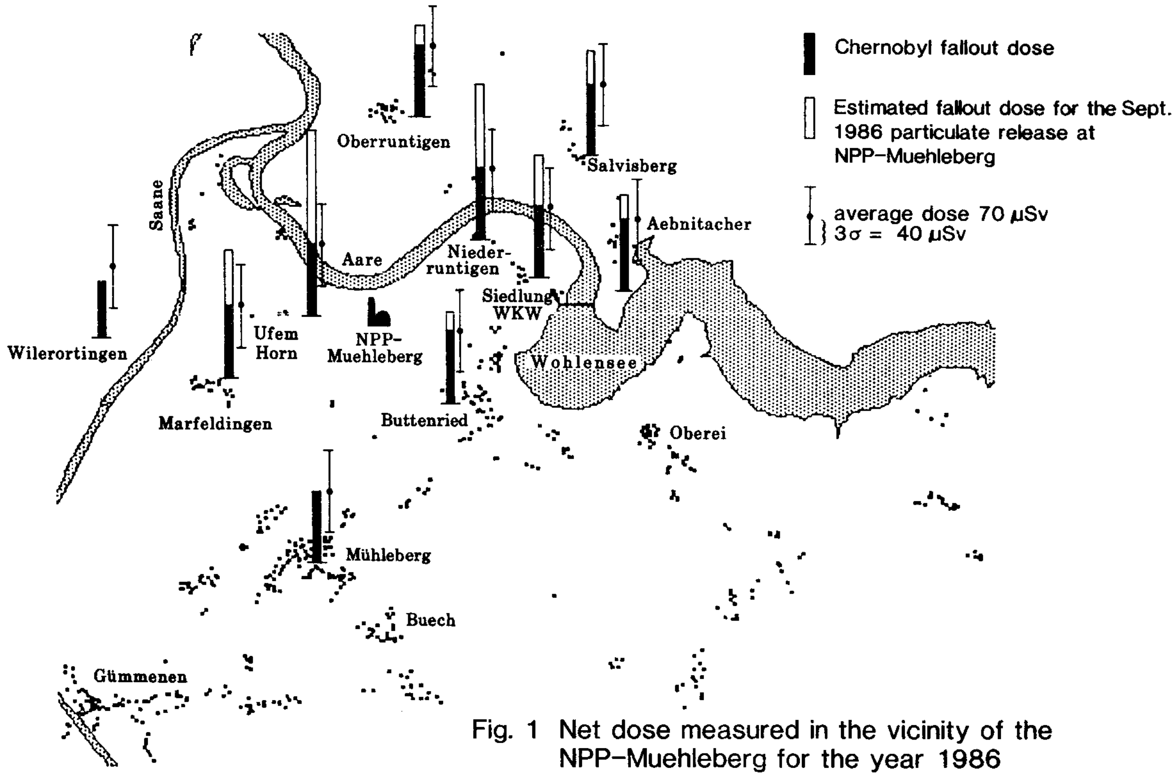

Fig. 1 Net dose measured in the vicinity of the NPP-Muehleberg for the year 1986

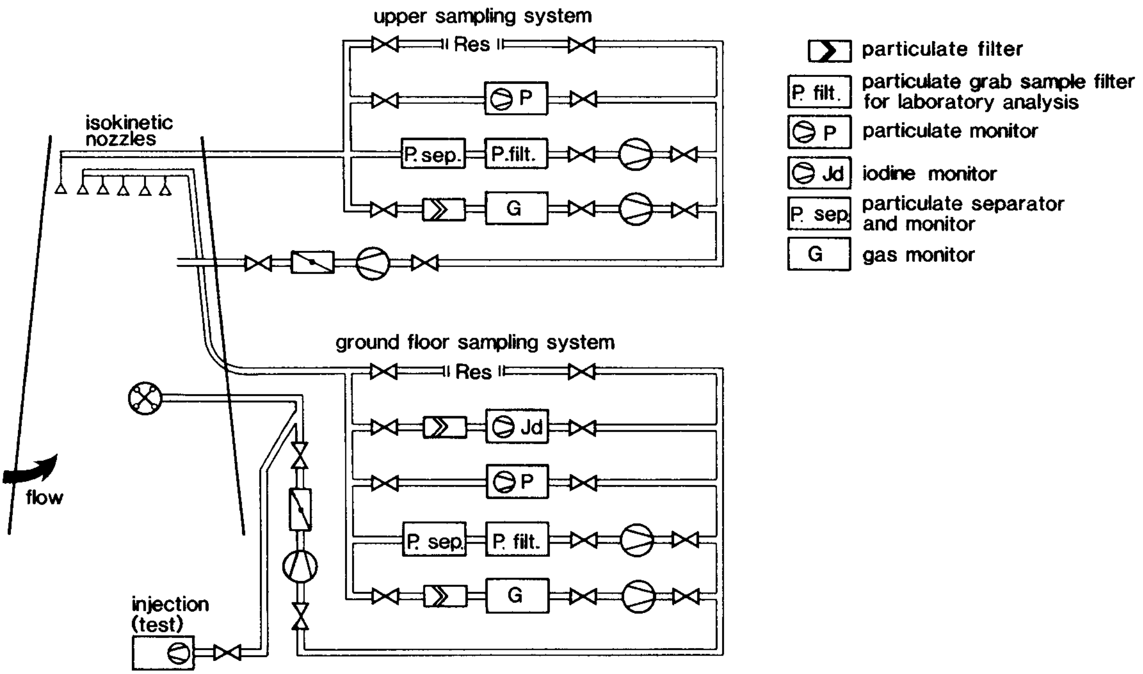

Fig. 2 NPP-Muehleberg backfited redundant stack effluent sampling and measurement system