DOUBLE TRACER EXPERIMENTS TO INVESTIGATE MODELS FOR THE CALCULATION OF GAMMA DOSES FROM A RADIOACTIVE CLOUD

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INTRODUCTION

This paper presents work from a series of atmospheric dispersion experiments in May 1981 at the Ringhals nuclear power plant in Sweden. The aim of the project was to obtain short-term observations of concentrations and gamma-ray exposures from stack effluents and to compare these results with corresponding values calculated from computer models.

Two tracers, sulphurhexafluoride (SF_6) and radioactive noble gases, were released from a 110-m stack and detected at ground level downwind at distances of 3-4 km. Calculations were made with two Gaussian plume models: PLUCON[1] developed at Risø National Laboratory and UNIDOSE[2] developed at Studsvik Energiteknik AB.

EXPERIMENTS

The Ringhals nuclear power plant is situated on the Swedish west coast 50 km south of Gothenburg. The radioactive noble gases used for the experiments were routine emissions from unit 1 (BWR). The experimental site, Fig. 1, is a rather level rural area reaching about 60 m above mean sea level at its highest. The vegetation comprised partly coniferious trees and partly agricultural fields covered with grass.

The experiments were based upon a good meteorological forecast, and required one hour for the setting-up of the sampling network. Via radio control the one-hour sampling of SF6-concentrations and of gamma radiation was synchronized for all positions.

An 11-m meteorological mast was set up in a fairly homogeneous flow field east of the reactor stack, Fig. 1. The mast gave information at different heights on wind speed, wind direction, and temperature. During each experiment, a radiosonde was launched from here yielding information on the vertical structure of temperature and humidity in the atmosphere. A 96-m mast is permanently set up close to the power plant. However, due to very inhomogeneous surroundings the measurements from this mast are unsuited to a detailed analysis of the local meteotological conditions during the individual experiments.

During 3 of the 4 experiments the meteorological conditions were near neutral corresponding to Pasquill category D with wind speeds of 8-14 m/s. The remaining experiment was made under stable conditions, Pasquill category E, with a wind speed of 3.5 m/s.

The tracer SF_6 was injected at a constant rate to the stack. Prior to an experiment the automatic tracer sampling units were transported to positions marked out in advance, Fig. 1, and distributed according to the actual wind direction. The distance between the sampling units was typically 150 m. A total of 25 units were available. Air samples in bags were collected immediately after each experiment and later analysed for their content of SF_6 by use of electron capture detector gas chromatography. The uncertainty of the absolute tracer concentrations is about 20% and the short-term reproducibility is about 2%.

The amount of noble gases emitted from the stack was monitored continuously at the power station. The radiation from the plume was detected with 11 GM-counters, 3 ionization chambers, and 3 mobile Ge(Li) spectrometer systems. These instruments were intercalibrated prior to the experiments with certified gamma sources. The GM-counters and the ionization chambers gave information on exposure rates, whereas the gamma spectrometers gave information on unscattered gamma radiation, which permitted identification and quantification of the individual radionuclides.

During the experiments each radiation detector was placed near an SF_6 sampling unit. Due to the relatively small number of radiation detectors these were placed along the crosswind measurement line at every second SF_6 sampling unit.

RESULTS

Using the recorded radioactive source terms and meteorological data, calculations were made with the two Gaussian models of concentrations, exposure rates, and unscattered gamma fluence rates to be compared to their measured counterparts.

Considerable care was invested to estimate the effective release heights of the tracer gases from the stack during the experiments. Momentum, buoyancy, and downwash effects were taken into account.

The gamma spectrometer results showed unexpectedly a consistent significant surplus of the radioactive decay products of the noble gases relative to the noble gases themselves. This was interpreted as dry deposition of the non-gaseous decay products on vegetation and on the ground. The deposition velocities estimated to account for the surplus of the noble gas decay products were relatively high (2-10 cm/s), but not unphysical considering the circumstances.

Table 1 shows the ratios of the measured to calculated values of concentrations and exposure rates for the four experiments. The two Gaussian models yield rather similar results, so for simplicity only one set of calculations was used. The results for experiment I are displayed in Fig. 2.

In experiment II made under stable conditions the plume did not touch the ground at the measurement positions. In the other experiments the measurement positions were situated near the point of maximum concentration. This may have contributed to the difficulties encountered to estimate the vertical dispersion parameters, σ_z, probably caused by non-Gaussian vertical profiles of the plumes. A detailed report on the experiments is in preparation[3].

REFERENCES

1. Thykier-Nielsen, S. The Risø Model for Calculating the Consequences of the Release of Radioactive Material to the Atmosphere. Risø-M-2214 (1980) 65 pp.

2. Karlberg, O. et al. UNIDOSE-A computer program for the calculation of individual and collective doses from air-borne radioactive pollutants. Studsvik Report 79/1 (1979), Studsvik Energiteknik AB, Sweden.

3. Risø-R-492.

Table 1. Ratios of the measured to calculated values of concentrations and gamma exposure rates in crosswind measurement positions for the four experiments.

Experiment I			Experiment II			Experiment III			Experiment IV		
pos	con	exp	pos	con	exp	pos	con	exp	pos	con	exp
52	1.0		72	BDL	4.5	0	0.7		-1	1.6	0.9
53	1.5	2.1	73	-		1	1.1	0.2	0	1.4	
54	2.2		74	-	2.1	2	1.4		1	1.4	0.9
55	1.7	1.2	75	-		3	0.9	0.2	2	1.3	
56	1.8		76	-	0.4	4	0.9		3	1.8	1.0
57	1.2	0.9	77	-		5	1.4	0.2	4	2.0	1.5
58	1.2		78	-	0.4	6	3.0		5	1.0	
59	1.2	1.4	79	-		7	1.0	1.0			
60	1.9		80	-	0.7						
61	2.3	1.9	81	-							
62	1.4		82	-	1.3						
63	1.0	2.0									
Mean	1.5	1.6	Mean		1.6	Mean	1.3	0.4	Mean	1.5	1.1

BDL below detection limit

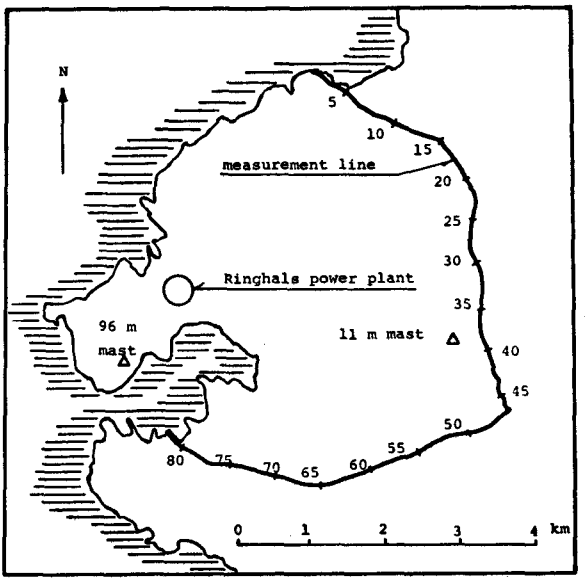

Fig. 1. Sketch of the experimental site.

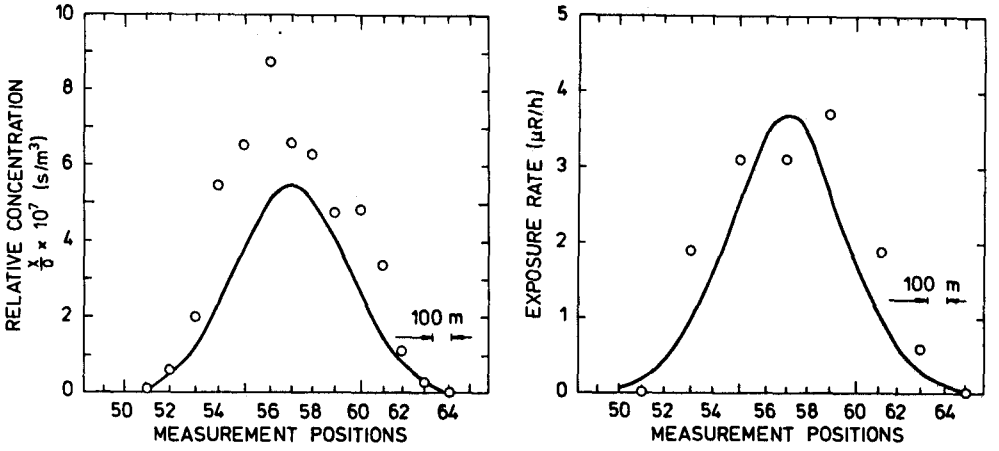

Fig. 2. Measured (O) and calculated (-) results from experiment I showing crosswind profiles of relative concentrations (upper figure) and of gamma exposure rates (lower figure).