REMOTE MEASURING SYSTEM FOR MONITORING THE IODINE IMMISSION IN THE VICINITY OF NUCLEAR POWER PLANTS *)

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Radioactive substances may be released into the atmosphere during major accidents at nuclear facilities. Since the emission rate and composition of the mixture of emitted nuclides is generally not known, appropriate measurements must be made in the vicinity of the plant. The radiation exposure in the possibly critical exposure pathways, i.e. the whole-body dose due to γ-submersion and the thyroid dose due to incorporation of radioiodine, should be determined immediately at various locations in the environment.

In general, existing systems only provide telemetric monitoring of the γ-dose rate during an accident. A suitable iodine measuring instrument and a data transmission and processing system have therefore been developed at the Nuclear Research Centre Jülich for use during accidents (1-3). This system consists of six iodine measuring instruments in the vicinity of the Nuclear Research Centre Jülich (KFA) and a central measuring unit which are connected to each other via a dedicated line. During an accident, the iodine measuring instruments determine the iodine thyroid dose which is proportional to the I-131 activity collected in the iodine detector.

The iodine measuring instrument contains a small NaI scintillator (10 mm in diameter x 10 mm in height) in a lead shielding 15 cm in thickness (Fig. 1). The scintillator is surrounded by a ring-shaped iodine collecting cartridge through which a controlled air flow of 100 l/h can be sucked via an aerosol filter. This air supply is only switched on from the central measuring unit in the case of an accident. A glass-fibre filter is used as the prefilter. The iodine collecting cartridge is filled with silver zeolite granules. All hose connections and the filter casing are made of Teflon. The lead shielding contains a heating element by means of which the collecting cartridge is heated to 10°C above the ambient temperature. This prevents a reduced iodine deposition at high atmospheric humidity. A Ba-133 source is mounted above the NaI scintillator. It serves to control the amplification of the detector by means of a two-channel discriminator adjusted to the Ba-133 γ-line. The pulses recorded in the NaI scintillator are measured by a single-channel discriminator adjusted to the 356 keV γ-line of the Ba control source.

The central measuring unit interrogates the individual stations at intervals of 1 minute, calculates 10-minute mean values and converts the count rates into dose values. The values are displayed on a screen, plotted on a multiple recorder and printed out together with date and time. Two threshold values

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can be preset. The failure of or a defect in a measuring station is identified by the central measuring unit and indicated in the measuring records.

The iodine measuring system can be extended to form a comprehensive accident measuring system which is also capable of measuring the γ-dose rate and assessing the aerosol concentration. In order to demonstrate this, one of the six iodine measuring instruments was extended by a γ-probe with two Geiger-Müller counters and by an aerosol monitor.

The measuring range for the iodine thyroid dose extends from 1.5 mSv to 20 Sv. The value of the lower detection limit is given by the statistical fluctuations of the count rates of the Ba-133 control source. The measuring instrument is equally suitable for measuring elementary and organically bound I-131. Even in the case of high atmospheric humidity, the collection of organically bound iodine is not impaired. The amplification of the iodine measuring instrument is controlled so well that the count rate varies by less than 2.5 % in the temperature range from 1°C to 40°C. The amplification control is insensitive to interfering radiation. If, for example, 9.3 times as much radiation from Cs-137 as from I-131 is recorded in the window of the I-131 line (Fig. 2), the amplification is nevertheless kept constant for at least a further 24 h. External γ-radiation is attenuated by a factor of more than 10,000 due to the lead shielding. Radioactive noble gases only increase the detector reading very slightly. The increase in this reading corresponds to a thyroid dose which is small in comparison to the dose rate in the cloud of radioactive noble gases. The iodine measuring instrument requires practically no servicing since the air flow is only switched on when required.

The iodine measuring system has been in operation since April 1985 and no major malfunctions have occurred to date. The iodine thyroid dose caused in Jülich by the reactor accident at Chernobyl was smaller than the lower detection limit during the normally applicable measuring time of 10 minutes. By increasing the measuring time to 1 hour it proved possible to measure the iodine thyroid dose caused by the disaster at Chernobyl (Fig. 3).

In order to be able to measure also the iodine thyroid dose in the case of minor incidents or accidents at great distances, the lower detection limit is in future to be reduced by a factor of at least 10. After preliminary measurements it seems possible to achieve a lower detection limit of at least 0.1 mSv using a selected CdTe detector 10 mm in diameter and 2 mm in thickness in conjunction with the iodine accident measuring system. Since the temperature dependence of the amplification of the CdTe detector is considerably lower than that of the NaI scintillator, no amplification control would be required for the CdTe detector and the entire accident measuring system would thus be further simplified.

REFERENCES

1 M. Heinzelmann, M. Keller, K. Heinemann
Ein Meßsystem zur Luftüberwachung in der Umgebung kerntechnischer Anlagen
Atom + Strom 31, pp. 1-5 (1985)

2 M. Heinzelmann, M. Keller
Remote Measuring System for Monitoring Accidents in the Environment of Nuclear Facilities
IAEA: Emergency Planning and Preparedness for Nuclear Facilities, Vienna, pp. 335-336 (1986)

3 M. Heinzelmann, M. Keller
Fernmeßsystem zur Erfassung der Jod-Immission nach störfallbedingter Freisetzung aus kerntechnischen Anlagen
6. Fachgespräch Überwachung der Umweltradioaktivität, Karlsruhe, Bonn, pp. 176-192 (1987)

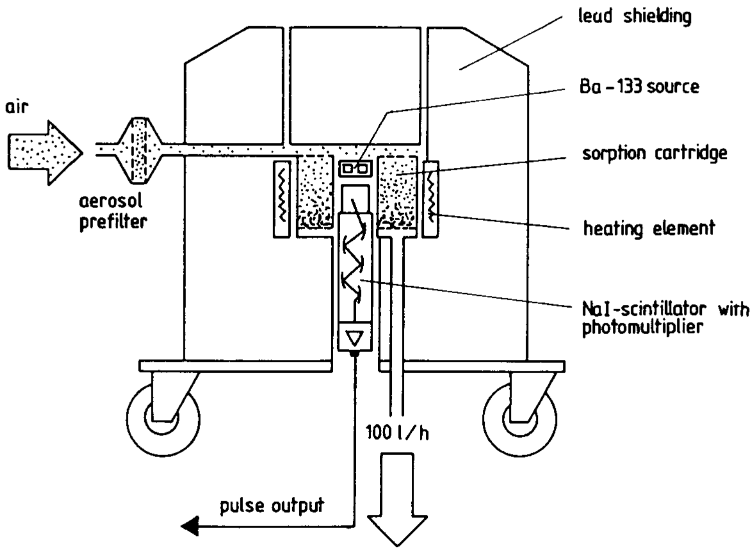

Fig. 1: Diagramatic representation of the iodine measuring instrument

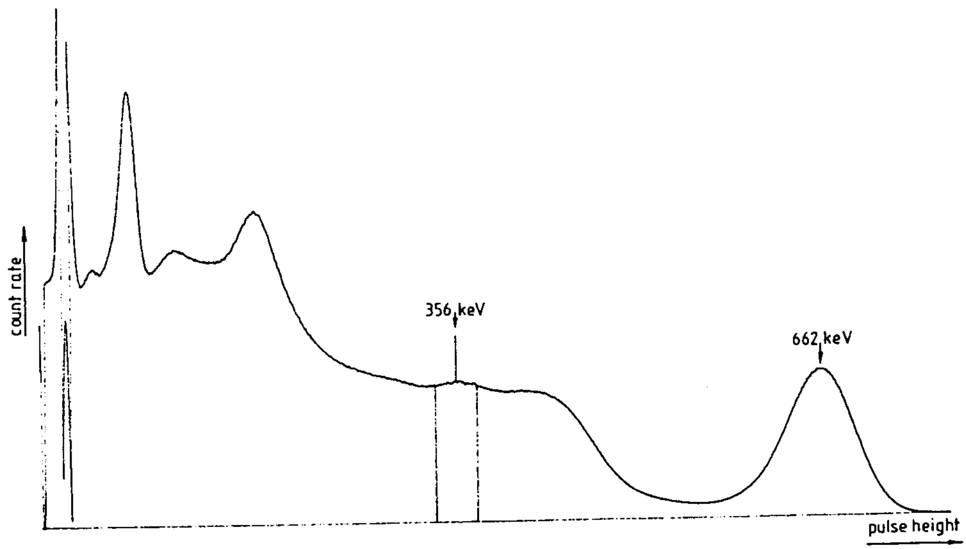

Fig. 2: γ-spectrum of Cs-137 and Ba-133 for a count rate ratio of Cs-137: Ba-133 = 9.3 : 1 in the window of the 356 keV Ba-133 γ-line. The position of the window is shown

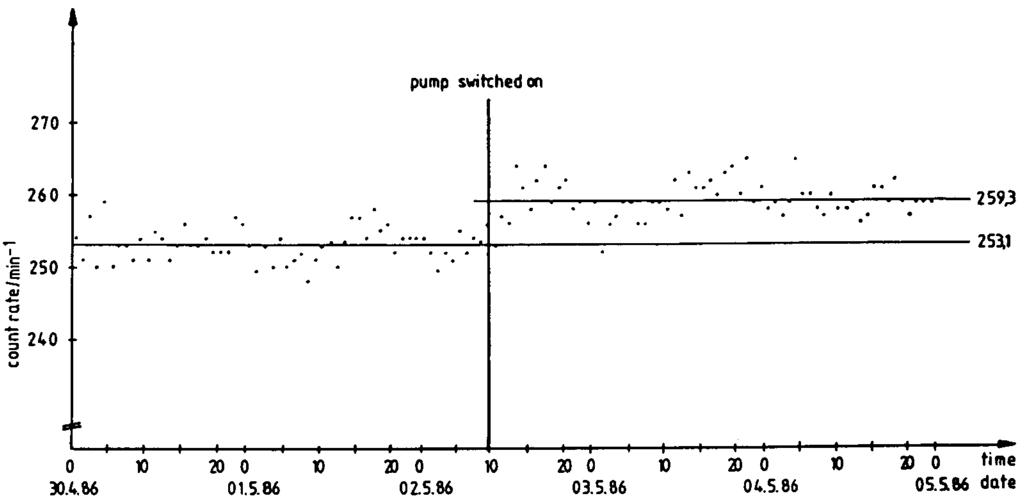

Fig. 3: Reading of an iodine measuring instrument after the Chernobyl accident