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# ENVIRONMENTAL MONITORING NETWORK FOR ACCIDENT MANAGEMENT AT KALPAKKAM NUCLEAR CENTRE

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The Department of Atomic Energy centre at Kalpakkam, India has two pressurized heavy water reactors (670 MW(th) each), an experimental fast reactor (40 MW(th)), fuel reprocessing facilities and associated radiological laboratories, spread over an area of about 2000 acres. While the radiation emergencies confined to plants and laboratories are handled by the Plant Emergency Committees, the responsibility for handling on-site and off-site radiation emergencies rests with the Kalpakkam Central Emergency Organization (KECO). In order to enable the KECO to take quick decisions during radiation emergencies, an extensive network of active as well as passive radiation monitors has been designed.

The basic components of the monitoring stations are environmental gamma monitoring using a sodium iodide crystal detector as well as a Geiger–Müller (GM) detector, a noble gas beta monitor with a GM counter and an airborne iodine sampler. There are seven monitoring stations on the site and the data from the monitoring stations are transmitted by telephone cables to a computer in the emergency control centre. The monitor displays the results from various stations together with the alert and intervention levels. Meteorological data such as wind direction, velocity and Pasquill category also form part of the input to the data processor.

For passive monitoring, thermoluminescent dosimeters (TLDs) using normal calcium fluoride have been found to be satisfactory for the estimation of cumulative dose [1]. TLDs are placed in a large number of locations in the environment around the site.

In addition to this environmental monitoring network, mobile monitoring vehicles with trained manpower to carry out a comprehensive radiological survey are also available. The pre-operational surveys that have been in progress for the last ten years have established the baseline activity and radiation levels at a large number of sampling stations in a belt of 16 km radius around the site. Goat thyroid has been established to be a very good indicator of iodine-131 [2]. Sampling and analytical methods have been standardized for a variety of samples such as milk, soil, vegetables, etc., to enable quick analysis at the time of the accident.

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## SAVRE: SISTEMA AUTOMATICO PARA EL CALCULO DE DOSIS EN EMERGENCIAS NUCLEARES

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El SAVRE es un sistema informático, de funcionamiento interactivo, para el cálculo de concentraciones y dosis debidas a descargas gaseosas en el entorno de instalaciones nucleares. Su objetivo principal es proporcionar a los grupos de planificación de emergencia, de una manera automática, clara e inmediata, un conjunto de datos con distintos grados de elaboración, que les ayude a tomar las medidas de protección adecuadas en caso de que sea previsible o se produzca un escape de sustancias radiactivas al exterior de la instalación.

El sistema comprende dos modos de operación: uno automático de recogida de datos, tanto de descargas como meteorológicos; y otro manual que, a partir de un conjunto de datos leidos del archivo histórico de las librerías internas o introducidas manualmente, realiza cálculos de concentraciones y dosis en el área de estudio para los períodos de tiempo fijados.

Para el cálculo de concentraciones y dosis, el sistema SAVRE incorpora el modelo de cálculo de "eje curvo", desarrollado por Empresarios Agrupados. Este modelo se basa en la división de la descarga gaseosa en una serie de descargas discretas que se difunden siguiendo una ley gaussiana, sometidas a condiciones meteorológicas variables espacial y temporalmente. Los parámetros de entrada que se utilizan en este modelo son las funciones que representan la variación de

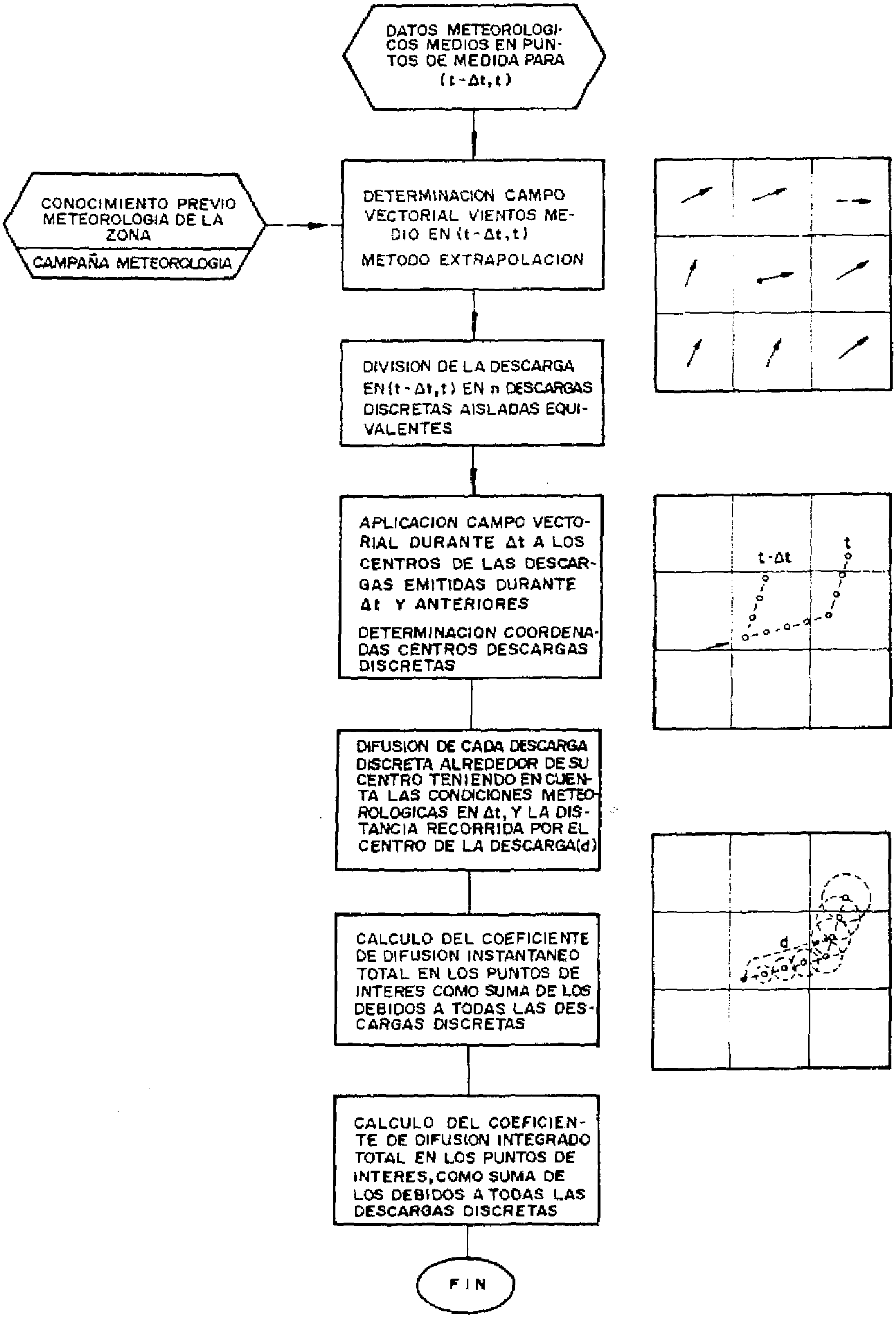


*FIG. 1. Secuencia de ejecución del módulo de cálculo de coeficientes de difusión atmosférica.*

los datos meteorológicos y de descargas con el tiempo para el período de cálculo, discretizadas adecuadamente para la realización del cálculo. Esta discretización se realiza a dos niveles. uno para el conjunto de datos meteorológicos, considerándolos constantes en cada uno de los intervalos que se definen (15 minutos) e igual al valor medio asociado a dicha variable en ese intervalo; y otro para los datos que cuantifican la descarga, considerando descarga uniforme en cada uno de los intervalos de esta segunda división.

Para cada uno de los intervalos meteorológicos en que se divide el período se realiza un proceso de cálculo que, partiendo de una situación al principio del intervalo, lleva a la descarga a la situación correspondiente al final del mismo. Este proceso se divide en cuatro partes:

1) Generación del campo de viento.
2) Transporte de los centros de las descargas.
3) Difusión de las descargas alrededor de un eje.
4) Cálculos de dosis.

En la Fig. 1 adjunta se indica la secuencia de cálculo del modelo de "eje curvo".

Asociada a la difusión de las descargas se introducen las modificaciones a la difusión gaussiana clásica, aprovechando las posibilidades de discretización del modelo: efecto suelo – capa límite; decaimiento; deposición; altura de emisión; topografía; y correcciones de los coeficientes de dispersión.

Al final de cada intervalo meteorológico se tiene, por lo tanto, un conjunto de valores asociados a cada punto de la malla de cálculo definida. Este conjunto está compuesto por concentración instantánea e integrada para cada grupo de isótopos, en aire y suelo, y dosis al cuerpo y tiroides. Con todos estos parámetros, y dependiendo de los puntos de cálculo definidos, se pueden obtener las curvas de isovalores asociadas a cada campo, o solamente los valores en las poblaciones y puntos críticos.

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# EXPERIENCES IN CO-ORDINATING A MONITORING PROGRAMME WITH A GAUSSIAN DIFFUSION MODEL

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Air pollution modelling of large stationary sources in Thailand was initiated in 1980, with the Mae Moh lignite-fired power stations as a pilot project. At that time expertises were totally non-existent. Since then, some US Environmental Protection Agency recommended models, such as VALLEY, MPTER, PAL, COMPLEX I and COMPLEX II, have been adopted in several projects such as the Mae Moh power plant projects, Ao Phai coal-fired project, Krabi lignite-fired project, Nong Ngu Hao Airport project, petrochemical project, cement plants project, etc. Later on some simplified diffusion models were developed in-house to suit local requirements. Several meteorological models (STAWIRO, STARTEMP, etc.) were developed to accommodate the local meteorological data which are needed as inputs to the diffusion models. At first, most of the studies were aimed at assessing the impact of various pollutants on the environment, based on modelling predictions alone. In one particular project, namely, the cement plant, where there were complaints about excessive particulate matter deposited at ground level, which causes nuisance as well as being a health hazard in the surrounding area, a co-ordinated study between the modelling prediction and field measurements was attempted. The results obtained were satisfactory and they proved that the deposition of particulate matter was actually in excess of the standard applying. The study undertaken did not attempt to be a Gaussian model validation but tried to evaluate the short-term impact of the existing plant on the ambient air quality by using both measurements and modelling. A network of four monitoring stations was carefully set up; three downwind in different probable wind sectors and one upwind. The locations of the stations were determined beforehand following a simple procedure based largely on Turner [1]. Measurements were taken simultaneously for nine consecutive days with each sampling period covering 24 hours as specified by the applicable short-term standard. At one station, the measured concentration of particulates reached 343 $\mu g/m^3$, which exceeded the 24-hour standard of 330 $\mu g/m^3$ [2]. For short-term impact modelling, different scenarios were devised according to various modes of emission from composite sources under consideration. The VALLEY model was adopted throughout the study. The calculated value at the same distance from source under a similar scenario could well exceed 188 $\mu g/m^3$. No direct correlation was attempted since no on-site measured atmospheric parameters were available. But the approach in general served as a basis for impact assessment of the project and gave more confidence in the short-term scenarios assumed. It is being used for the accident assessment project of the 2 MW research reactor of the Office of Atomic Energy for Peace in Thailand.

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# STUDY FOR AERIAL MEASUREMENTS IN A NUCLEAR EMERGENCY

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A feasibility study is being carried out with the object of providing the Italian public authorities involved in civil protection with suitable means to face situations which involve radioactivity measurements over large areas.

At the present time, when areas of several hundreds or thousands of square kilometres could be involved, contamination control is carried out by means of survey networks which, generally, need a very large number of stations even though they never give sufficient resolution.

In order to replace or to integrate the local and national survey networks set up for an emergency, we took into consideration the possibility of employing measuring systems in aircraft. These systems allow better scanning of the territory with better resolution within given time limits.

In order to cover a wide variety of accident situations, the study attempts to define measures suitable to deal with specific cases, for example:

(1) Search for lost sources of radioactivity;
(2) Measurements of ground radioactivity after fallout;
(3) Air sampling of a radioactive cloud and monitoring the samples ($\gamma$-spectrometry and gross $\gamma$-$\beta\gamma$).

As regards points (1) and (2) NaI(Tl) crystal radiation detectors have been used exposed to several located sources and $\gamma$-spectrometry analysis in real time. A detector has been placed on a helicopter to determine how the sensitivity of the measurements (lowest detectable source activity for the point 1 and lowest detectable contamination for the point 2) depends on parameters such as flight altitude, integration time, background, scanning speed, flight pattern, etc.

Special care was given to the background study in order to define diagnostic functions. These remain practically constant in the area under reconnaissance when there is only natural radioactivity, but they assume very different values when other sources of radioactivity are present.

As regards point (3) the study attempts to achieve optimum air sampling.

To ensure that the samples are representative of the air contamination, the sampling, carried out by mobile vehicle or in a forced flux, must be isokinetic, that is with the speed of the air inlet mouth equal to the speed of flow of the air itself.

The feasibility study for air sampling at altitude to measure the radionuclides' concentration and the distribution of the particles according to size, indicates the possibilities for isokinetic sampling in conditions where there are large fluctuations in the parameters, especially the relative speed of the air and the aircraft.

The data gathered from measurements at different heights have been elaborated in order to arrive at conversion factors to determine exposure and the area of ground contamination.

# PROTECTIVE MEASURES AND RECOVERY OPERATIONS
## (Session 6)

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Invited Paper

# PRINCIPLES FOR THE ESTABLISHMENT OF INTERVENTION LEVELS FOR THE PROTECTION OF THE PUBLIC IN THE EVENT OF SERIOUS NUCLEAR ACCIDENTS

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Abstract

PRINCIPLES FOR THE ESTABLISHMENT OF INTERVENTION LEVELS FOR THE PROTECTION OF THE PUBLIC IN THE EVENT OF SERIOUS NUCLEAR ACCIDENTS.

The system of dose limitation recommended by the International Commission on Radiological Protection (ICRP) in Publication 26 and incorporated into the International Atomic Energy Agency's Basic Safety Standards for Radiation Protection applies to exposures resulting from controlled sources under operating conditions. In accident situations, the source of exposure is, by definition, not under control and the exposure of the public can only be limited, if at all, by some form of action which will disrupt normal living. Such action has been termed "intervention" by the ICRP, the IAEA and the Commission of the European Communities. The paper presents a summary of guidance developed by the IAEA on radiological principles for defining levels of dose (intervention levels) at which various measures that can be taken to protect the public should be introduced. This guidance is seen as providing the radiological basis for the future activities of the Agency in emergency preparedness.

## 1. INTRODUCTION

The accident at Three Mile Island nuclear power station in the USA [1] stimulated all countries with nuclear power programmes to review the emergency arrangements that had previously been made. In addition it provoked a series of meetings amongst international agencies to consider the principles for protection of the public in the event of uncontrolled releases of radioactive material. The fact that ICRP had previously published, in 1977 [2], new recommendations for radiological protection, incorporating a number of new concepts, such as Effective Dose Equivalent, as well as stochastic and non-stochastic dose limits, added to the need for reconsideration of principles for emergency planning.