HAEA NEPO
TOOLS USED IN NUCLEAR EMERGENCY RESPONSE

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ABSTRACT

Decisions concerning the implementation of countermeasures following nuclear accidents have to be based on quick and reliable predictions of the possible environmental effects. In Hungary, decisions are supported by three main sources.

Whenever the site of the accident is the Paks NPP the emergency is detected and declared by the shift supervisor. Radiation conditions in and around the plant are detected on a real-time system. The plant transfers these data to the emergency centres of both the Governmental Committee for Nuclear Emergency Preparedness and of the Hungarian Atomic Energy Authority.

The Centre of Emergency Response Training and Analysis (CERTA) of the Hungarian Atomic Energy Authority is primarily meant for making analysis of a nuclear emergency situation, based on data obtained from the power plant or from the international nuclear community. The most important results of the analysis are the source term estimates and the forecast of the possible on-site consequences. The computer program system CERTA VITA collects, processes and displays the data for further analysis and reporting. The source term estimation is performed by using two alternative tools. A simple but rough estimate is obtained from the InterRAS program. A more detailed analysis is given by the SESAME code.

The environmental consequences are evaluated by the program NACOS. Atmospheric dispersion, plume depletion, doses, dose commitments, early and late health effects are computed. Effects of the introduction of countermeasures are taken into account. The program works as a simulator, various scenarios can be specified and results obtained by these scenarios can directly be compared to each other. The user can execute two parallel runs – with and without countermeasures – and compare the consequences. Results (path of the plume, contaminated area, doses, health effects) are displayed on maps with spectacular symbols, and/or in tables showing the computed values.

These tools have been successfully applied during the INEX2-HUN exercise.

INTRODUCTION

Decisions concerning the implementation of countermeasures following nuclear accidents have to be based on quick and reliable predictions of the possible environmental effects. In Hungary, decisions are supported by three main sources.

ON-SITE EVALUATION

Whenever the site of the accident is the Paks NPP the emergency is detected and declared by the shift supervisor. The criteria are based on Emergency Action Levels, which can be either radiation levels or technological parameters. Radiation conditions in and around the plant together with meteorological parameters are detected on a real-time system. The plant transfers these data to the emergency centres of both the Governmental Committee for Nuclear Emergency Preparedness and of the Hungarian Atomic Energy Authority.

OFF-SITE EVALUATION

The Nuclear Emergency Preparedness Organisation of the Hungarian Atomic Energy Authority is primarily meant for making analysis of a nuclear emergency situation based on data obtained from the power plant or from the international nuclear community. The Centre for Emergency Response Training and Analysis (CERTA) is the centre where the groups of the HAEA Nuclear Emergency Preparedness Organisation perform their tasks.

In a case of a nuclear emergency in Hungary these groups are responsible for plant state assessment, source term evaluation and answering the international expert questions and providing the IAEA and the bilateral countries with expert information. Three groups work in the CERTA: analysis group, information group and logistic group: the emergency leader co-ordinates the work of these groups. The information group has to prepare expert information and to answer questions arriving from abroad. The logistic group is responsible for communication, catering, etc. The task of plant state assessment and source term evaluation belong to the analysis group.

After approval the analysing group sends the plant state assessment and the source term to the Emergency Information Centre of the Governmental Committee for Nuclear Emergency Preparedness. The members of this centre have the task of the estimating of environmental consequences.

FORECAST OF CONSEQUENCES AND EMISSION ESTIMATION

The most important results of the analysis are the source term estimates and the forecast of the possible on-site consequences. To fulfil these tasks of the HAEA Nuclear Emergency Preparedness Organisation, number of tools are installed and information come from the plant in CERTA. The information can come through MLLN line, phone or fax. In addition there is a site observer delegated to the on-site emergency team too to provide the analysis group with further information, if required.

The most significant tool is an on-line data transfer system, which provides the experts with more than 500 data from each units of the NPP Paks in every ten seconds and display them in the centre. A sophisticated computer program system, CERTA VITA, collects, processes and displays the data in a format suitable for further analysis and reporting. CERTA VITA gives a concise description of the status and numerical characteristics of all critical safety functions as well as detailed graphical presentation of every parameter obtained from the plant. In exercises the software can connect to the full scope simulator of the NPP (the scenario of the INEX-2 HUN exercise ran in the simulator). The software is was developed by the Hungarian KFKI Atomic Energy Research Institute. Four display methods are possible in the system [8]:

(i) Safety Parameter Display shows the most important data of the units,
(ii) the same data can be displayed on more than 25 plant schemes,
(iii) P-T (pressure-temperature) diagram shows the status of the hot and cold loops and
(iv) each data can be plotted on trend-diagrams.

Two software tools are installed in CERTA for source term evaluation: the InterRAS [7] distributed by the IAEA and the SESAME developed by the French IPSN Institute and adapted in the framework of a PHARE project. The InterRAS is a fast, but rough estimator software, which requires only a few relevant information. Therefore this software is used in the first phase of an emergency, when the source term is to be communicated to the Emergency Information Centre as soon as possible.

The SESAME [5] is a more sophisticated software, which requires more than hundred data in every minute, therefore it is on-line fed by the CERTA VITA system. The SESAME software has five modules: acquisition, diagnosis and prognosis, break size evaluator, time of core uncovery estimator, source term evaluator. The source term evaluation is divided into two parts, based on the type of the accident (LOCA or SGTR case).

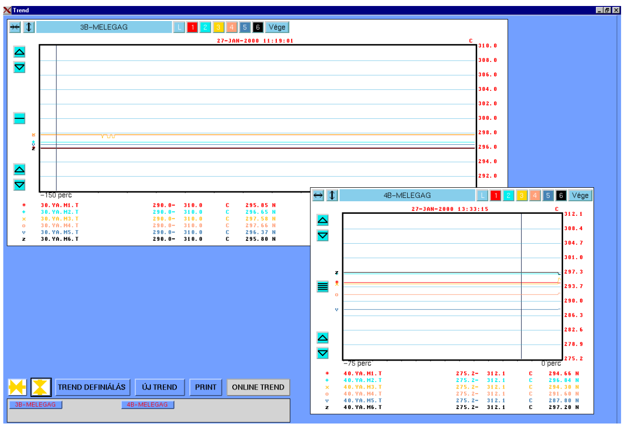

FIGURE 1. Trend screen of CERTA VITA

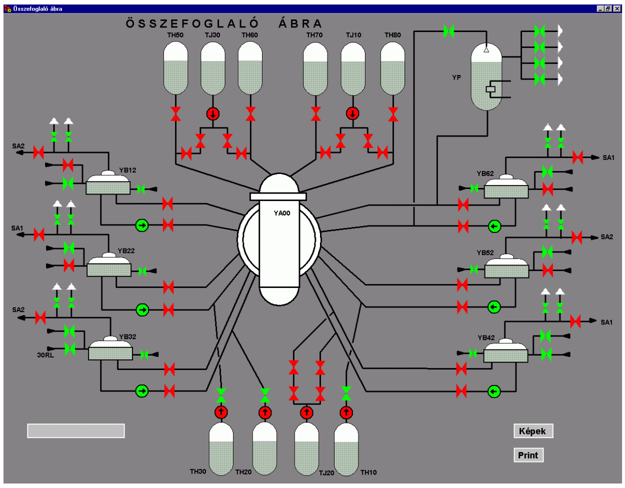

FIGURE 2. The main plant scheme

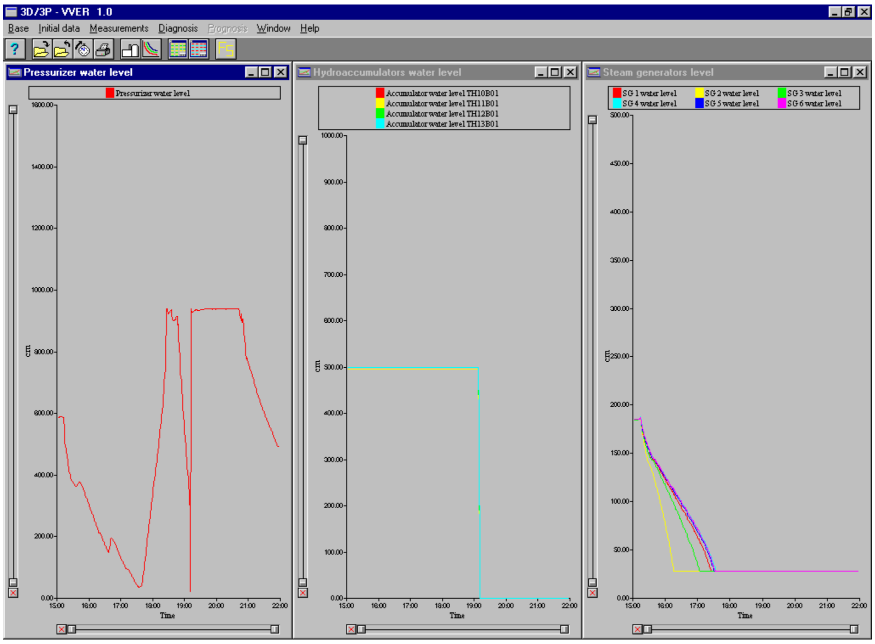

FIGURE 3. A typical display of SESAME-VVER

ENVIRONMENTAL CONSEQUENCES

Modelling goals

The environmental consequences are evaluated by the Hungarian program NACOS (Nuclear Accident Consequences Simulation) [1]. A twofold task is fulfilled by the program:

(i) it is a tool for education and training,

(ii) in the case of a real accident it gives fast, easy-to-understand visual information on the radiological state of the environment.

Simulation feature

The program works as a simulator: various scenarios can be specified (different emissions, meteorological conditions, countermeasures, etc.) and the corresponding results can be directly compared to each other. Computations are carried out in one hour steps. There is a possibility to return to earlier phases and repeat the simulation under different conditions.

Source modelling

There are two types of sources considered:

(i) if the accident takes place at the Paks NPP the emission centre is set there, and the program works on a polar co-ordinate system. The area of the country is cut into 16 wind sectors and 34 rings (about 500 segments). In another option, in the vicinity of Paks all radiological parameters are computed for the centres of villages. There is a built-in default inventory, however, at the beginning of each run the user can change it to the actual inventory. Release rates can be specified by the user at the beginning of every hour or are taken on-line from the files supplied by CERTA Moreover, pre-calculated release terms are available from a library for several typical accident scenarios.

(ii) in the case of a distant accident the point where the plume enters Hungary is to be specified together with the plume parameters. In this case a 18 * 23 segment Cartesian grid is set upon the map. The radioisotope content of the plume is to be specified at the entrance.

Atmospheric dispersion

Meteorological conditions can be given by the user at each one hour step, or read on-line from the data files supplied by the National Meteorological Service. For training purposes data can alternately be taken from a library containing data observed at Paks in one year (8760 hours).

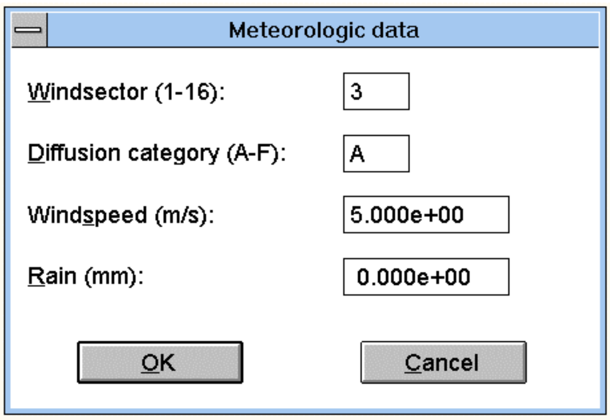

FIGURE 4. A dialog box for actual meteorological data input

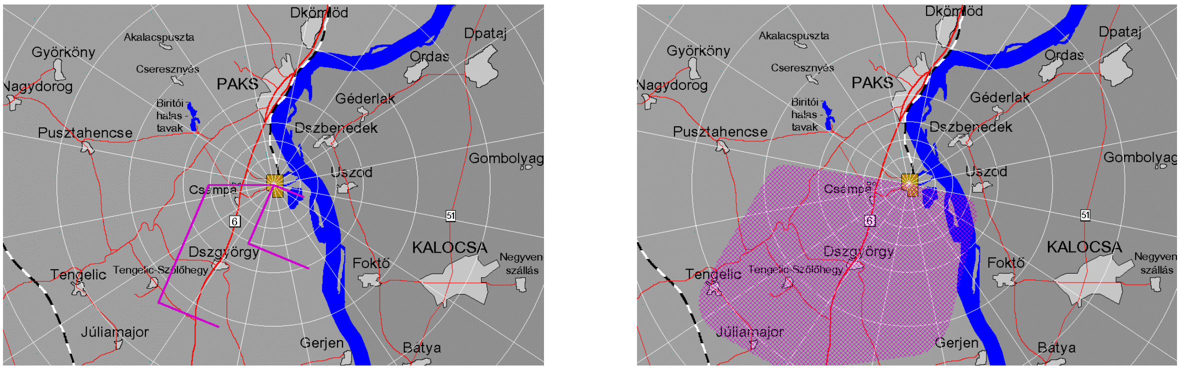

FIGURE 5. The paths of the centre-lines of two plumes (left panel) and the contaminated area (right panel)

Each hour's emission is cut into nine puffs, separated in time, each carrying one-ninth of the emission. A Gaussian dispersion of the puffs is assumed [2].

Surface activity concentrations and time integrated activity concentrations in air at a height of 1 m above the ground are computed for each segment.

Dose calculation

External gamma air kerma rates and effective doses, skin beta doses are determined for all segments. Thyroid and effective inhalation doses are calculated, separately for adults and children. Effects of shielding by housing are taken into account.

Food pathway is included is the computation of the committed doses. Different consumption data and soil to vegetation conversion factors are given for the four seasons [3].

Collective doses are derived based on the population data stored in a library.

Health effects

Early morbidity and mortality are estimated from deterministic health effect models. Late effect probability calculations are based on LNT hypothesis both for morbidity and mortality [4].

Countermeasures

Three types of early countermeasures can be implemented during the simulation: sheltering, iodine prophylaxis and evacuation. Warnings are given to introduce these countermeasures whenever pre-set criteria are reached. The actual decision is for the user. To help the decision, and this is a unique advantage of the simulator, the user can execute two parallel runs – with and without countermeasures – and compare the consequences. For the long-term countermeasures (relocation, pasture ban and food ban) actions are assumed to be taken automatically if the pre-set criteria are reached.

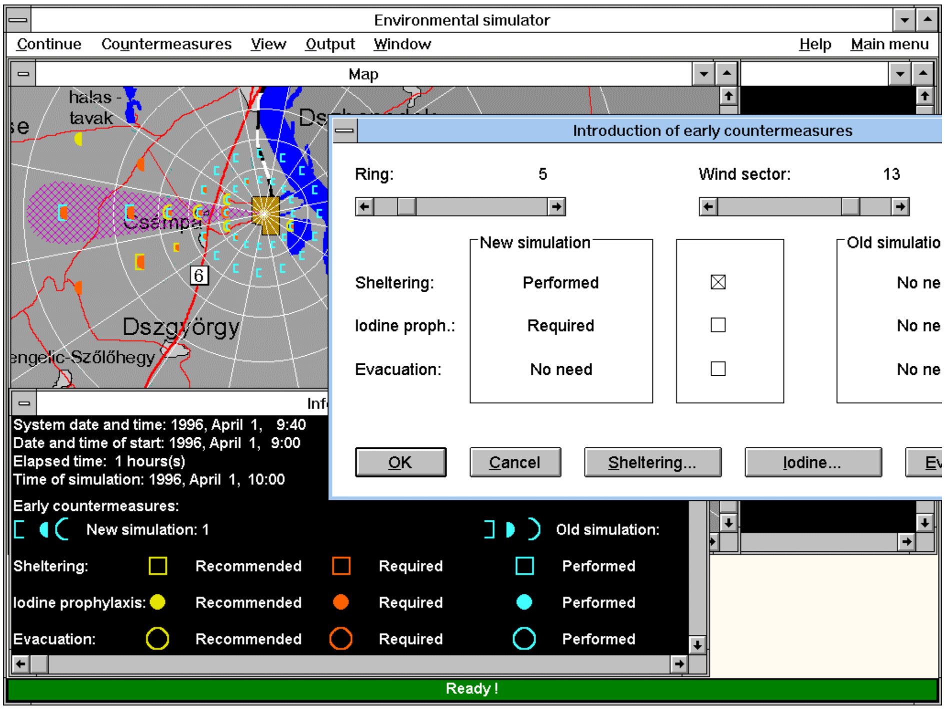

FIGURE 6. Recommendations for countermeasures and the dialog box for user decisions

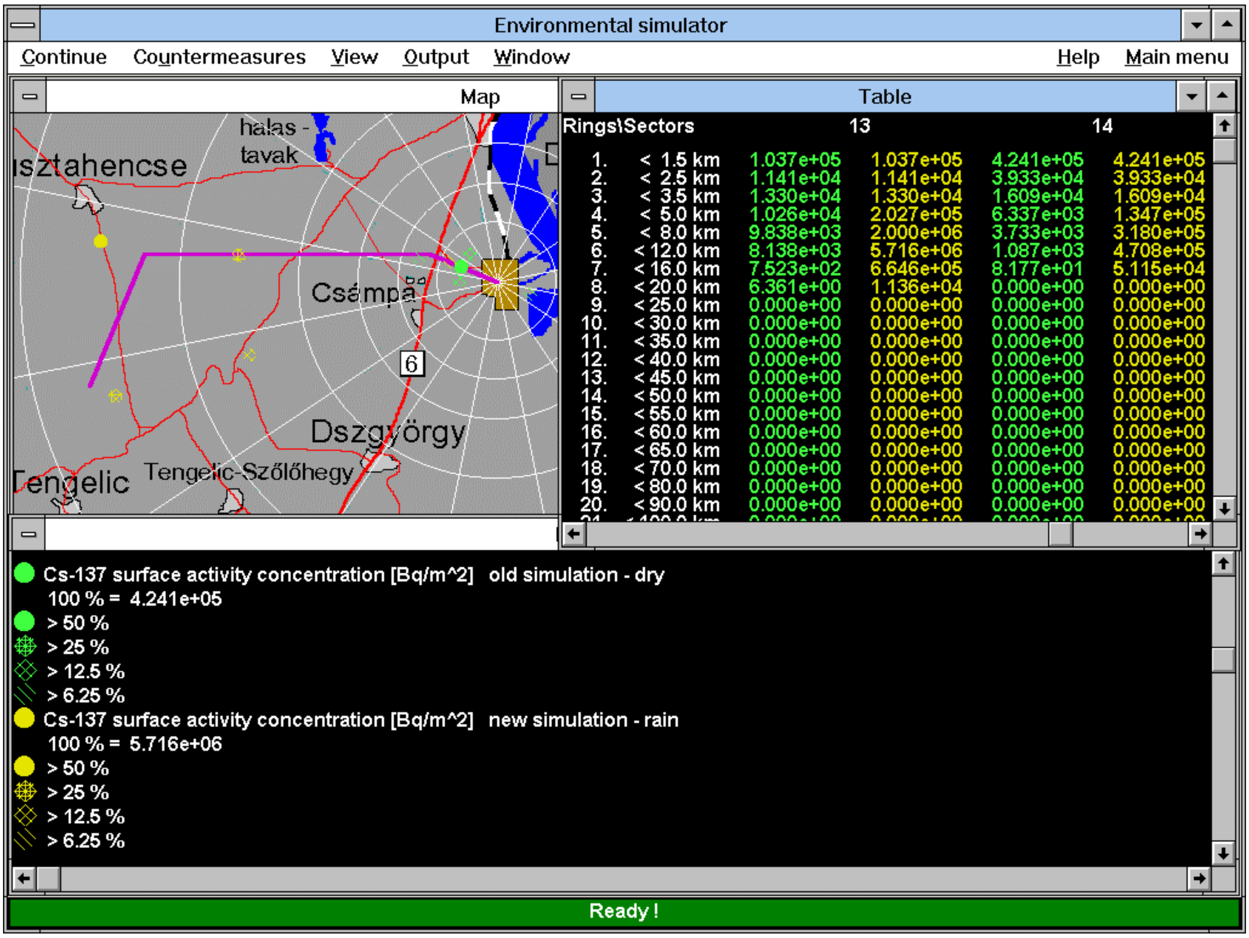

FIGURE 7. A typical screen of NACOS results:
the plume centre-line and Cs-137 depositions for dry and rainy weathers

Presentation of data

Results (path of the plume, contaminated area, doses, health effects) are displayed on maps with special symbols, and/or in tables showing the computed values. Time variations of the quantities are also displayed on request.

All results can be printed by black and white or colour printers, or stored in files for further evaluation.

Computational environment

The program works on IBM compatible PCs, under the WINDOWS operating system. All the site-specific data bases are relevant to Hungary, or even to the Paks site/reactor. The segmented structure of the program and the separate set of data files, however, makes the adaptation for other sites relatively easy.

INEX-2 EXPERIENCES – CONCLUSIONS

The first international challenge for the CERTA was the INEX2-HUN exercise [6]. In this exercise besides Hungary, more than 30 countries and international organisations took part. All hardware and software tools were used during the exercise like in a real situation. The initiator of the exercise was a collector cover lift off. The failures of the main gate valve and one of the safety valves belonging to the injured steam generator made the event more severe. Direct release occurred into the environment from the primary system through the open safety valve. The plant state could be assessed by evaluating the trends of some significant parameter, for example primary and secondary pressure and temperature, the water-levels of the injured and the intact steam generators. Because of the continuous loss of the primary coolant firstly core uncovery, later core melt occurred. Based on the support of the CERTA and the EIC the governmental committee decided some countermeasures (iodine blocking, sheltering, evacuating) in the surrounding villages.

The appropriate tools made it possible to evaluate the state of the plant and the source term accurately. Due to sufficient working of the groups all the questions were answered, reports sent and decision made on time during the exercise. Based on the success of the INEX2-HUN and the national exercises the suitability of the Hungarian emergency preparedness was proven.

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