



**NUCLEAR TECHNIQUES IN HEALTH
AND ENVIRONMENT PROTECTION
MANAGEMENT OF HAZARDS**

CENTRE OF EXCELLENCE "MANHAZ" – MANAGEMENT OF HEALTH AND ENVIRONMENTAL HAZARDS

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The mission of the Centre of Excellence MANHAZ is to provide leadership, expertise and integration of efforts related to risk assessment of activities involving hazardous substances in Poland. The main targets to be achieved by the Centre are the following:

- to create a common forum both for developers of the models for risk assessment, management of major accidents and decision support systems, and for members of emergency centres, inspectors of environmental protection and people responsible for safety management in chemical plants. The forum will enable to initiate a broader discussion and interaction, both to provide essential feedback to the developers and to familiarise the users with the nature and level of support they can expect in practice,
- to consolidate efforts of experts in environmental protection to include advanced models in the currently used software,
- to familiarise a broad spectrum of specialists working in the field of environmental protection with new trends in mathematical methods used in risk assessment.

The following work packages have been predicted in the MANHAZ project of EU for the three year period:

- Modelling of pollutant transport in atmosphere and water bodies for decision support systems in case of emergencies.
- Models and tools for assessment of risk related to transportation of dangerous goods by road and railway.
- Methods and models for assessment of risk related to transportation of dangerous goods by pipelines.
- Approaches to comparative risk assessment of fuel cycles of electricity generation.
- Organisation of national working team on safety assessment for medical applications of radiation.
- Organisation of summer school "Management of environmental hazards".
- Clearing house and information.

In 2005 the activity of the Centre encompassed:

- carrying out four workshops foreseen by WP1, WP2, WP3 work packages;
- organisation of summer school;
- maintaining WWW MANHAZ portal and collection of relevant materials.
- The subjects of the workshops concerned:
- Modelling of pollutant transport in water bodies for decision making.

- Undertaking decisions related to activities using dangerous substances (for stationary installations and transportation by road, railway or pipelines) supported by "Value Tree Methodology".

The main aim of the workshops carried out in 2005 was to present to the broad spectrum of specialists and persons engaged in decision making process, "the state of the art" of systems, models and tools relevant for management of environmental hazards. A particular stress was put on decision making process. More specific information about each workshop is included in separated summary.

One of the most important MANHAZ activity in 2005 year was organization of the thematic school: "Management of Health and Environmental Hazards" at the premises of the Faculty of Environment Engineering, Warsaw University of Technology. The most important aspects of management of environmental hazards were presented mainly for young researchers and undergraduate students. More detailed information is given in separated summary.

Another direction of MANHAZ activity is development of numerical methods and algorithms for solving problems in pollutant transport in atmosphere and water bodies, and in the field of nuclear reactor physics.

The MANHAZ Centre acts also a Technical Support Organization for the Centre for Radiological Events of the National Atomic Energy Agency. The staff of the Centre has been also engaged in the development of:

- environmental systems for management of air quality,
- project of chemical monitoring system for Warsaw agglomeration.

In addition the following tasks have been performed in connection with MARIA reactor operation:

- start-up computations of MARIA reactor after the one year break in operation,
- computations of neutron physics parameters of proposed MARIA fuel element with U_3Si_2 meat enriched to 19,7% and their comparison with the parameters of existing fuels,
- criticality computations of 19A storage pool with encapsulated MR-6 fuel elements,
- criticality computations of chosen configurations of AGATA critical assembly,
- comparison of thermal fluxes in the measurement and reference fuel channels of MARIA reactor.

IMPLEMENTATION OF MULTI-SCALE MODEL CMAQ FOR SIMULATION OF THE AIR QUALITY

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The Community Multiscale Air Quality (CMAQ) [1] model is a three-dimensional atmospheric chemistry and transport modeling system designed to simulate ozone, acid deposition, visibility, and fine particulate matter in the troposphere. As a one-atmosphere model, CMAQ can address the complex couplings between several air quality issues at once from local to hemispheric spatial scales. CMAQ source code is designed to be highly transparent and modular to facilitate extensibility through community development. CMAQ is a third-generation air quality model designed for applications ranging from regulatory and policy analysis to understanding the complex interactions of atmospheric chemistry and physics. Third generation models, like CMAQ, treat multiple pollutants simultaneously up to continental scales and incorporate feedback between chemical and meteorological components. Air quality models integrate our understandings of the individual complex processes that affect the concentrations of pollutants in the atmosphere. Establishing the relationships between meteorology, chemical transformations, emissions, and removal processes in the context of atmospheric pollutants is the fundamental goal of an air quality model. In contrast to statistical air quality models that use historical trends in observed atmospheric conditions to predict air pollution, CMAQ uses coupled mathematical representations of actual chemical and physical process to simulate air quality. Based upon the underlying concept of preserving mass through a series of contiguous three-dimensional boxes covering a fixed model grid, CMAQ belongs to the Eulerian class of mathematical box models. Eulerian models calculate a mass balance within each grid cell by solving the transport across each cell boundary and chemical transformations within each cell during a given time period. As a framework for simulating the interactions of multiple complex atmospheric processes, CMAQ requires inputs from meteorology and emissions models to provide information about the atmospheric energy balance and sources of pollution.

The major CMAQ components are:

Model Builder (M3BLD) - M3BLD is required to create all of the CMAQ executables, it is the first pro-

gram that needs to be compiled after installing the CMAQ source code on your system.

Photolysis Rate Preprocessor (JPROC) - calculates chemical mechanism-specific clear sky photolysis rates at fixed altitudes, hour angles, and latitude bands. Output from JPROC is an ASCII look up table of photolysis rates that the CCTM uses to calculate gas-phase chemical transformations and pollutant concentrations.

Initial Conditions Processor (ICON) - generates a gridded binary netCDF file of the chemical conditions in the modeling domain for the first hour of a simulation.

Boundary Conditions Processor (BCON) - generates a gridded binary netCDF file of the chemical conditions along the horizontal boundaries of the modeling domain.

Meteorology-Chemistry Interface Processor (MCIP) - converts MM5 binary meteorology output files to netCDF files for input to the CCTM.

CMAQ Chemical Transport Model (CCTM) - is the chemical transport modeling component of CMAQ. It integrates the output from all of the preprocessing programs, including emissions and meteorology, to simulate hourly atmospheric chemical conditions.

Plume Dynamics Model (PDM) - is the Plume in Grid preprocessor to CMAQ. The PDM generates plume dynamics, such as dimensions and location, from special emissions input files generated by an emissions model for Plume in Grid simulations.

Chemical Mechanism Compiler (CHEMMECH) - creates mechanism include files for the CMAQ from a mechanism definition file. This program is needed to add new species that require the addition of new reactions.

References

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**METHODS FOR PROCESS INSTALLATIONS RISK ASSESSMENT, SEVESO II
DIRECTIVE AND ITS CONSEQUENCES, SAFETY REPORTS - THE THEMATIC
SUMMER SCHOOL ON MANAGEMENT OF HEALTH
AND ENVIRONMENTAL HAZARDS**

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Damages and disasters which appeared in years 70-80 in the chemical industry, e.g. Flixborough, Bhopal and Seveso, caused the necessity of undertaking of concerning activities of preventing to such events and limitations of their results. This had its own image in legal solutions and practical activities initiated in countries of the European Union. They determine the realization of decisions of EU Council – earlier Seveso I"(82/501/EEC from 24 July 1982), and later "Seveso II" (96/82/EC from 9 December 1996). Seveso II Directive (Law Act of the Protection of the Environment) since the year 2001 it refers serious damages in works using dangerous matters in this inflammable matters. An aim of the Directive is the assurance of the safety to workers and to the environment what demands introductions of management techniques, particularly of risk management techniques whose a base is the making the risk assessment.

Seveso II refers serious damages whose results can influence outside the institution, so such damage events in which are great amount of dangerous matters is released. The directive regulates so-called the process safety. The Centre of Excellence MANHAZ along with the Faculty of the Engineering of the Environment of the Warsaw Technical University on 26-30.09.2005 organized the thematic school: "Management of Health and Environmental Hazards". One of the objective of the school was methods for process installations risk assessment comprising Seveso II consequences and safety reports [1].

In compliance with obligatory regulations the safety report (SR) is a key- element of the strategy of preventing damages and administering a safety of the installation. It is assumed that SR should:

- 1) to create the base for administering with the risk of serious damages: resources of preventing to damages, safety measures for the inspection of the development of the damage situation and limitations and mitigation of consequences,
- 2) to deliver the information on processed materials, processing and spatial placing of elements of the installation,
- 3) to identify threatening (reasons, results, the frequency of appearing),
- 4) to make easy the dialogue on the matters of the safety,

- 5) to make easy the dialogue with proper authorities both in the range of the safety inside the installation as well as of the safety out of the installation.

Generally SR should consist of the descriptive part and the analytic part. The descriptive part should contain the synthesis of all important information on to the construction of the installation and rules of her exploitation and services. The description has to be on so much detailed, so that it be possibly in the next analytic part to prove that the producer used indispensable resources for preventing to serious damages.

In analytic part built-in guilds of the safety of the object servants to preventing to serious damages and to the limitation of their results should be presented and assessed. Such assessment should be supplemented with the risk analyses containing estimations of the answer of the installation on different possible disturbances/defection of the nominal process parameters values and/or on postulated not efficiencies of systems of the installation or their elements.

Regulations Seveso II refer serious damages with the potential of causing serious threatening for people, or environments in that case, the safety report should be rated by the team representing different departments/specialized institutions in each these elements.

Experts passing of the estimation should possess definite competences in suitable prepared recommendations by competent authorities.

Best, so that procedures of estimations and process of estimations itself be in compliance with the ISO9001 requirements.

For realizing above-mentioned requirements is necessary worked out, publication and spread of suitable elucidative materials (guidelines, reviews and recommendations) important deciding of laws and concerning orders of the problems of the safety reports as well as denominative in detail the process of the estimation of the safety reports and methods of each estimations of its elements.

This makes easy to the operator and to competent authorities initiating of decisions of the right in the matter of the safety reports. Such materials should make possible the necessary unification practical approach and assure properly high level professionalism.

References

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PRACTICAL APPROACH TO SAFETY ANALYSES FOR INCINERATION OF HAZARDOUS WASTES

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Incinerations of hazardous wastes as plants of high risk are obliged to developed detailed safety analyses. The incineration of municipal waste involves the generation of climate-relevant emissions. These are mainly emissions of CO₂ (carbon dioxide) as well as N₂O (nitrous oxide), NO_x (oxides of nitrogen) NH₃ (ammonia) and organic C, measured as total carbon. CH₄ (methane) is not generated in waste incineration during normal operation. It only arises in particular, exceptional, cases and to a small extent (from waste remaining in the waste bunker), so that in quantitative terms CH₄ is not to be regarded as climate-relevant. CO₂ constitutes the chief climate-relevant emission of waste incineration and is considerably higher, by not less than 10², than the other emissions.

A practical approach to safety analyses for incinerations of hazardous wastes using example of modern incineration Kommunekemi, Denmark has been presented in the report [1]. With more than 30 years of experience in treating a wide range of waste products from Danish industry, institutions and households, Kommunekemi has gained an exceptionally competence and know-how within the treatment of hazardous waste. This expertise forms the basis of the development of new and better treatment methods, in particular focusing on increased utilization and recycling. The evaluation of alternative technologies is based on theoretical knowledge and practical tests. In particular the following elements have been described: wide analysis of possibility of major accident, new technological solutions for safety management, identification of sources of major accidents, emergency scenarios and their consequences taking into account national law regulations related to safety analyses based on Directive Seveso II.

The Waste Incineration Regulations came into force on 28th December 2002. Together with directions issued at the same time to the Environment Agency and the Local Authorities, who are the regulators, they transpose the Waste Incineration Directive, 2000/76/EC ("WID"). The WID incorporates and extends the requirements of the 1989 municipal waste incineration (MWI) Directives (89/429/EEC and 89/369/EEC) and

the Hazardous Waste Incineration Directive (94/67/EC), forming a single Directive on waste incineration.

All hazardous waste incinerators must obtain operating permits from an authorized state agency. To obtain a permit, as a first step the facility must submit a detailed, multi-volume permit application, providing detailed engineering and other data which specify how the incinerator is designed and how it will operate. The application must include a trial burn plan to evaluate the emissions from the process, and to demonstrate that the incinerator meets regulations. Public hearings must be held at the time of submission of the application to get the views of those near the site. After an extensive review of the application by the regulatory agency and the public, the incinerator must conduct a trial burn (discussed further below) which demonstrates the incinerator's capability to operate within regulatory limits. The emission results from the trial burn are then evaluated in a comprehensive risk assessment study that considers both direct and indirect risks to the public. A draft permit, detailing operating and other requirements that will govern the incinerator's performance, is then issued for public review and a public hearing.

Finally, after all regulatory requirements have been met to assure protection of public health and the environment, a final operating permit is issued. The incinerator must operate at all times in accordance with its permit. This assured, in part, by extensive and sophisticated control equipment, continuously recorded monitoring and automatic waste-feed cutoffs (discussed below). Further assurance is provided by frequent inspections by the regulatory agencies. In addition, most commercial incineration facilities maintain an open door policy that provides public access to the facility on virtually a daily basis. Community involvement and outreach is an integral part of facility operations, with many facilities conducting household hazardous waste collection days and technical seminars for their local communities.

References

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STRUCTURE AND FUNCTIONS OF THE DECISION SUPPORT SYSTEM FOR EMERGENCIES FROM INSTANTANEOUS EMISSIONS

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The structure and functions of the environmental decision support system for management of air quality has been described [1]. The system is able to undertaking various analyses for emission and transport in environment many kinds of pollutants for different spatial and temporal scales. In particular the system can: 1) simplify using of complex air quality models; 2) make easier modification of models for new areas of application and taking into account better description of physical phenomena; 3) integrate models for different pollutants and scales for transport and transformation of pollutants in atmosphere; 4) increase flexibility of currently used models for implementation on various hardware and software platforms; 5) consider many spatial-temporal scales without necessity of using dedicated computer packages.

A prototype version of the system SWD-ES was developed and implemented on Beowulf cluster, operating under Linux system with application of MPI standard for distributed and parallel processing.

In the system several modules was integrated, with the most important:

- emission modelling subsystem,
- emission manager,
- mesoscale numerical weather prediction system,
- pollutant transport and transformation subsystem,
- data bases.

One of the key element in the decision support systems is emission modelling. In the pollutant dispersion and transport models system for processing emission data is absolutely necessary. One of the most advanced such a system is Sparse Matrix Operator Kernel Emissions Modeling System (SMOKE), witch can produce data for air quality models like CMAQ. The SMOKE model is well suited to American classification of emission sources (SCC), which is not used in Poland. The

model uses ten digits code for emission data according to SCC.

The question how to apply SMOKE model in Poland has also been analysed [2]. Output files of SMOKE are crucial for proper run of CMAQ model in the current version of the development.

The only available emission data for Polish territory are prepared by National Center for Emission Data according to EMEP. Voievodship Environmental Protection Inspectorates have typically data not completed and properly validated. One of the solutions is to change SMOKE source code in order to avoid preparation of very detailed data according to SCC. The other possibility is to produce emission data in the file of a proper format that can be used as input for CMAQ model. Methods and programs have been proposed [2], which could be utilized to solve the problem.

In general emission data can be classified as point, linear and from areas. The point data are quite well known as the most of them is strictly related to industry activities. The linear emission data are those from transportation systems, like roads and railway. There are some tools and methodologies how to estimate them. The problem is usually with emission data from areas like inhabitant zones as they coming from private households. It should be mentioned that a number of useful information of this kind is available in the Main Statistical Office. However the information is not public and cannot be accessible even by environmental protection agencies.

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REMOVAL OF VOLATILE ORGANIC COMPOUNDS AND PAHS FROM EXHAUST GAS USING ELECTRON BEAM FROM ACCELERATOR

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The growing stringency of regulations controlling gaseous pollutants emission to the atmosphere requires the consideration of methods for reduction of the volatile organic compounds (VOCs) and polycyclic aromatic hydrocarbons (PAHs) emissions. The investigations of PAHs removal efficiencies from coal-combustion flue gas using high-energy electron beam from accelerator were carried out in the pilot plant at EPS Kawęczyn [1]. High removal efficiencies of strong – carcinogenic PAHs were found. The total toxicity of flue gas after irradiation decreases. In the Institute of Nuclear Chemistry and Technology (INCT) in Warsaw, the laboratory plant was built to study the removal efficiencies of VOCs from different gaseous mixtures [2]. At the beginning, the study of benzene removal from vaporized benzene in air mixture was performed [3].

In 2005, INCT equipped the laboratory plant with two chromatographic systems from Shimadzu (Japan): GC17A and GC/MS System QP5050. These new instruments improve the analysis of the by-product formed in this process. The decomposition of different volatile organic compounds in the air has already been investigated in the Japanese [4], German [5] and South

Korean [6] laboratories. We decided to start the study of usability of the e-beam process for the air pollution control at municipal waste incineration, in which case, besides the acidic pollutants, PAHs and VOCs are emitted. Sample of exhaust gas from Municipal Waste Incinerator in Warsaw will be analysed using the installed Shimadzu instruments. In the laboratory plant, the gaseous mixture with identical composition will be prepared and irradiated using electron beam from IŁU-6M accelerator.

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MATERIAL TEST CENTRE

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Material Test Centre (MTC) has been established within the consortium of Material Research Laboratory (MRL) of the IAE and the Radioactive Waste Management Plant (RWMP) for quick identification and categorisation of the unidentified or of unknown origin radioactive or nuclear items in field and laboratory conditions. The MTC has been one link of Polish system for the response to illicit trafficking and inadvertent movement of radioactive materials.

The MTC is prepared for quick identification and categorization of radioactive and nuclear materials in field by non-destructive assay as well as for precise analysis of such materials in laboratory. The complete mobile ISOCS Shield System (Canberra) comprising the liquid nitrogen cooled High Purity Ge detector (BEGe), the set of collimation shields and dedicated computer programs is the main equipment used for identification

of a suspicious material. The hot cell laboratory of MRL forms the basis for detailed analysis of seized radioactive material.

In 2005 the MTC was called several times to the common waste disposal sites (mainly in Warsaw) for identification of suspicious items, that eventually were found to contain I-131 from medical applications. In one case the Tc contamination of a medical waste container was identified. Only in one case the Co-60 and Th contamination was found. In some charcoal delivery from Byelorussia the enhanced contamination with Cs-137 was identified. To test the sensitivity of the measuring system a series of tests of the WWER spent fuel were performed from the distance of 48 m. For secure categorization of the material the 180 s measurement time was needed in most cases. Only in one case 600 s measuring time was necessary.