H14-90

WESTIGAUSS – AN ATMOSPHERIC DISPERSION MODELLING AND ENVIRONMENTAL IMPACT ASSESSMENT TOOL FOR NUCLEAR INSTALLATIONS

Tim Vidmar, Johan Camps, Damien Braeckers and Geert Olyslagers

SCK.CEN, Belgian Nuclear Research Centre, Mol, Belgium

Abstract:A Gaussian plume atmospheric dispersion modeling computer code, called WESTIGAUSS, has been developed for environmental impact assessment of accidental and routine releases of radionuclides from nuclear installations. It is tailored to the needs of the licensing process of the MYRRHA reactor and uses locally developed and adapted atmospheric dispersion parameterization.

Key words: *Nuclear installation; Atmospheric dispersion; Gaussian plume; Dilution factor; Dose calculation; MYRRHA project.*

THE MYRRHA PROJECT

MYRRHA – Multi-purpose hYbrid Research Reactor for High-tech Applications – is a versatile irradiation facility the design of which has been under development at the SCK•CEN, the Belgian Nuclear Research Centre in Mol for several years in order to replace the ageing BR2 reactor, a multi-functional materials testing reactor in operation since 1962. MYRRHA, a flexible fast spectrum research reactor (50-100 MWth) is conceived as an accelerator driven system (ADS), able to operate in sub-critical and critical modes. It contains a proton accelerator of 600 MeV, a spallation target and a multiplying core with MOX fuel, cooled by liquid lead-bismuth (Pb-Bi).

MYRRHA is foreseen to become operational around 2023. During the 2010-2014 period the following items have to be accomplished:

- The Front End Engineering Design (FEED) and the associated R&D programme.
- The licensing process.
- The set-up of the international consortium.

The licensing process is currently in its initial stage (pre-licensing consultations), which requires an initial environmental impact report (EIR) to be delivered to the Belgian Nuclear Authority. It is this report that sets the frame for our atmospheric modelling code, its features, abilities and characteristics. The code must be capable of coupling the atmospheric transport calculations to dose assessment algorithms for both routine and emergency releases from the future MYRRHA facility and for all relevant exposure pathways.

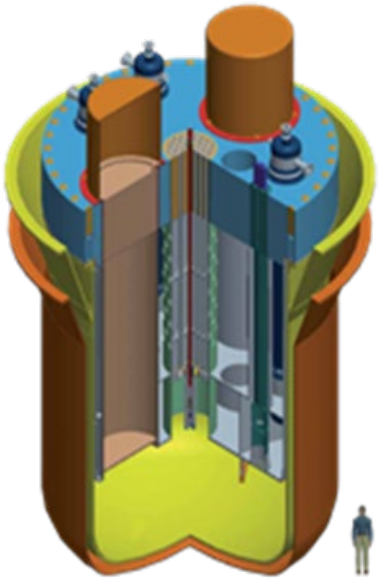

Figure 1: The MYRRHA reactor.

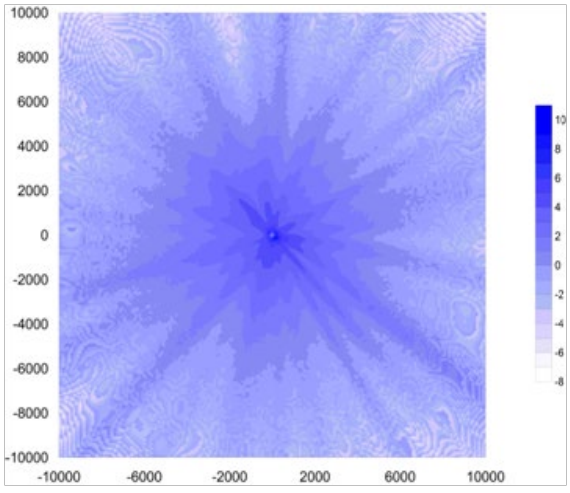

Figure 2: The differences (in percent) between the average yearly dilution factors caclulated with the same input data by WESTIGAUSS and by IFMD.

THE WESTIGAUSS CODE

As an atmospheric dispersion code tailored to the specifics of the MYRRHA licensing process, WESTIGAUSS employs a tested Gaussian model of plume formation with a dispersion parameterisation that has been locally developed and tested and is as such especially well suited to the specifics of the local environment at the SCK.CEN (hence the acronym WE STIck to GAUSS). This feature of the code also maintains its compatibility with earlier ones developed at the site and their results for other nuclear installations present there, which is an important advantage from the point of view of the Belgian Nuclear Authority who wish to assure a coherent approach to the environmental impact assessment and emergency management of the SCK.CEN site as a whole.

The extensive experiments required for the establishment of the local parameterisation of the Gaussian plume model were carried by means of controlled releases from the weather mast on the site, which is still in routinely use. They established a specific definition of whether stability classes and the accompanying parameterisation of the dispersion coefficients, used in Gaussian plume modelling(Bultynck and Malet, 1972).

A typical year of hourly meteorological data from the sensors on this mast is available and has been used in our MYRRHA studies. The data encompass the wind speed and direction, the rainfall (in mm/h) and the Bultynck-Malet stability class, derived from temperature-gradient measurements.

Other main characteristics of the code include:

- A Cartesian grid for air concentration, deposition and dose calculations with tuneable dimensions and spacing;
- Dry and wet deposition, separately for aerosols and Iodine isotopes (Sohier, 2002);
- Doses from inhalation, groundshine and immersion;
- Simplified treatment of terrain features;
- Briggs formulae for the plume rise (Briggs, 1965 and 1971);
- Reflections from the ground and the inversion layer.

The dose conversion factors required have been taken from the Belgian legislation, where available (Reference Missing !, Johan, please provide one), and from EPA recommendations otherwise (Eckerman and Ryman, 1993).

The WESTIGAUSS tool is a collection of FORTRAN 77 programs and input and output ASCII text files. No development of a graphical user interface is currently envisaged.

The code was first validated by comparison with a well-established and commercially available package for modelling of routine atmospheric releases, called IFDM (Cosemans et al., 1982), for a full year of hourly weather data and on a 50 by 50 km grid. The relative agreement of the calculated dilution factors was within a few per cent. The same was true when modelling much shorter releases and when considering a smaller spatial scale.

For MYRRHA calculations, a direct verification with Excel spreadsheets was first performed for a somewhat simplified version of the programme. Full calculations were then performed of 24-hour, one-hour and ten minute accidental releases, according to the scenarios specified by the Nuclear Authority. For each of these conditions a full (typical) year of weather data was used and the critical period was selected, being the one with the resulting dose corresponding to the 95-th percentile of its distribution.

The MYRRHA calculations will be extended to other accidental scenarios and to routine releases.

We also intend to adapt the code for general emergency management calculations at the SCK.CEN site and the sites of the Belgian nuclear power plants by employing a segmented Gaussian model or a puff model and developing an advanced user interface.

REFERENCES

Bultynck, H. and Malet, L., 1972: Evaluation of atmospheric dilution factors for effluents diffused from an elevated continuous point source. Tellus, Vol. 24, pp. 445-472.

Briggs, G.A., 1965: A plume rise model compared with observations, JAPCA, Vol. 15, pp.433–438.

Briggs, G.A., 1971: Some recent analyses of plume rise observation, Proceedings of the Second International Clean Air Congress, Academic Press, New York.

Cosemans, G., Kretzschmar, J.G., De Baere G. and Vandervee J., 1982: Large Scale Validation of a bi-Gaussian Dispersion Model in a Multiple Source Urban and Industrial Area, in De Wispelaere C. (Editor), Air Pollution Modeling and Its Application II. Plenum Press; pp. 709-728.

Eckerman, Keith F. and Ryman, Jeffrey C., 1993: Federal Guidance Report No. 12 -- External Exposure to Radionuclides in Air, Water, and Soil. EPA-402-R-93-081.

Sohier A., Ed., 2002: A European Manual for Off-site Emergency Planning and Response to Nuclear Accidents. The EU Commission, DG Environment.