SYNTHESIS OF THE MODELS USED IN FRANCE FOR THE EVALUATION OF THE CONSEQUENCES OF ACCIDENT

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Summary

In order to evaluate the consequences of an atmospheric release in case of an accident on a nuclear installation, different predictive models have been developed by the organisations involved in the management of the crisis. These models are of different numerical complexity: precalculated graphs, gaussian puff models or 3D models. The harmonization of these models, the definition of their use, notably in the first phases of the accident (predictive and real-time phases) have been discussed in a working group including representants of the utility, the safety authorities and the Meteorological Office. The reflexions of the group, the models already operational, those still under discussion and their use in the different technical crisis centers are presented.

I Introduction

In case of an accident on a nuclear installation, a crisis organization is settled in France in order to take the appropriate counter-measures for the protection of the population. The decision makers are adviced by teams in charge of assessing the situation of the damaged plant, performing a prognosis of the evolution of the situation and of the possible release of radionuclides in the atmosphere and finally predicting the radiological consequences of the accident. The work of these teams is helped by the use of numerical methods for simulating the dispersion of the radionuclides in the atmosphere. A great effort has been put in France since several years for the harmonization of the tools used by the different teams and on the definition of their use during the crisis. Most of this effort has been done in the framework of a group, with representants of the utility EDF, the French Meteorological Office and the Institute for Protection and Nuclear Safety -IPSN- (the technical support of the safety authorities). The work of the group consisted first to identify the actual needs of information of the authorities in the context of a crisis situation and then to choose the mathematical tools adapted to these needs. This paper gives an overview of the conclusions of this work, highlighting the reasons of the choices. Such effort of harmonization has also

been extended on an international scale and is briefly presented.

II The reflection teams of the national crisis organization.

The reflection teams for the radiological consequence assessments are distributed into three centers at the national level:

- the Emergency Crisis Center of the utility,
- the Emergency Technical Center of the IPSN,
- the Crisis Center of the French Meteorological Office,

and one at the local level, which is the crisis team of the operating utility.

During the early phase of the accident (corresponding to the off-site emergency response plan -Plan Particulier d'Intervention-), when the short term counter-measures have to be considered, the work of the utility and of the IPSN crisis teams is to predict the radiological consequences in the environment. During the later phase of the accident (corresponding to the off-site post-accident response plan - Plan Post-Accidentel-), the role of the IPSN crisis team is, according to the measurements performed in the environment, to analyse the radiological situation, notably for the longer term counter-measures.
The role of the Meteorological crisis center is to provide the other crisis centers with meteorological informations, especially, during the early phase, the forecast of the local weather, and also, if needed, at regional and long range scales.
The different crisis teams are in close contact through different channels : phone conference network, computer system terminals or fax.

III Mathematical tools used for the evaluation of the consequences in the environment

The modeling work performed in the three technical organizations involved in the crisis management, EDF, IPSN and the Meteorological Office, has led to the development of several methods which can be distinguished into three main categories:

- precalculated graphs,
- gaussian plume or puff models,
- 3 dimensional wind field models, associated with a lagrangian or eulerian diffusion model.

The need of coherence of the evaluations performed in the different crisis centers has conducted the three organizations to work together on the following objectives:

- harmonization of the methods used in the different teams,
- choice of methods adapted to the needs of the situation, according to the different phases of the crisis and the different spatial scales to be covered,
- complementarity of the work done by the teams during the crisis.

The scheme (however, not yet fully frozen), drawn hereafter and summarized on the table 1, describes the present situation concerning the calculation tools retained for operational purposes and their use during the crisis. It results for a large part from the reflection of the group, but also from the experience acquired during the numerous simulations of crisis performed in France since several years. This scheme relies on the following simple ideas which guided the work of the group:

- the purpose of the calculation tools is mainly oriented to the prediction of the consequences in the early phase of the accident for the short term counter-measures; in the later phase, as soon as contamination measurements are available, or concerning the longer term counter-measures (restriction of food commercialization or comsuption), the decisions will essentially be based on the results of the contamination measurements;
- simple tools are used when only informations with large uncertainties (at the beginning of the crisis) are available; they are run, according to the needs, in all the crisis centers, at local and national level;
- more complex tools are used when more information are known; they are run in one center, the results being communicated to the other centers.

For the consequences at local scale (approximately ten km around the site), two main methods of calculation have been developed. They are both based on the gaussian puff model using the Doury's standard deviations [1] (function of the travel time, with two classes of stability) -see remark at the end of this paper-.
During the early phase of the accident (before the beginning of the release), the main objective is to determine the zones where short-term countermeasures have to be taken. Both a prediction of the source term and the forecast of the local weather are required. In the context of such a situation, characterized by large uncertainties in the input data, a simple tool, consisting of precalculated graphs, giving values of atmospheric and surface transfer coefficients, has been adopted (see an example figure 1). These graphs correspond to different meteorological conditions (stability, wind velocity, precipitation) and are suitable for gases or aerosols. They take into account an uncertainty of ± 15° on the wind direction for simple sites (without significant topographic effect). This uncertainty corresponds to the one estimated concerning the forecast of the wind direction locally. In fact, later studies conducted by the french meteorological

office [2] have shown that it may be higher: the tests performed on some of the french nuclear sites have shown that the prediction locally of the wind direction is done with an uncertainty of ± 30° with a confidence level greater than 70 % on rather simple sites and with a lower confidence level for more complex terrain. Therefore, specific adaptations of the graphs for such sites (complex terrain) have been brought. They consist in an increase of the angle of the sector which may be reached by the plume. This increase has been evaluated, site by site, according to studies performed on the site itself or to the expert judgment of the participants of the group.

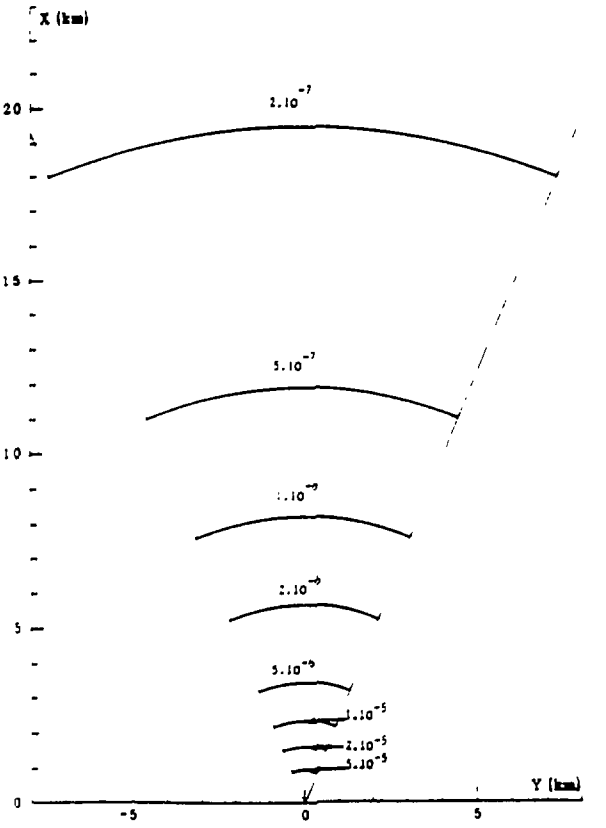

Figure 1 : Atmospheric Transfer Coefficient ($s.m^{-3}$)
Aerosols - Neutral atmosphere -
Wind between 3 and 7 $m.s^{-1}$

The second method consists in a gaussian puff model. All types of release kinetics and all types of meteorological conditions, eventually varying versus time during the release, can be taken into account.
EDF has developed, in the framework of the GEEE project, a version of such code adapted to real time assessment. This code is run locally (on the accidented site); it takes into account the meteorological data measured every ten minutes on the site and the radionuclides release rate measured at the stack. In case of necessity, the results of such real time assesssments can be sent to the national crisis centers by one of the link mentioned hereabove.
A version of such code, but not operating with on-line measurements, Sirocco [3], is also available at the IPSN crisis center.

For regional and long distances, two complementary methods have been developed: gaussian puff models applied on trajectories considered as the locations of the mass centers of pollution and 3D models. The first type of model permits a rapid estimation of the consequences and can be used during

the first phase of the accident, in order to rapidly judge the possible consequences at mesoscale and long distance, notably concerning the neighbour countries. In the later phases of the accident, when more informations are available, a 3D model can be run and gives in some cases(1) more accurate results.
A model of the first type has been developed by IPSN. The puffs follow the trajectories generated by the models of the french meteorological office every three or six hours. The concentration and doses are computed, at different times, for each point of a grid of maximum 160 x 160 points. Such model Sirocco-LD is used at the IPSN crisis center. A version with a smaller mesh size for regional problem (the code Sirocco-MD) is under development.
Concerning the second type of models, for long range transportation, the french meteorological office has developed two 3D models for the analysis or forecast of the wind, temperature,... fields [5] : Emeraude covering the whole atmosphere with a grid mesh of 1.5° in latitude and 2° in longitude and Péridot covering western Europe with an horizontal resolution of 35 km x 35 km. The wind fields generated by the models permit to calculate trajectories of transportation of pollutant. Also, an eulerian diffusion model, Média, has been developed and, coupled with the calculated wind field, permits to determine the concentration field resulting from a pollutant release. The results can then be transmitted to the other crisis centers.

For regional scale problems, different 3D prognosis models, with a smaller mesh size (of the order of 5 km) are available, while not yet ready for operational purposes: one developed at EDF (Hermes), one by the Meteorological Office (Péridot-meso), one by the IPSN (Adrea) in collaboration with the greek institute NCRS. They all permit a forecast of wind and turbulence fields over areas exhibiting complex topography, as well as the prediction of the transport-diffusion of an atmospheric release. For practical reasons, linked with the necessity of knowledge of the conditions, calculated by the Meteorological Office, at the boundary of the domain of interest, the model of this last organization will probably be retained and the results transmitted, when needed, to the other crisis centers. However, a preliminary exercice will be soon performed in order to compare the results of the wind field given by the three models (in the case where important divergences will be noticed between the results, studies would continue in order to understand the reasons for them).

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(1) the moderation in the words comes from the recent international Atmes exercice [4] which concluded that there was no obvious link between the complexity of the model and the accuracy of its prediction.

Remark: in the framework of the french-german commission, a collaborative work has been done in order to develop a common model for short distances to be used in both countries in case of emergency. A new set of standard-deviations, to be used in a gaussian puff model, has been elaborated. These standard-deviations will replace those presently used. A full presentation of this work is given in an other paper of this seminar [6].

IV Conclusion

In the framework of the french crisis organization, a great effort has been put on the harmonization of the work performed by the different teams involved in the crisis, notably on the methods used to simulate the atmospheric dispersion in case of accident. Therefore, a working group with representants of the utility EDF, the Meteorological Office and the IPSN (technical support of the safety authorities) has been set up. The work of the group consisted first to identify the actual needs of information of the authorities in the context of a crisis situation and then to choose the mathematical tools adapted to these needs.

The scheme of the situation, resulting from the work of the group, but also from the experience acquired thanks to the simulations of crisis performed in France, can now be drawn :

- a simple tool, consisting in site-specific precalculated graphs, is used when only informations with large uncertainties (at the beginning of the crisis) are available, in order to orientate the short-term counter-measures; this tool is run, according to the needs, in all the crisis centers, at local and national level;
- more complex tools (notably, gaussian puff model for real time assessment or 3D prognosis models) are used when more informations are known; they are run in one center, the results being communicated to the other emergency centers via different links, computer system terminals or fax.

Work is still to be done, notably concerning the meso-scale dispersion evaluations. Moreover, the new set of standard-deviations, developed in the framework of the french-german commission in order to harmonize the evaluations performed on both sides of the border, have to be tested and integrated in the methods for short distance consequence evaluations; such work would have to be extended, when needed, to other neighbour contries. Finally, the whole organization described hereabove, and particularly the links between the different technical emergency centers, still need tests; they will be done at the occasion of the future crisis simulation exercices to be performed in France.

References

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TABLE 1 : synthesis of the methods for the calculation of atmospheric dispersion used in the different technical emergency centers in France

	METHOD	OBJECT
IPSN emergency center	precalculated graphs	consequence evaluation for short term counter-measurements
	gaussian puff type models	consequence evaluation from local to long range distances
EDF national emergency center	precalculated graphs	consequence evaluation for short term counter-measurements
EDF local emergency center	precalculated graphs	consequence evaluation for short term counter-measurements
	gaussian puff type model	real time consequence evaluation at short range
Meteorological Office emergency center	3D prognosis models	weather forecast
		meso-scale and long range transport-diffusion calculation