ZONING OF CONTAMINATED AREAS : A KEY ASPECT OF POST-ACCIDENT MANAGEMENT

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At the last IRPA Conference in Buenos Aires (2008), ASN presented the approach implemented in France for the definition if national doctrine related to the risk management during the post-accident period following a nuclear accident (so called "CODIRPA program). Four years later, the first French doctrine is to be published in the first half of 2012. It covers the first few days following radioactive releases from the damaged facility, but also the first few months (the period referred to as transitional) and the first few years after the accident (long-term period).

The French doctrine was built around fundamental objectives and is based on a number of principles, including the justification and optimisation principles defined internationally and more specific principles resulting from works performed in France since 2005, such as the anticipation principle and the co-construction principle, involving the public authorities and the stakeholders. It also comprises a number of action topics organised around operational objectives.

The fundamental objectives of post-nuclear accident management

Long-term contamination of the environment by radioactive atmospheric releases from a damaged nuclear facility creates a complex situation that affects all aspects of the life of the populations, including the economy of the area concerned. It can affect an extensive area and have impacts on human activities performed outside this area. The long-term nature of this deposited contamination means that management arrangements have to be made for a period of several years, if not several decades.

In terms of health issues, it is accepted that the committed doses in the event of a nuclear accident involving radioactive releases and liable to be received by individuals living in the areas contaminated by the radioactivity deposited on the ground, are at a level that could lead to an increased risk of eventually developing chronic pathologies (cancers in particular). The appearance of these pathologies is not immediate and can occur several years or even several decades later. Furthermore, the worry and the distress caused by the accident and its consequences are immediate effects constituting important risk factors from the psychological viewpoint.

Over and above the health aspects, managing the consequences of a post-nuclear accident situation must take into consideration numerous economic and social issues, involving numerous actors, both nationally and locally, and covering various areas of competence and preoccupations.

In the light of these issues, three fundamental objectives were adopted for post-accident management of a nuclear accident :

1. protect the populations against the dangers of ionising radiation ;
2. provide support for the population suffering the consequences of the accident ;
3. restore the economic and social life of the areas affected.

The key points of post-accident management

To meet these three objectives, the measures specified by the doctrine involve management of the transitional and long-term periods, although some measures need to be implemented early, on exiting the emergency phase. Particular attention must be paid to the following key points :

- the immediate implementation of zoning of the contaminated areas, which can evolve during the transitional phase, is a major decision and constitutes the basic structure for managing the population protection and health monitoring steps and then for preparing the economic recovery of the contaminated areas ;
- the population affected by the consequences of the accident, some of whom are liable to be permanently evacuated from their homes, must receive medical and psychological care, radiological monitoring, financial support and compensation for the prejudice suffered ;
- characterisation of the radioactivity in the environment, in foodstuffs and in drinking water remains a priority and a permanent issue throughout the post-accident phase ;
- restarting economic activity and revitalising the areas affected implies a new form of governance based on vigilance and the active participation of the populations concerned;
- the large-scale influx of contaminated waste of various origins means that long-lasting management solutions must be gradually implemented to replace the temporary management solutions adopted on exiting the emergency phase.

Planning the initial protection measures

On exiting the emergency phase, the first steps must be implemented or initiated rapidly in order to protect the population from the radioactive substances present in the environment and to take charge of the populations affected. Decisions will need to be taken rapidly on whether to allow the populations to remain or to organise long-term evacuation for those living in the vicinity of the damaged facility, on whether to ban the sale and consumption of locally produced foodstuffs, on initial clean-up operations for buildings and on opening accommodation and information centres for the populations affected.

Criteria for determining the perimeter of the initial post-accident zoning

The initial post-accident zoning, established on exiting the emergency phase, is based on a determination of two zones : the population protection zone (ZPP) and the local enhanced surveillance zone (ZST).

The population protection zone (ZPP) corresponds to the perimeter within which measures to reduce the exposure of the persons living there are justified. This zone is

defined according to a radiation protection criterion applying to the population living within the most heavily contaminated areas.

The initial definition of the perimeter of the ZPP is based on the forecast evaluation of the doses liable to be received in the month following the end of releases, ignoring the effectiveness of any contamination mitigation measures taken in this zone. The ZPP is thus determined on the basis of whichever is the most penalising of the following two exposure indicators :

- the forecast effective dose received during the first month following the end of releases, all exposure routes taken together, including the ingestion of contaminated local produce, the guideline value adopted being about 10 mSv over the first month;
- the forecast equivalent dose to the thyroid received during the first month following the end of releases, the guideline value proposed being about 50 mSv over the first month.

The dosimetric guideline values should not be interpreted as thresholds or limits. It must be remembered that the uncertainties concerning the dose effects and the health effects at these exposure levels mean that parameters other than the dose must also be considered, linked to the performance conditions of the measures concerned and which should be assessed more at the local level.

In principle, the ZPP is a zone in which individuals may circulate freely, except in forests or other places where there is a concentration of radioactive substances, identified after characterisation of the contamination and for which access restrictions could be stipulated. In the accident scenarios considered, the main long-term potential source of exposure of the population is the consumption of contaminated locally produced foodstuffs. The consumption and sale of foodstuffs produced in the ZPP is therefore prohibited, whatever their level of contamination. These foodstuffs would thus be considered as waste, at least for the first month.

It is possible that for a part of the ZPP, despite the ban on the consumption of locally produced foodstuffs, the exposure of the population is felt to be too great owing to the deposition of radioactivity in the environment, in which case it would then be necessary to evacuate some of the residents of the ZPP, **by creating an evacuation perimeter (PE) within which the inhabitants would be evacuated, probably for a lengthy period.**

If an evacuation perimeter were to be necessary within the ZPP, it would be determined according to the results of a predictive evaluation of the forecast effective dose over the first month following the end of releases, without taking account of any consumption of contaminated locally produced foodstuffs, comparing these results with a guideline value of about 10 mSv over the first month.

For operational purposes, the indicators defining the ZPP and the evacuation perimeter shall be given in values that can be measured in the field, for example, in equivalent dose rate (mSv/h or µSv/h) or surface activity concentration quantity (Bq/m^2).

The local enhanced surveillance zone (ZST) extends beyond the population protection zone. It is characterised by lower environmental contamination that does not warrant the implementation of population protection measures, other than recommendations aimed at limiting the consumption of locally produced foodstuffs, or locally hunted, fished or picked food items.

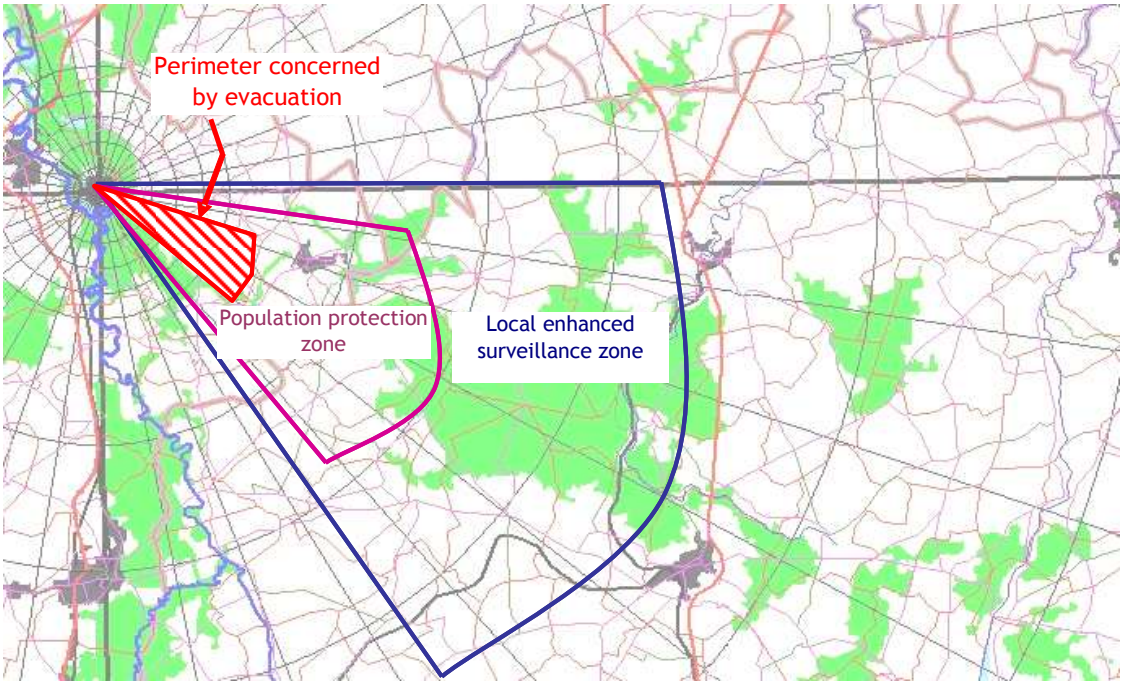
This contamination is nonetheless significant and can in particular affect agricultural foodstuffs and produce, justifying the implementation of particularly robust surveillance. The contamination of certain agricultural produce and foodstuffs could in fact, even if temporarily, exceed the regulation Maximum Permitted Levels (MPL) set at a European level.

The ZST is thus defined as being the zone encompassing all the perimeters within which, for given agricultural produce liable to be produced and harvested during the coming month, the Maximum Permitted Levels could be exceeded. In this zone, a systematic ban on all forms of sale and consumption of the various local agricultural produce is first of all pronounced pending the implementation of inspection arrangements appropriate to each agricultural production sector and aimed at allowing the sale of those products complying with the MPL.

Unlike the ZPP, which focuses primarily on protection of the populations, the purpose of the ZST is also to preserve the economic activity, ensuring that only those products with a radiological quality meeting the MPL are liable to enter the distribution circuits. In this respect, the MPL should not be considered to be a health indicator.

Figure n°1 below gives a schematic representation of the ZPP (including the possible evacuation perimeter) and the ZST.

Figure n° 1: Schematic representation of post-accident zoning



The technical bases of initial zoning

On exiting the emergency phase, the predictive modelling approach is the only one able to provide the public authorities with dose evaluations for the population and for agricultural produce contamination, used to determine the ZPP and the ZST[1].

The modelling approach requires large amounts of data and information about the characteristics of the damaged facility and its environment (in particular the agricultural produce) as well as about the lifestyles and eating habits of the populations concerned, in order to provide an estimate that is as accurate as possible. It is important to point out that this method, even when used with realistic data, gives results that comprise a considerable degree of uncertainty, linked to the wide variability of the phenomena involved, the partial or imprecise data used for the evaluations and the intrinsic lack of precision of the models used.

In a context such as this, reasonably prudent data and hypotheses will be used for the calculation parameters, in order to avoid the risk of "over-evaluating" the consequences used as the basis for implementing the ZPP and the ZST. The expression "reasonably prudent hypotheses" here means hypotheses leading to dose estimates on the basis of which sufficiently protective measures will be decided on, but without exaggerating the scope of the ZPP and the ZST, which could unnecessarily prejudice the populations and the local economy.

Subsequently, these initial evaluations will be regularly updated on the basis of new data acquired from the field, in particular the results of actual environmental contamination measurements acquired using existing resources (monitors, measurement stations) and resources deployed exceptionally (laboratory trucks, etc.). In particular, helicopter-borne radiological mapping of the area will be carried out as rapidly as possible. The two approaches (modelling and measurement) are in fact inseparable.

Modifying the initial post-accident zoning

On exiting the emergency phase, the zoning is established for an indicative period of one month (based on calculations performed over an initial one-month period) and then re-assessed regularly (by means of calculations with a time pitch of one year). This arrangement is able to take account of the kinetics of the accident and implement increasing levels of consultation. These two time-frames allow visualisation of the dynamics of the accident, identification of the most urgent measures on exiting the

1 In France, IRSN uses predictive modelling approach for the delimitation of ZPP and ZST.

emergency phase and adjustment of these measures according to the changing situation and the consultations carried out.

Modification of the zoning during the first few months following the accident (transitional period) can be spatial (the surface area of a zone increases or decreases) but also qualitative (the requirements and stipulations concerning a zone are modified). Independently of the areas, the populations who lived in an area at a given time and thus received particular monitoring (health, epidemiology, etc.) will continue to be part of the cohorts monitored, even if the area in which they live is subsequently reclassified.

Why modify the initial post-accident zoning ?

Post-accident zoning is established towards the end of the accident release phase, on exiting the emergency phase. Zoning is a tool able to anticipate the population protection measures ; it must thus evolve to take account of the changing radiological situation (radioactive decay of the radionuclides, effectiveness of contamination mitigation measures) and adapt to the new data (characterisation of the radiological situation, modelling results).

How should post-accident zoning be modified during the transitional period ?

The zoning approach during the transitional phase is based on the same guideline levels as for zoning on exiting the emergency phase, but the indicators are calculated with a different time base :

- the indicator for the evacuation perimeter is an anticipated dose of about 10 mSv excluding ingestion over 12 months (2nd-13th month period); if this guideline level were to be exceeded, deferred evacuation of the population would be implemented;

- the indicator for the ZPP is only expressed in terms of forecast effective dose. The guideline level is about 10 mSv over 12 months, taking account of all exposure routes (it is no longer felt necessary to take account of the thyroid dose owing to the rapid radioactive decay of iodine in the environment);

- the indicator for the ZST remains compliance with the maximum permitted levels (MPL) set by Community regulations for locally produced foodstuffs.

Consultation and an improvement in the situation should lead to a gradual drop in the guideline levels (for the forecast doses and/or the MPL) used to determine the zoning.