REDUCTION OF RADIOXENON EMISSIONS FROM RADIOPHARMACEUTICAL FACILITIES – A PILOT STUDY.

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Progress with the revision of the Euratom Basic Safety Standards and consolidation with other Community legislation

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Abstract

The revision of the Euratom Basic Safety Standards (Directive 96/29/Euratom) was undertaken to allow for the new ICRP Recommendations (Publication 103) as well as to consolidate all radiation protection legislation in a single BSS Directive. In line with ICRP the new Directive will allow for the three exposure situations: planned, existing and emergency. This required significant restructuring, together with the consolidation or recast. The new Directive will fully integrate all natural radiation sources, introducing more binding requirements for NORM industries, building materials, radon in dwellings and workplaces. The protection of the environment is now within the scope of the Directive. The Directive develops the concept of a graded approach to regulatory control, so that it is commensurate to the risk and to the effectiveness of such controls. In this context also the concepts of exemption and clearance have been worked out in more detail and new consideration is being given to the harmonisation of exemption and clearance levels. Further issues that emerged from the revision process are the definition and use of constraints and reference levels, as introduced by ICRP, and the principle of justification, in particular with regard to the deliberate exposure of people for reasons other than medical (e.g., for security screening). The revision and recast process was completed in February 2010. Harmonisation with the International Standards (IAEA and co-sponsors) is vigorously pursued in view of co-sponsorship by Euratom.

1. Consolidation of the Community legislation

The Community *acquis* in radiation protection, derived from Title II, Chapter 3 of the Euratom Treaty, constitutes a comprehensive and evolutionary legislative framework, with the Basic Safety Standards Directive (EU, 1996) as principal piece of legislation, and supplemented by eight binding instruments (Directives, Regulations, Decisions in addition to non-binding Recommendations and Communications).

The Commission undertakes the simplification of its "*acquis*" of Community legislation by the codification of related acts (without modification, e.g., amendments or complementary legislation) or recasting these if necessary (e.g., allowing for different definitions). Such recast will be undertaken for the five main Directives (all except

shipment of radioactive waste (EU, 2006)). The very recent Council Directive 2009/71/Euratom on nuclear safety of nuclear installations was not considered for a recast at the present stage. In addition to the Basic Safety Standards, this recast thus concerns the following Directives:

- Medical applications of ionising radiation: Directive 97/43/Euratom (EU, 1997)
- Information in case of radiological emergency: Directive 89/618/Euratom (EU, 1989)
- Protection of "outside workers": Directive 90/641/Euratom (EU, 1990)
- Control of high-activity sealed radioactive sources and orphan sources ("HASS Directive"): Directive 2003/122/Euratom (EU, 2003).

The Basic Safety Standards Directive had introduced in 1996 some new features. A specific Title VII was introduced for the regulatory control of "work activities" involving natural radiation sources. With the exception of aircrew exposure, the Directive left the responsibility for the identification of work activities (NORM industries and workplaces with high radon concentrations) with national authorities. This flexibility was needed in order to achieve consensus on the inclusion of these new features at a time when there was little experience with such matters. The experience gathered since 1996, with transposition in national legislation (due by May 2000) and with operational implementation, demonstrated a need for enhanced harmonisation. Thus a revision of the Basic Safety Standards was undertaken amongst others to strengthen and broaden the requirements on natural radiation sources.

2. Revision of the Basic Safety Standards

The Community's Group of Experts established under Article 31 of the Euratom Treaty had established a four year work programme for the revision of the Basic Safety Standards. Initially it followed a topical approach. Working Parties took on board the redrafting of requirements on natural radiation sources, on exemption and clearance, and on a graded approach to regulatory control. Specific attention was given to the requirements on Education and training as well as to the definition of the responsibilities and qualifications of the Radiation Protection Expert, the Medical Physics Experts, and Radiation Protection Officer.

2.1. Exposure Situations

The revision of the Euratom Basic Safety Standards took account of the ICRP recommendations in Publication 103 (ICRP, 2008). While these do not necessarily require major changes in regulatory requirements, the Commission undertook to structure the requirements along the concepts of planned, existing and emergency exposure situations.

The distinction between the three exposure situations proved very helpful in structuring the Standards. However, very precise definitions are needed in a regulatory context, rather than the somewhat loose descriptive formulations in ICRP Publication 103.

For instance, ICRP defines a planned exposure situation merely as one involving the planned operation of sources. Existing exposure situations relate to "sources that already exists when a decision on control has to be taken". We strongly believe that when an activity significantly affects or alters an exposure situation caused by existing sources, such as NORM (Naturally Occurring Radioactive Material) or cosmic radiation, this is a planned exposure situation. Hence NORM industries and the exposure of aircrew are planned situations and the activities can be labelled as practices. On the other hand, NORM materials with levels of activity concentration that are common in the earth's crust should be exempted from the requirements for practices. The boundary is established through identification of those types of NORM industries that should *a priori* be managed as a practice. The concept of a threshold in activity concentration, for the application of requirements for practices, matches the concept of exemption from such requirements. The new Directive has introduced the values of 1 Bq/g for U-238/Th-232 and 10 Bq/g for K-40 taken from IAEA RS-G-1.7 (IAEA, 2004), together with a graded approach to regulatory control using dose thresholds of 1 mSv and 6 mSv per year.

Truly existing exposure situations are those for which the exposure results from where you are, rather than what you do. Radon ingress in a dwelling, from soil, is not related to any activity, so it yields in general an existing exposure situation. Any exposure at work, not necessarily resulting from the work, is however the responsibility of the employer. High levels of radon in the workplace thus should be subject to a reference level, to a threshold for the management as a planned exposure situation (which may be the same as the reference level) and to the dose limit for workers.

There are other boundaries where pragmatic choices need to be made. The production or import of commodities clearly is an activity. However, if the radioactive substances arise from an existing exposure situation, then it is more convenient to manage such commodities in the same context. Hence, building materials and contaminated food are managed under the heading, "existing exposure situations".

An emergency exposure situation eventually leads to the existing situation of living in a contaminated area. The delineation in this case requires a management decision.

In earlier drafts of the new Directive the provisions for emergency and existing exposure situations had been laid down in specific titles. Later if was found preferable to have, for example, all aspects of occupational exposure, including emergency workers and the follow-up to accidental exposure of workers, in a single title. Hence there is a title on “justification and regulatory control of planned exposure situations”, but the chapters on the protection of workers, patients and members of the public are no longer part of an overall title on “planned exposure situations” (as is the case with the current draft of the international standards.) It was proposed to have a clear 3 x 3 matrix structure with the categories of exposure (occupational, public and medical) on the one hand, and the three exposure situations on the other hand. (see Table 1).

Table 1: New matrix structure of the Euratom BSS

OCCUPATIONAL EXPOSURE	PUBLIC EXPOSURE	MEDICAL EXPOSURE
Planned exposure situations	Planned exposure situations	Planned exposure situations
Emergency exposure situations	Emergency exposure situations	Emergency exposure situations
Existing exposure situations	Existing exposure situations	

2.2. Emergency exposure situations

The new management scheme for emergency exposure situations builds on recent guidance of ICRP (ICRP, 2009). The old approach of an emergency plan with different *intervention levels* is replaced by a more comprehensive system:

- threat analysis;
- overall emergency management system;
- emergency response plans for identified threats;
- pre-planned strategies for the management of each postulated event.

The key difference is that each strategy should aim at keeping doses below the *reference level*, optimising the available preventive and protective actions rather than justifying each action. New Annexes list the elements to be included in the management system and in the emergency response plan.

2.3. Natural radiation sources

The Working Party of the Article 31 Group of Experts on natural radiation sources undertook in the first place the harmonisation of the identification and regulatory control of NORM-industries. The Working Party agreed on a "positive list" of types of industries that will be subject to controls in all Member States. It will be the task of the national authorities to inform the concerned industries and to make sure that they understand the radiation protection issue and take, if necessary, appropriate measures to reduce exposures within the overall Health and Safety policy of the undertaking.

The industries (those listed and such other industries as identified at national level) will be requested to investigate activity concentration levels at any point of their process. On the basis of an assessment of occupational exposures in identified industries a graded approach to regulatory control will be applied. Where doses are all below 1 mSv per year, the practice is exempted. Where doses are in the range of 1 to 6 mSv per year the only requirement is to review whether optimisation calls for further reduction of exposures, and whether the exposures remain broadly the same over many years. Since there is in general no risk of accidental exposure, there is no need for individual dosimetry or medical surveillance. In the exceptional case that doses exceed 6 mSv per year the full set of requirements for classified workers will apply.

In the same way as for practices involving artificial radionuclides, the concepts of exemption and clearance should merge (even more so, since the output of one NORM industry often is the input to another). The values proposed for this purpose in earlier Community guidance (Radiation Protection 122 part II (EC, 2000)) were 0.5 Bq/g for (U238/Th 232 and 5 Bq/g for K-40, on the basis of an exemption criterion of 300 μSv per year for natural radiation sources. The values endorsed for the sake of international harmonisation (RS-G-1.7), twice as high as in (EC, 2000), are not always suitable for clearance of residues from NORM industries. The Euratom Directive therefore establishes unambiguously that the values in RS-G-1.7 for naturally occurring radionuclides apply neither to the recycling of residues into building materials nor to situations where there is a specific risk such as groundwater contamination.

While NORM industries and the exposure of aircrew are managed as planned exposure situations, a management system for existing exposure situations applies to:

- building materials;
- radon in dwellings and public buildings (workplaces are considered either as an existing or as a planned exposure situation).

An indicative list of types of building materials considered for control in view of the emitted gamma radiation has been included in an Annex. On the basis of earlier guidance (EC, 1999), requirements for the placing on the market and use of building materials have been incorporated in the Basic Safety Standards. The activity concentration index I :

$$I = C_{Ra226}/300\ Bq/kg + C_{Th232}/200\ Bq/kg + C_{K40}/3000\ Bq/kg$$

may be translated into two classes of building materials depending on the use of the material and on whether a common reference level of 1 mSv per year (above background) would be exceeded. This is the only reference level that will be imposed through the Directive. Indeed, leaving a free choice to Member States would lead to very complex requirements to allow for free trade within the EU.

Currently, radon in dwellings is excluded from the scope of Directive 96/29/Euratom and is covered by a Commission Recommendation (EC, 1990). Recent epidemiological findings from residential studies demonstrate a lung cancer risk from indoor radon exposure at levels of the order of 100 Bq m^{-3}. ICRP is currently re-considering its earlier guidance on the dose conversion factors relating to concentrations of radon gas and its progeny in the decay chain. The ICRP Main Commission has issued a statement in November 2009 now proposing a maximum value for the reference level in dwellings of 300 Bq m^{-3}, in line also with the WHO handbook on indoor radon (WHO, 2009). The new Directive has incorporated this value for existing dwellings. The lower value for the reference level proposed by WHO, 100 Bq m^{-3}, is suitable as a long-term goal but a maximum value of 200 Bq m^{-3} for new dwellings has been maintained in the Directive.

A maximum value for the reference level for radon in workplaces has been set at 1000 Bq m^{-3}, in line with the ICRP Statement and with the current draft of the international standards. With the possible doubling of the dose conversion factor, a

radon concentration of 1000 Bq m^{-3} would correspond to around 10 mSv per year, which is a high threshold for managing radon at work as planned occupational exposure and well above 6 mSv per year, used in the definition of Category A workers. It is expected that most Member States will set or maintain a reference level much lower than 1000 Bq m^{-3}.

Member States will be required to establish a national action plan which will cover radon in dwellings and in workplaces. The action plan will offer transparent information on the scope and objectives pursued at national or regional level, define the rationale for the conduct of surveys and for the delineation of radon-prone areas or other means of identification of affected buildings, and establish reference levels and building codes. An Annexe to the Directive gives an indicative list of items to be covered in the national action plans for radon.

2.4. Graded approach

The current system of regulatory control is a two-tier system: reporting of practices above exemption levels, and prior authorisation for certain categories of practices. IAEA (IAEA, 1996) had introduced a three-tier system: notification, registration and licensing. The Directive identifies which type of practices will be subject to each pillar, which general conditions need to be fulfilled and what is the content of requirements laid down upon registration or as part of a specific operating licence.

The current system for exemption of apparatus and of consumer goods relies very much on the concept of "type approval". This concept was not worked out further and there is a lack of harmonisation of conditions for type approval and corresponding decisions in the EU. A system of mutual recognition (or at least allowance for) type approvals granted in other Member States has now been introduced.

Directive 96/29 had introduced exemption values in terms of activity (Bq) and activity concentration (Bq/g). In addition, the reuse or recycling of materials with negligible levels of contamination, especially arising from dismantling, could be authorised so that the materials would be released from regulatory requirements, subject to compliance with clearance levels. The clearance levels should be established in such a way that individual doses would be below about 10 μSv (and collective doses below 1 man Sv), taking Community guidance into account. Such guidance has been adopted by the Group of Experts for specific materials such as metals (scenarios for steel, copper and aluminium), buildings and building rubble, and default values for any type of material (EC, 2000).

Meanwhile the IAEA adopted similar guidance in RS-G-1.7 (IAEA, 2004), on the basis of scenarios to a large extent inspired by those underlying RP 122 part I. The IAEA levels were not specifically developed for the purpose of clearance, but it was suggested to use them for this purpose. For the sake of international harmonisation it was decided to introduce in the Directive the RS-G-1.7 values rather than those in RP-122. A study (EC, 2009) has investigated whether the differences between the two approaches and series of values has any significance in practical terms. In general the RS-G-1.7 values are equal to or higher than those in RP 122, but the differences can rather well be explained through the scenarios and assumptions. Nevertheless, several Experts

consider that the Community guidance has a better scientific basis, and they are concerned with the increase of some of the values for artificial radionuclides.

The same concentration values now apply by default both to the concepts of exemption and clearance. It has been investigated whether lowering the exemption values will affect any consumer goods placed on the market. While the EC study (EC, 2009) concluded that there would be indeed no adverse practical consequences, it also highlighted some Member States' reluctance to abandon the old numbers already incorporated in national law. In addition IAEA's transport standards committee (TRANSC) advocated keeping the existing values.

As part of the graded approach exemption from any requirements is built in at all levels of control. Specific exemption and specific exemption or clearance levels are a powerful tool in addition to the criteria for general exemption of practices from the scope of the requirements. Whenever the exempt activity concentration values laid down in Directive 96/29/Euratom, on the basis of Radiation Protection 65, would be preserved in national legislation, these values should be used only for moderate amounts of material, as defined in legislation or as specified by the competent authority.

2.5. System of protection

The overall “system of protection” mirrors the wording used in ICRP Publication 103. The main elements of the system of protection: justification of practices, optimisation of protection and limitation of individual doses are not essentially different from those in the current BSS. More weight is given to the principle of optimisation, subject to constraints and reference levels. The bands of constraints/reference levels proposed by ICRP (0-1 mSv, 1-20 mSv, 20-100 mSv) have been introduced explicitly, including the societal criteria that ICRP listed for each band (Table 5 of Publication 103).

The concepts of justification and authorisation in planned exposure situations were brought together in one title in view of the fact that they are the two main pillars of regulatory control. Also, the more elaborate requirements for the type approval of apparatus or consumer goods relate both to justification and to authorisation.

The concept of justification is described very much in the same terms as before. The so-called "medico-legal" exposures introduced in the Medical Directive (EU, 1997) have now been clearly identified as "non-medical imaging exposures" (deliberate exposure of individuals for other than medical purposes), and have been put under appropriate regulatory control. The need for justification of such practices, in three stages as for medical exposures, and for establishing associated conditions, has been worked out, including differentiation between procedures implemented by medical staff using medical equipment and procedures implemented by non-medical staff using non-medical equipments (e.g. security screening). While, in general, the annual dose limit and corresponding constraints for public exposure should apply, exceptions should be allowed for some specific non-medical exposure procedures carried out in a medical environment (e.g. drug search within the body).

The current dose limits for practices are kept, but the annual dose limit for occupational exposure will be simply 20 mSv per year. There should be no need for averaging over 5 years, except in special circumstances specified in national legislation.

On grounds of the precautionary principle, the Directive applies the optimisation principle also, where appropriate, to keep organ doses as low as reasonably achievable. The Scientific Seminar in 2008 (EC, 2008) on emerging evidence for radiation induced circulatory diseases indicated that epidemiological evidence is accumulating on an increased risk in circulatory diseases for cumulative doses higher than 0.5 Gy low-LET radiation.

In view of the conclusion of the Scientific Seminar in 2006 (EC, 2006) on the issue of radiation induced cataract and the further review of scientific literature performed by the Group of Experts, the dose limits to the lens of the eye should be reduced. ICRP will soon issue guidance on this matter and the Commission will take this guidance into account. Furthermore, the Directive requires the set-up of adequate systems for individual monitoring of (significant) doses to the lens of the eye.

3. Categories of exposure

3.1. Occupational exposure

A specific title covers all types of occupational exposure: of workers, apprentices and students, emergency workers, workers in identified NORM industries, aircrew and space-crew.

The graded approach to arrangements for occupational exposure is made more explicit, with a threshold of 1 mSv per year. The categories A and B workers are preserved. For workers in NORM industries, as part of the graded approach and if doses are in the range 1 to 6 mSv, it is sufficient to keep the exposures under review.

Emergency workers are subject to a dose limit of 50 mSv or, for specific cases identified in national emergency plans, an appropriate reference level. In the current Directive provision was made also for "specially authorised exposures". This provision will now be applied to the exposure of space-crew.

3.2. Medical exposure

Medical exposure applies to the protection of patients, carers and comforters and volunteers in bio-medical research ("other individuals submitted to medical exposure"). There are very few changes to Directive 97/43, except the removal of "medico-legal" exposures and emphasis being given to the information to patients, to interventional procedures, diagnostic reference levels and dose indicating devices. A new feature is the introduction of accidental or "unintended" exposures.

3.3. Public exposure

There are little changes to the protection of members of the public. More precise requirements on the establishment of discharge authorisations have been introduced, as well as on the monitoring of discharges, with reference to a Commission Recommendation (EC, 2004).

3.4. Protection of the environment

The general objective of the Directive is the health protection of workers, members of the public and patients. The recast introduces complementary objectives on the control of sealed sources and on providing information to the public in the event of a radiological emergency. The health protection of the population and workers against the dangers of ionising radiation includes the protection of the human environment as a pathway from environmental sources to the exposure of man. In line with ICRP Publication 103 it is now felt that this should be complemented with specific consideration of the exposure of biota in the environment as a whole.

This extension of the scope of the Basic Safety Standards Directive will enable a better integration of the Euratom legislation with overall environmental legislation adopted under EC Treaty provisions, as well as the observance of international agreements, such as the OSPAR Convention on the protection of North-Atlantic waters, and meet the concerns of stakeholders.

While Chapter 3, "Health & Safety" of the Euratom Treaty only relates to the health protection of workers and members of the public, the policies for the protection of man and the environment should be coherent. For instance, environmental criteria as well as dose constraints should be considered for the authorisation of discharges of radioactive effluent.

Publication 108 of ICRP (ICRP, 2008) offers guidance on the definition of reference animals and plants, and the assessment of the impact of radiation on non-human species. The application of the principles of radiation protection on non-human species and ecosystems needs to be further developed however. The protection of the environment does not seem to warrant a high level of regulatory control, and the means for the demonstration of compliance should be proportionate to the expected relevance of the issue, in line with the graded approach. Also in view of the limited experience so far, the Commission envisages to leave enough time for transposition of these requirements in national law, pending the results of further research and international guidance of ICRP.

4. Prospects

The Group of Experts under Article 31 of the Euratom Treaty finalised the text of the new Directive in February 2010. The text of the Experts and their Opinion are the basis of a Commission proposal scheduled for the end of 2010. Adoption of the Commission's proposal by the Council may take another few years and, taking into account the time granted for transposition into national legislation, it may not be before 2014 that the requirements become truly effective.

Meanwhile the Commission is closely following the revision of the international Basic Safety Standards. As a result of the decision making rules in the European Union, the EC has so far never formally co-sponsored the international Standards. It is now envisaged to do so, in the same way as for the Safety Fundamentals. The aim is to harmonise as much as possible the definitions and requirements, both reflecting the ICRP Recommendations.

It should be emphasised, however, that the Euratom Standards and the international Standards will still look very different, on the one hand because the structures are not the same as well as the amount of detail in existing legislation; on the other hand because of the legally binding nature of the Euratom Standards, applicable to the 27 Member States of the European Union.

As a result of the rules of the recast procedure the current draft of the new Basic Safety Standards has in principle not introduced any requirements that had not been part, possibly in a different way, of the earlier Directives (except for the much broader requirements on natural radiation sources). In particular, no major changes have been made to the most recent Directive on High Activity Sealed Sources and orphan sources, except for the application of some of the requirements to any sealed sources, where this is considered to be good practice. The HASS Directive had introduced new safety, security and enforcement aspects, some of which have now been applied to all radiation sources. On the other hand there are still problems with orphan sources, and there have been important cases of contaminated metal being imported from third countries. Some requirements on orphan sources have therefore been strengthened, and a requirement on the notification of incidents with orphan sources or the contamination of metal has been introduced. Further international efforts are needed in this area to meet the conclusions of the Conference held in Tarragona in February 2009, striving for world-wide consensus on further legislative initiatives, in particular with regard to the restriction of trade in metal and scrap metal.

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Individual response to communication about the August 2008 131I release in Fleurus: results from a large scale survey with the Belgian population.

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Abstract

Nuclear and radiological events, such as the one referred to in this article, have taught us that communication is one of the most important challenges in emergency management. In the crisis reported here, communication to local authorities, local actors and population proved to be challenging during this crisis.

On Friday, August 22nd, 2008, a release of 131I started from the Institut des Radioelements (IRE) in Fleurus, Belgium. The release was not noticed until after the weekend, and people living in neighbouring areas were informed no sooner than 6 days after the onset of the incident. It was only then that the Belgian authorities activated a nuclear emergency plan, taking protective actions for the population.

In the summer of 2009, SCK•CEN initiated a large-scale survey on risk perception, using computer assisted personal interviews (CAPI). The survey focused on nuclear risk communication, with one chapter on reception and acceptance of messages during the Fleurus crisis. To the representative sample of the Belgian population, we added a sample of 100 persons living in the zone impacted by the Fleurus incident.

It discusses how people living in the vicinity of Fleurus perceived and evaluated communication the local crisis, and examines the degree to which these perceptions vary according to the information sources attended to, and the media used. Finally, we compare the Fleurus data emergency risk communication with the results for the general population.

Introduction: reconstruction of the event

On Friday, August 22nd, 2008, 131I started to be released from IRE, in Fleurus, Belgium. IRE produces isotopes for the medical sector, by extraction of fission products from highly enriched uranium targets irradiated in reactors such as the BR2 in SCK•CEN in Mol, Belgium. The production is a batch process and, after processing, waste liquids are collected in waste tanks. On that Friday, contents of smaller waste tanks were transferred to a larger tank, starting a chemical reaction and leading to the release of 131-I to the stack, through filter batteries. The bulk of the release took place over the weekend, after which smaller quantities kept being discharged for several days, amounting to a total of 50 GBq 131I. The release was not noticed till after the

weekend, when a safety engineer started his work on Monday morning. The problem was first examined in cooperation with the technical support organisation, BEL-V, and the Belgian agency for nuclear control (AFCN-FANC) was not notified about the release until 5:15 p.m. on Monday evening.

On Tuesday, August 26th, the agency made its first mention of the event on its website, announcing that inspectors were being sent to the installation to examine the situation. More details were given in a press release the same afternoon that classified the event as a "serious incident" (INES-3), and that announced that production in the IRE as well as the neighbouring MDS Nordion facility were temporarily stopped. The statement specified the occurrence of a "very small release" to the environment that neither called for activation of the Belgian nuclear emergency plan nor for measures to protect the environment. The press release announced follow-up measurements by the Belgian automatic radiological measurement network TELERAD.

It may be worth mentioning that, in fact, four additional mobile TELERAD stations were placed on and near the Fleurus site that, due to the characteristics of the release, were not able to register the release. The fact that only pure 131 Iodine was discharged at a low concentration during a relatively long period, made it impossible for the TELERAD network to capture dose rates increases.

On Wednesday August 27, AFCN-FANC (the Belgian agency) informed IAEA about the incident, stating *"The waste division of the IRE has performed a transfer of liquid radioactive waste from one tank to another one. Immediately afterwards – for reasons still unknown – radioactivity was released through the stack. The quantity of radioactivity released into the environment is estimated at 45 GBq I-131, which corresponds to a dose of 160 microsievert for a hypothetical person remaining permanently at the site's enclosure. This incident did not cause a contamination of the personnel, and their dose limits were neither exceeded."* [BVS 2008]

On Thursday August 28, the first results for three environmental samples became available. These samples, taken by the agency in the close vicinity of the IRE, and analyzed in the lab of the scientific institute of Public Health ISP/WIV, shed new light on the situation. Radioactivity was established at up to 5000 Bq/kg for one grass sample, suggesting that the intervention limits for the food production might have been exceeded and, therefore, activation of the Belgian emergency plan was needed. On Thursday evening governmental web sites issued the first recommendations to the population: People living in a zone of 5 km north east of the IRE were neither to eat fruits and vegetables from their own gardens, nor to use rain water. The press publicized these recommendations. Moreover, local and provincial emergency managers received a FAQ list specifically compiled for the occasion [Crisiscenter 2008]. The local police and the city of Fleurus communicated directly with the concerned population on Friday August 29th and an information phone line was opened. Further characterisation of potential water, air, grass, vegetables and milk contaminations was carried out.

On Saturday August 30th, new measurements somewhat alleviated the concerns. These allowed a reduction of the area for which protective measures were recommended to 3 km-area north east of the IRE. In addition, they confirmed that no significant contamination of milk had occurred. (Maximum measurement was 17 Bq/liter where the intervention level is 500 Bq/liter). Nevertheless, a large-scale campaign to do thyroid measurements was announced to start on Monday, September

1st. These measurements assess a potentially enhanced risk for thyroid cancers and are especially important for children [Public Health 2008].

In the next week, the crisis management team focused on complete certainty that the release had stopped. It requested that the IRE installed extra filters between the waste tank and the stack, and it further monitored the situation by environmental sampling, and active charcoal air sampling. By Saturday September 6th, there were no more uncertainties: No measurements of over 100 samples of vegetables and fruits had been near the intervention levels [FAVV2008], the maximum was 86 Bq/kg, while the intervention level is 2000 Bq/kg, however the WHO has a recommendation to take action when baby food exceeds 100 Bq/kg, and at no time there had been a need to trigger direct protective action for the population (sheltering, evacuation or intake of iodine tablets). Therefore, recommendations to avoid eating fruits and vegetables from the gardens were lifted, and the emergency plan scaled down to a U1 level. Nevertheless, thyroid testing for possible contamination continued to be offered to the local population, with the idea that this could be re-assuring. The medical examinations, performed on Monday September 1st and Tuesday September 2nd, prioritized the most sensitive persons, children and pregnant women. A total of 1320 persons were examined, and no signs of contamination found.

Media coverage of the incident

The event was covered by all mass media in Belgium, both in the French speaking southern part, and in the northern Dutch speaking part of the country. The event was no headline news, but it remained a daily news items for several weeks. The news items were mostly informative, based on the information provided by the crisis management or informed by interviews with the important actors: crisis managers, experts, managers from the installation and local and national politicians. The incident was not sensationalised in the mass media; there was neither amplification of negative messages nor stigmatisation of the technology. Discussions focused on the responsibility for the incident, with a focus on the unacceptable late response of the authorities and the lack of information to the population in the first days. Another issue of discussion was the failure of the automatic measuring network TELERAD to register the release; this failure was interpreted as another instance of poor performance of this network that had received some negative press before. Blame of the IRE management for their lack of communication was another theme, framed as an illustration of the existing problematic relation between IRE, the local authorities and the local population [Fleurus 2008]. Part of the news framing was also on the expected shortage of medical isotopes, a consequence of the incident.

Public opinion survey: material and methods

The Belgian Nuclear Research Centre SCK·CEN conducts periodically large-scale public opinion surveys among a representative sample of the Belgian population [Carlé and Hardeman, 2003; Van Aeken et al., 2007; Perko et al., 2010]. Alongside with recurrent issues such as risk perception, confidence in authorities and other actors, and the use of nuclear energy, the surveys include detailed research sections on topics such as expert functioning, emergency planning, food safety or risk communication.

The data for this study originate from the 2009 SCK•CEN survey.

1. Background Variables
2. Risk perception and confidence in authorities for 17 risk items
3. Attitude towards:
    3.1. Science and technology
    3.2. Stakeholders engagement in decision process related to industrial installations with risks
    3.3 Nuclear energy
4. Acceptance of legal norms for food products
5. Use of different information media
6. Evaluation of different actors in the nuclear domain
7. Risk perception of an accident in a nuclear installation
8. Safety behaviour and anomy
9. Knowledge about the nuclear domain

Newsflash: TV-report about topics related to preparedness for nuclear emergencies

10. Reception & acceptance of messages communicated in the TV-report
11. Reception & acceptance of the iodine predistribution / information campaign
12. Reception & acceptance of messages communicated by authorities during the Fleurus event in 2008
13. Consumer's attitude towards food with radioactive contamination

Fig. 1 Main topics of the SCK•CEN risk barometer survey in 2009

The content of the entire survey is summarised in Fig.1, more details can be found in Perko et al. (2010). In this paper we present results relevant for the respondents' perception of the communication during the IRE 131I release incident in Fleurus.

Sampling procedure

Field work in the SCK•CEN 2009 survey was performed by a market research bureau using CAPI - computer assisted personal interviews. These interviews were carried out at the home of the respondent; the average duration was 43 minutes.

The bulk data of the 2009 survey consisted of 1031 interviews in French or Dutch. This sample is representative for the Belgian adult population with respect to province, region, level of urbanization, gender, age and professionally active status.

In the general Belgian population, 163 out of the 1031 persons remembered the IRE incident, the questions about what they remembered, to what degree they agreed with the communication during the crisis, and how what media and information sources they used were asked to this subset.

In addition, we asked the same set of questions to a supplementary set of 104 persons from the Fleurus area, the municipality in the French speaking part of Belgium, where the IRE incident happened.

In the next paragraphs, the results for the specific Fleurus group are compared with those from the 16% of the Belgian population who remembered the incident. We provide the results from these directly involved communities as a second line in the graphs, to allow comparison.

Results

Reception of the crisis management communication during the incident.

The first set of five questions measures the degree to which people still remember what happened. During the incident, which took place about 11 months prior to this survey, all issues covered in the questionnaire, had received extensive media coverage.

Table 1. What do people remember about the incident?

Question	Sample	Correct answer	Incor. answer	Incor. answer	Incor. answer	No answer
What was the main pollutant?		Radioiodine	Tritium	Caesium	Uranium	
	BE 163	19%	4%	4%	15%	58%
	FL 104	63%	1%	1%	1%	35%
For what purpose was it produced?		Medical	Indus- trial	Energy		
	BE 163	58%	15%	7%		20%
	FL 104	33%	11%	21%		36%
What is the risk of a large intake of Radio-iodine?		Thyroid cancer	Lung cancer	Skin cancer		
	BE 163	68%	7%	2%		23%
	FL 104	77%	3%	0%		20%
What countermeasures were adviced ?		No fresh food from garden	No dairy products	To evacuate		
	BE 163	67%	9%	14%		10%
	FL 104	74%	1%	14%		11%
What was measured in the children?		Radioiodine in thyroid	Blood analysed in lab	Children's urine test		
	BE 163	19%	21%	6%		53%
	FL 104	3%	11%	18%		68%

Less than 20% of the people in Belgium who remember the incident with a radio-active release know it was radio-iodine which was accidently released, but in Fleurus, over 60% remembers the radio-iodine. Remarkably, more people in the general population than in Fleurus connect the incident to the production of radio-iodine for medical purposes. This might be because the subject of a shortage of radio-iodine in the hospitals was in the press during a long time, and it was connected to the incident in Fleurus and the long shutdown of the facility. The majority of the respondents, both in the population in the Fleurus area and also in the part of the population that remembers the incident, are aware of the link between radio-iodine and thyroid cancer. About 80% of both groups remember correctly that people were advised no to consume fruits and vegetables from their gardens if they lived in an area situated up to 5 km north east of the facility. Neither the local population nor the part of the general population, who remembered the incident, appear to have been aware of the thyroid measurement campaign.

Acceptance of the crisis management communication

We asked respondents to indicate their agreement with six statements regarding the information and guidance given during the crisis Six statements were proposed, to which the respondents had to state their agreement degree on a 5-point Likert scale (from 1="strongly disagree" to 5="strongly agree"). Again, the results presented in

graph. 1 come from the 16% of the Belgian population who remembered the incident and are compared with the Fleurus sample.

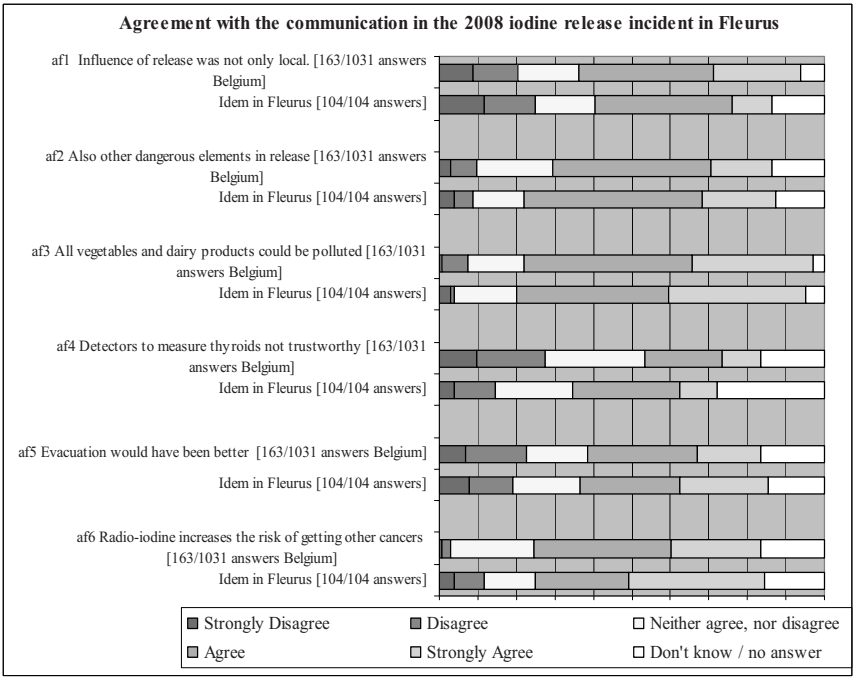

Fig. 1 Agreement with the crisis management communication in the 2008 iodine release incident in Fleurus, Belgium.

Most people think that the incident had consequences for a larger area than was communicated by the authorities (first statement). There is little difference between the people from Fleurus and the general population of Belgium. A large majority of people think that the situation was worse than communicated by the authorities (statements 2 and 3), agreeing with the view that other dangerous elements were released (60% to 80% of the samples), or that other products than garden fruit and vegetables from a larger area could have been affected (50% to 80% of the respondents). Agreement with the last statement also indicates that people think the situation is worse: they believe that other health effects will result from the release.

The population is more balanced on whether evacuation would have been a better countermeasure: about 50% agree, against 20 % disagree and 30 % people with no clear opinion. And finally, statement 4 shows that people don't really trust the physical measurements from the detectors, although the agreement with the statement ".results from detectors used for the measurements of presence of radio-iodine in the thyroid are not completely trustworthy" is lower than for the other statements, between 30 and 40% agree. Remarkably there are no big differences between the general population and the people in Fleurus who were in the affected zone.

Information channels used during the incident.

In this paragraph we look at the media use during the incident in Fleurus. First we ask the respondents what media and information sources they used, and then we ask their appreciation for each information source, specified by how credible, how timely and how extensively they evaluated each source. The first part lists the mass media, the second part personal contacts and other information sources. The results are presented separately for the two parts.

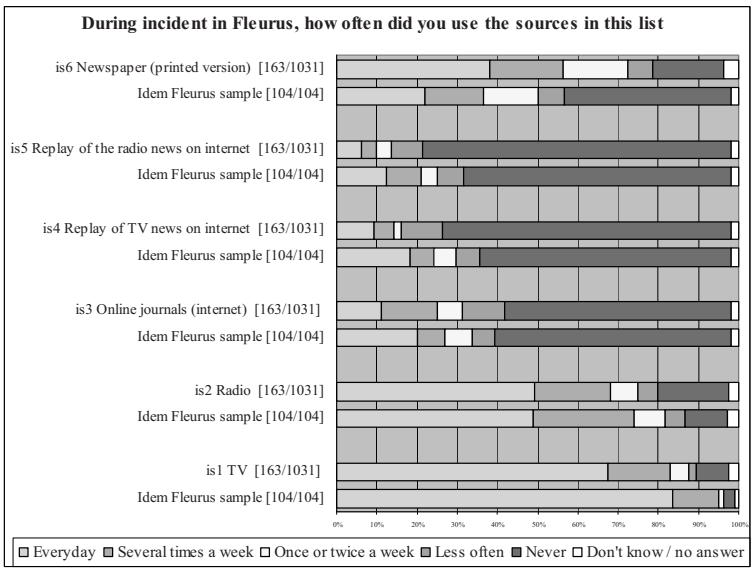

Fig. 2 Information channels used during the 2008 iodine release incident in Fleurus, part A.

In Figure 2 we see that television was the number one mass communication channel, over 80% of the respondents in Fleurus say the watched TV daily, while nearly 70% of the population in the rest of the country indicate they followed the Fleurus incident daily on TV. Radio is clearly the second most important information channel, around 50% both in the local population and in the rest of the country followed the news daily on the radio, and another 20 % did so several times a week.

Newspapers are the third mass communication channel, consulted daily or several times a week by 55% of the general population (or at least by the part of the general population who remembered the incident). For the local population, newspapers were less important, 50 % of the Fleurus population says they read the newspaper never or less than once a week during the incident. We differentiated between 3 types of internet use: internet online journals, replays of TV news on internet and replay of radio news on internet. In general internet is used less than the other media; over 60% of the respondents indicate they never used internet in any of the three ways specified. About 25% of the Fleurus respondents say they used internet journals daily or at least several times a week, and 22% used the replays of TV and radio news as often. The responses for the general population indicate a marginally lower use of the internet sources.

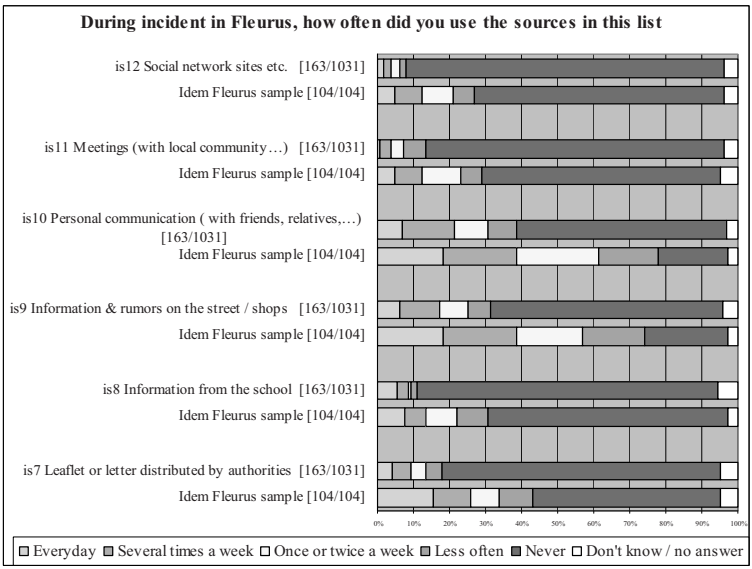

Fig. 3 Information channels used during the 2008 iodine release incident in Fleurus, part B.

While even in Fleurus, TV and radio news were important sources of information, here personal communications such as discussions with friends and relatives, and information and rumours in the street and in local shops etc. were relatively important also: about 40% of the Fleurus sample self-reported to have turned to others daily or several times a week. Other sources, such as letters or leaflets from authorities, local information communications by the schools were used as information by 30 to 40% of the local population at least once a week.

In the next series of questions, we asked the respondents to evaluate the information sources on credibility and being timely. The questions were only asked for the communication sources for which the respondents previously indicated some use, therefore, the total number of answers is different for each source. Results are presented in Tables 2 and 3.

Table 2. Evaluation of credibility and timeliness of media during 2008 iodine release incident in Fleurus Part A

Sources	#	Credibility Little	Credibility Average & No Answer	Credibility Much	Timeliness Little	Timeliness Average & No Answer	Timeliness Much
TV (Belgium)	146	14%	39%	47%	13%	37%	50%
TV (Fleurus)	100	46%	30%	24%	49%	26%	25%
Radio (Belgium)	130	10%	42%	48%	9%	42%	48%
Radio (Fleurus)	90	42%	31%	27%	40%	36%	24%
On line Journals (internet) Belgium	68	13%	40%	47%	12%	37%	51%
On line Journals (internet) Fleurus	41	41%	46%	12%	41%	46%	12%

Replay of TV news on internet (Belgium)	43	16%	42%	42%	14%	37%	49%
Replay of TV news on internet (Fleurus)	37	43%	46%	11%	41%	43%	16%
Replay of Radio news on internet (Belgium)	35	14%	46%	40%	17%	43%	40%
Replay of Radio news on internet (Fleurus)	33	36%	48%	15%	30%	55%	15%
Newspaper (printed version) Belgium	128	8%	43%	49%	11%	40%	49%
Newspaper (printed version) Fleurus	59	27%	47%	25%	29%	44%	27%

A first observation is that credibility of the media is considered lower in the Fleurus sample than in the general population. Furthermore, the general population expresses lower confidence in TV and radio news when answering to questions about the Fleurus incident than to more general questions on nuclear accidents, as they occurred earlier in the questionnaire. People from Fleurus have a negative evaluation of the timeliness of news in all media, which may reflect the delay of communication by both authorities and media: It took 5 days after the start of the release before it came first in the news. . The general population has a more positive view on how fast the media gave information about the crisis.

Table 2. Evaluation of credibility and timeliness of media during 2008 iodine release incident in Fleurus Part B

Sources	#	Credibility Little	Credibility Average & No Answer	Credibility Much	Timeliness Little	Timeliness Average & No Answer	Timeliness Much
Leaflets & letters by authorities (Belgium)	29	14%	21%	34%	21%	41%	38%
Leaflets & letters by authorities (Fleurus)	45	46%	24%	58%	24%	58%	18%
Information from the school (Belgium)	18	17%	39%	44%	17%	28%	56%
Information from the school (Fleurus)	32	19%	28%	53%	19%	31%	50%
Information and rumors on the street etc (Belgium)	51	18%	31%	51%	18%	31%	51%
Information and rumors on the street etc (Fleurus)	77	23%	23%	53%	21%	26%	53%
Personal communication (discussion with friends, relatives...) Belgium	63	29%	27%	44%	30%	29%	41%
Personal communication (discussion with friends, relatives...) Fleurus	81	22%	30%	48%	23%	26%	51%
Meetings (with local community…) Belgium	22	18%	36%	45%	18%	59%	23%

Meetings (with local community…) Fleurus	30	37%	50%	13%	40%	47%	13%
Social network sites (facebook,…) Belgium	13	23%	62%	15%	15%	38%	46%
Social network sites (facebook,…) Fleurus	28	21%	50%	29%	21%	57%	21%

Information given by the school is evaluated as the most credible information (over 50% high or very high credibility) by the small subset of the Fleurus sample that indicated schools as a source of information (one third). Informal discussions with friends and rumours on the streets or local shops etc. are considered more credible than the information gained from information spread by the authorities (written information, public meetings). Compared to the general population, those from Fleurus whom the crisis concerned most, evaluate communications by both governmental officials and the press as less credible; they put more trust in information given by the school, and gained from personal conversations.

Direct communication and certainly personal communication is evaluated more as timely than media coverage by radio and TV; an exception forms the "town hall" meeting that was *not* perceived to be timely. The results for the Fleurus sample are for these communications also more consistent with the responses from the people from the general population.

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