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# **Incidental release in IRE**

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- **Root cause**
- **Conservative estimation of the source term**
- **Corrective actions set up by the licensee and followed by Bel V/FANC**
- **Conclusion**

# Presentation of Fleurus site I

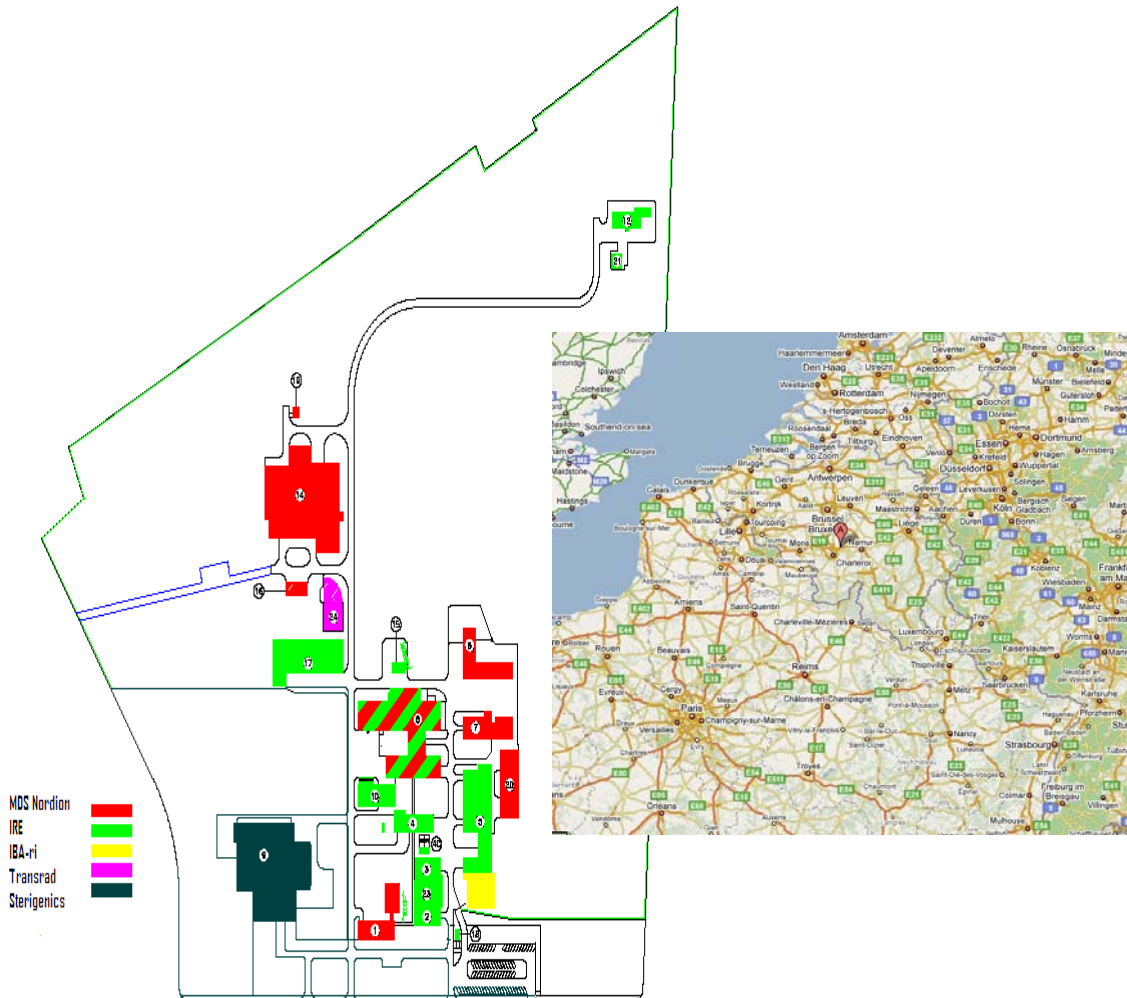
## Location

+/- 50 km South of Brussel  
+/- 30 km North from the  
French border

Located in Fleurus, Belgium, IRE is a public utility foundation whose main missions are to contribute to public health and environmental protection. IRE is a major worldwide producer of radioelements used for diagnoses and therapeutics in nuclear medicine : Mo-99/Tc-99m, Xe-133, I-131, Sr-90/Y-90

Other companies present on Fleurus site :

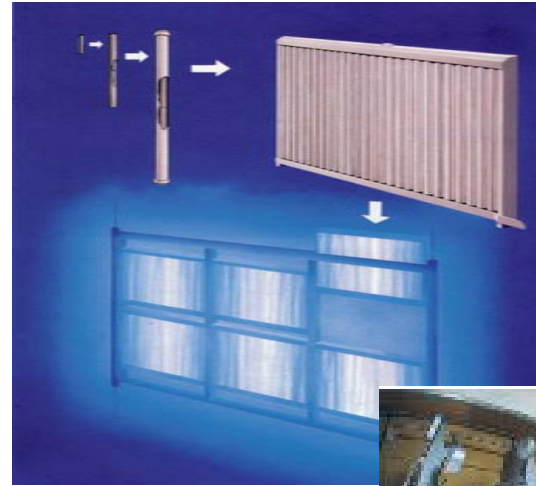
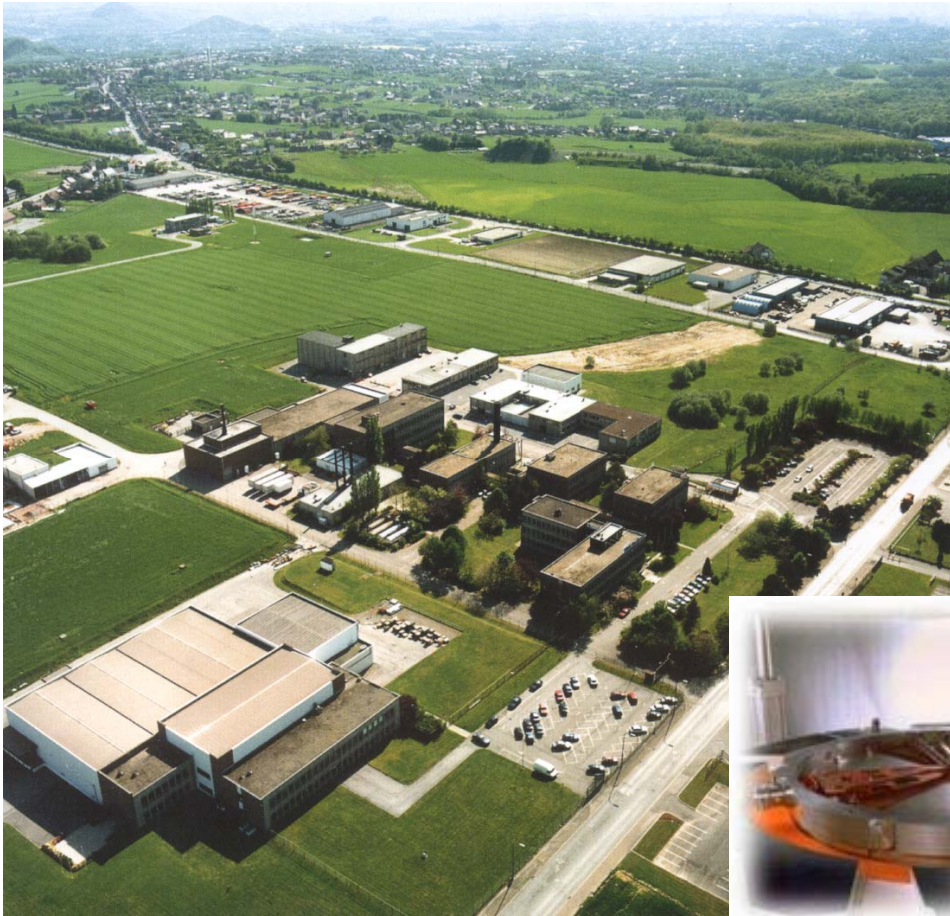
MDS Nordion  
IBA-RI  
Transrad  
Sterigenics



# Presentation of Fleurus site

- **+/- 300 workers**
- **Main equipments**
  - 24 buildings (2/3 have a controlled area)
  - 2 cyclotrons used for radioisotopes productions
  - 1 cyclotron waiting for dismantling
  - 3 irradiators used for sterilisation purposes
  - About 40 shielded cells and annex equipments
    - Liquid waste intermediate storage tanks
    - Complex ventilation systems
    - Complex monitoring systems
    - ...
  - **But no reactor (irradiated targets are shipped from HFR Petten, Osiris Saclay, BR2 Mol)**

# Main installations on Fleurus site



## Medical radioisotopes produced in Fleurus

MDS Nordion	IRE	IBA-ri
<sup>18</sup> FDG	<sup>99</sup> Mo/ <sup>99m</sup> Tc	<sup>18</sup> FDG + other PET
<sup>131</sup> I	<sup>131</sup> I	
<sup>90</sup> Sr/ <sup>90</sup> Y	<sup>90</sup> Sr/ <sup>90</sup> Y	
<sup>133</sup> Xe	<sup>188</sup> Re/ <sup>188</sup> W	
<sup>201</sup> Tl		
<sup>123</sup> I		
<sup>192</sup> Ir		
<sup>60</sup> Co, <sup>137</sup> Cs, <sup>75</sup> Se		

Safety concerns have been raised by the nuclear safety control authorities (AVN/Bel V and FANC (and external audit ASN/IRSN)) since 2005 in Fleurus. Actions plans were set up in order to correct the situation. These actions plans were followed by IRE with some difficulties and delays in 2007 and 2008. It should be noted that safety concerns were also raised towards Sterigenics and MDS Nordion (see website of the FANC [www.fanc.fgov.be](http://www.fanc.fgov.be) for INES declaration)

# Chronology

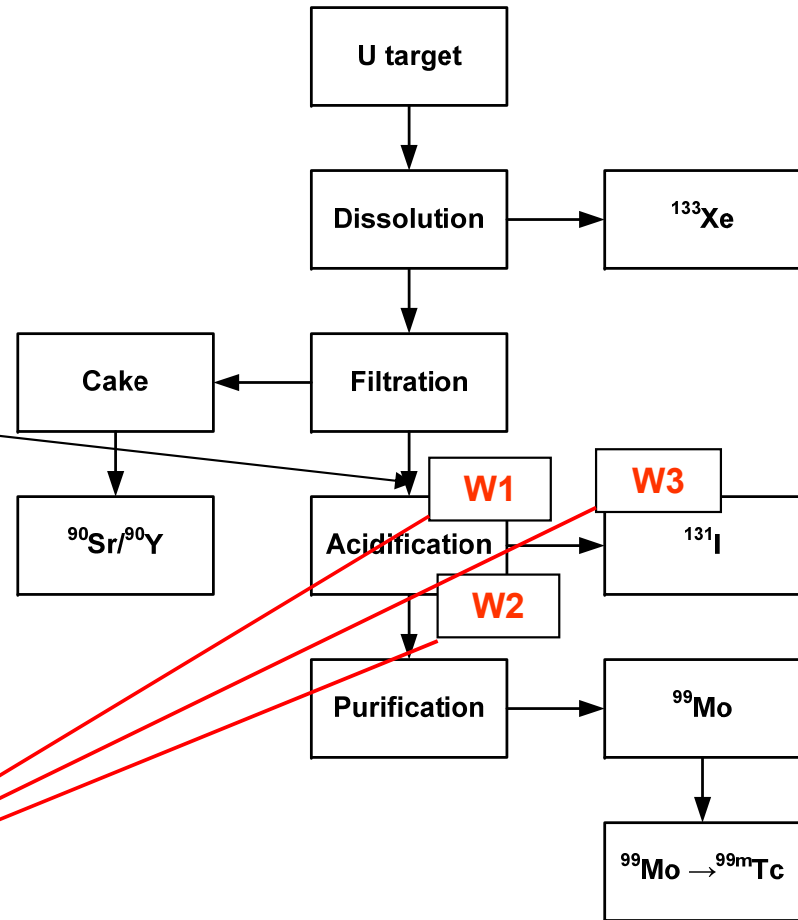
- **22.08.2008 start of iodine-131 release-but on 22.08.2008, the precursors, initial indication of abnormal events were not correctly analysed and taken into account**
- **25.08.2008 First phone contact between IRE and Bel V, IRE and FANC, Bel V and FANC-unclear informations were exchanged**
- **26.08.2008 FANC and Bel V present on Fleurus site-decision to stop all activities in IRE and estimation of the remaining source term**
- **26.08.2008 FANC and Bel V on MDS Nordion site-decision to stop the purification of iodine-131**
- **27.08.2008 Bel V on site to work with IRE in order to secure building B6**
- **28.08.2008, Bel V on the site of IBA-ri, MDS Nordion, Sterigenics, Helio**
- **05.09.2008 a new barrier (3 new charcoal filters and one absolute filter) is set-up on the release path at 23h30**

# Liquid waste management



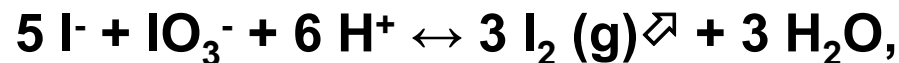
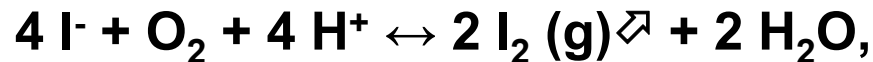
**W1 XeMo 1 :  $\text{HNO}_3/\text{I}^-$**   
**W2 XeMo 1 :  $\text{HNO}_3/\text{I}^-$**   
**W3 Procel :  $\text{H}_2\text{SO}_4/\text{H}_2\text{O}_2/\text{IO}_3^-$**

**R3  
 tank  
 (2700l)**



## Root cause I

- IRE : An unexpected chemical reaction occurred in a big tank (2700 litres) collecting the liquid wastes of the small reservoir. Because the liquid wastes were not correctly separated, a peroxide solution came into contact with a solution of iodide (I<sup>-</sup>). An oxydo redox reaction most probably started in the waste tank :



- During 4 days, about 48 GBq of iodine-131 were released.
- Various corrective actions and urgent modifications to the installation (filtering) eventually allowed stopping the iodine release to the environment.

## Root cause II

- **Measurements confirmed that only iodine as gaseous I<sub>2</sub> form was released, no other fission product was released**
- **Iodine was not released as water solution, excluding ebullition or nebulisation inside the tank**
- **A criticality accident has not taken place, no fission products were detected at unexpected places**
- **Experimental chemical simulation of the incident has shown that the postulated chemical elements were present in the tanks and that the accidental scenario tabled by the operator is credible**
- **This event was rated at level 3 on the international INES scale.**

# Aggravating factors

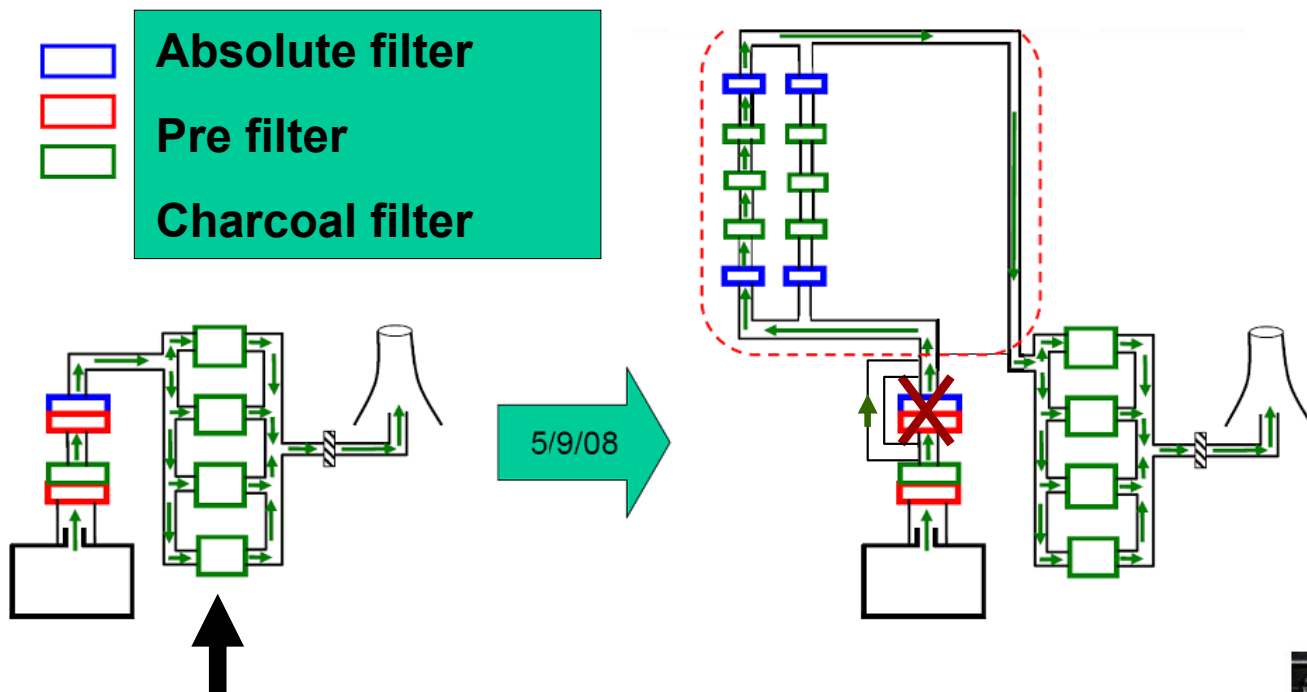
- The transferred waste had a short decay time giving a high source term;
- The initial content of the 2700 l tank was low ( $\pm 200$  l), causing a weak dilution of the three small tanks contents;
- Three tanks contents have been transferred nearly simultaneously, what only occurred exceptionally in the past;
- The small tanks were relatively new, reducing the decomposition rate of  $\text{H}_2\text{O}_2$
- The transfers were done under vacuum driving the oxydo-reduction reaction towards the products formation

## Conservative estimation of the source term

- On 26 august 2008, IRE and Bel V could not establish with great accuracy the radioactivity that was transferred in the waste tank and at the origin of the iodine release.
- Taking account of the decay we decided to estimate the global activity of iodine-131 which came in the hot cells of the production line XeMo1 and Procell. We retrieved the activity of purified iodine-131 that was ready to be shipped or eventually used in further steps.
- We considered in a conservative way that there was no loss of iodine inside the hot cell. This means for instance no radioactive iodine-131 trapping in molecular sieve or charcoal used in the process. We acted so because at this date we did not have accurate estimation of the loss inside the hot cell.
- We came to the conclusion that in the worst case 31.82 TBq (862 Ci) of iodine-131 were transferred in the waste tank
- A post incidental estimation made on more realistic data drove us to the conclusion that probably it was one third of the initial estimation : about 11.1 TBq (300 Ci) of iodine-131 were in reality transferred

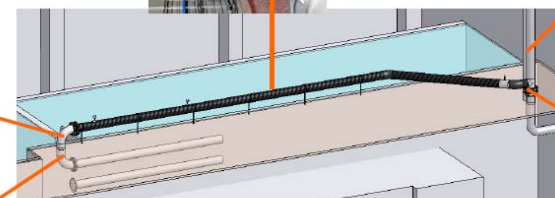
# Short term ventilation modification 05/09/08

-  Absolute filter
-  Pre filter
-  Charcoal filter



Ventilation modification 26/08/08,  
Replacement of the four final  
absolute filters by four charcoal  
filters

Secure building B6 where in some  
places we could find quite high  
doses (hundred mSv/h in contact  
of some filter shielding)



## Mid term corrective actions I

- **What was the root cause ? What can IRE do to avoid the repetition of this type of incident ?**
  - Separation of the waste tubing between XeMo1 and Procell
  - Stabilisation of iodide in some liquid waste (neutralisation of the acidic solution)
  - Hazop analysis of liquid waste
  - Modification of the liquid waste transfer procedure with lock mechanism on valves
  - Introduction of foolproofing shape mechanism between basic and acidic liquid media to be transferred from the hot cell
  - Very simple color code to avoid inappropriate mixture
  - Requalification of the chemicals before coming in the controlled area
  - Use of one chemical kit per production instead of bulk products
  - ...

## Mid term corrective actions II

### ● **improvement of the iodine-131 release monitoring**

- Intensive use of the passive monitoring system
- Recalibration of the dynamic monitoring system
- Setting-up of a new dynamic monitoring system
- Improvement of the existing system
- Study of the replacement of monitoring system by a spectroscopic system in order to get an accurate measurement of the atmospheric release composition
- ...

## Mid term corrective actions III

- **Refurbishment of the alarm system**
  - Review of the communication procedure between regulator and IRE
  - Starting false alarms reduction program
  - Centralization of alarms
  - Improvement of the recall system
  - Scaling-up procedure
  - Revision of site emergency plan and notification call, ...
- **Reengineering B6-Filtration system**
  - Reintroduction of filters barriers
  - Definition of room data sheet
  - Ventilation reequilibrium of B6
  - Interlocking of area in building B6
  - Rapid qualification of new filters after installation, ...

## Mid term corrective actions IV

- **Modification of the organization of the company**
- **New definition of departement responsibilities**
- **Training program**
- **Recruitment program**
- **Redesign of the chemistry. Start to study the reduction of iodine and noble gaz releases at the level of the production system**
- **Most important : commitment of the new manager of IRE to carry out long-term improvement actions**

# Conclusion

## IRE

- **New management-new communication**
- **Modification of the liquid waste management**
- **Modification of the ventilation system**
- **Improvement of the monitoring system**
- **Taking care of the alarms**
- **Until now reduced improvement of the radioisotopes purification process**
- **A lot has still to be done**

## Bel V/FANC

- **More thematical inspections compared to routine controls**
- **Improvement of the communication between IRE and Bel V and inside Bel V**
- **Inspections by Bel V outside working hours**
- **Study of the scientific litterature (paper, patent) to complete the safety guidelines**
- **Information exchange with VROM (Petten site visit)**