OSPAR COMMISSION

Implementation Report of PARCOM Recommendation 91/4 Report from Belgium

Radioactive Substances Series

2011

OSPAR Convention

The Convention for the Protection of the Marine Environment of the North-East Atlantic (the "OSPAR Convention") was opened for signature at the Ministerial Meeting of the former Oslo and Paris Commissions in Paris on 22 September 1992. The Convention entered into force on 25 March 1998. It has been ratified by Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Luxembourg, Netherlands, Norway, Portugal, Sweden, Switzerland and the United Kingdom and approved by the European Union and Spain.

Convention OSPAR

La Convention pour la protection du milieu marin de l'Atlantique du Nord-Est, dite Convention OSPAR, a été ouverte à la signature à la réunion ministérielle des anciennes Commissions d'Oslo et de Paris, à Paris le 22 septembre 1992. La Convention est entrée en vigueur le 25 mars 1998. La Convention a été ratifiée par l'Allemagne, la Belgique, le Danemark, la Finlande, la France, l'Irlande, l'Islande, le Luxembourg, la Norvège, les Pays-Bas, le Portugal, le Royaume-Uni de Grande Bretagne et d'Irlande du Nord, la Suède et la Suisse et approuvée par l'Union européenne et l'Espagne.

Contents

1 Introduction

At its 2010 meeting in Stockholm, Sweden, the OSPAR Radioactive Substances Committee established, on a trial basis, revised “Guidelines for the submission of information on the assessment of the application of Best Available Technology (BAT) in nuclear facilities”. In this report the requested information for Belgian nuclear installations is given. The report covers the four (five)-year period 2006-2009 (2010) inclusive.

The first section gives general information regarding national legislation, dose limits, discharge limits, … The next sections give site specific information about each of the nuclear installations in Belgium.

2 General information

2.1 Implementation of BAT/BET in Belgian legislation and regulation

The first law concerning protection of the population from ionising radiation dated 29 March 1958. The legislation with respect to radiological protection was based on the Royal Decree of 28 February 1963. After some modifications by the Royal Decrees of 17 May 1966, 22 May 1967, 23 December 1970, 23 May 1972, 24 May 1977, 12 March 1984, 21 August 1985 the legislation was thoroughly adapted by the Royal Decrees of 16 January and 11 February 1987 when the ICRP-26 and 30 (regarding the methodology for calculation internal radiation dose) were taken into account. Other modifications were made by the Royal Decrees of 12 February and 6 September 1991, 17 June 1992, 7 September 1993, 2 October 1997 and 3 May 1999.

The Federal Agency for Nuclear Control (FANC) was established by law of 15 April 1994 and according to its position it has a great independency, necessary to take up its responsibility to the society in an impartial way. It is led by a board of directors and the daily management is overseen by a General-Director.

A new legislation was created by the Royal Decree of 20 July 2001 (*General Regulations for the Protection of the population, workers and the environment against the dangers of Ionising Radiation - GRPIR*), which was necessary to harmonise the Belgian legislation with the European Directives (that take into account some recommendations of the ICRP-60). This Royal Decree attributes to the FANC the objectives of “protection of the population, workers and the environment against the dangers of ionising radiation” that consist to:

- propose, apply and improve law and regulations;
- control human (and non human) activities responsible for exposure of man to radioactivity;
- ensure the surveillance of radioactivity on the territory (TELERAD automatic network - Radiological Surveillance Monitoring programme);
- co-operation to nuclear emergency plans;
- distribute neutral and objective information.

Law of 5 August 2006 gives right to the public to access information with regard to the environment, which transposes the EU directive 2003/4/CE of the European Parliament and Council of 28 January 2003 regarding the public access to information related to the environment, led to the diffusion of a note from the Belgian Safety Authority that regulates the periodical reporting of radioactive releases from nuclear installations (see §2.9).

2.2 Basis for national legislation/regulation

The Belgian policy is based on EC Directives, on international conventions and on recommendations of appropriate international bodies like the International Commission on Radiological Protection (ICRP) and the International Atomic Energy Agency (IAEA). The major principles in these regulations are:

- justification of exposure: exposure to radiation is only allowed if the advantage is larger then the possible risk and damage of the exposure;
- optimalisation: known as the ALARA-principle (As Low As Reasonably Achievable), exposure has to be as low as possible, taking social and economic factors into account;
- dose limits: exposure of individuals as result of the combination of different exposures, has to be subject to limits to prevent unacceptable risks.

2.3 Dose constraints/limits for nuclear installations

The limits, which are given by the Belgian regulation *General Regulations for the Protection of the population, workers and the environment against the dangers of Ionising Radiation* (GRPIR), are the following.

Dose	Public art. 20.1.4	Workers art. 20.1.3	apprentices and students ≥ 18 years art. 20.1.5	 16≤ <18 years art. 20.1.5
Effective (whole body)	1 mSv/a	20 mSv/a *	20 mSv/a *	6 mSv/a
Equivalent for any individual organ or tissue	-	500 mSv/a *	500 mSv/a *	-
Equivalent for lens of the eye	15 mSv/a	150 mSv/a *	150 mSv/a *	50 mSv/a
Equivalent for skin **	50 mSv/a	500 mSv/a *	500 mSv/a *	150 mSv/a
Equivalent for hands, arms, feet and ankles	-	500 mSv/a *	500 mSv/a *	150 mSv/a

* for 12 consecutive months.
** average dose for each area of 1 cm² of skin
Remark: the above limits do not take into account medical exposure

Nuclear installations apply for their workers a dose constraint of 10 mSv/a.

2.4 Discharge limits

The annual limits for discharges and emissions are specified for a nuclear facility in such a way that the resulting doses to the population shall not exceed 1 mSv per year for all pathways combinated (art. 20 of the Royal Decree of 20 July 2001).

The Royal Decree introduces also a notion of dose constraint (optimisation principle-ALARA): the discharge limits have to be based on a fraction of the public annual limit of 1 mSv. Dose constraints have been discussed with the FANC: the following table shows the dose constraint used by the nuclear sites.

	Dose constraint (mSv/a)			Evaluation of real committed dose (average over the last 10 years) (mSv/a)			Reduction Yes / No
	Atmospheric discharge	Liquid discharges	Total	Atmospheric discharge	Liquid discharges	Total**	
Belgoprocess (Site of Mol)	0.3	0.2	0.5	$60\ 10^{-6}$	$625\ 10^{-6}$	$685\ 10^{-6}$	Y
NPP Tihange	0.19	0.08	0.21	$47\ 10^{-3}$	$2.5\ 10^{-3}$	$49\ 10^{-3}$	N
NPP Doel	0.18	0.23*	0.37	$18\ 10^{-3}$	$2.3\ 10^{-3}$	$19\ 10^{-3}$	N

* take into account a specific critical group
** maximum dose does not necessary correspond to the sum of doses due to atmospheric or liquid releases: the critical individual, even localised at the same place, is not always in the same age category

The model used to estimate the radiation exposure for a critical group caused by radioactive effluents of nuclear power plants was based on the NUclear REgulatory Guide (NUREG) 1.109 rev. 1, USNRC. Some conservative adaptations have been made by taking into account:

- Dose conversion factors (RD of 20 July 2001) based on the ICRP 72;
- 6 classes of age (RD of 20 July 2001) : ≤ 1y, 1-2y, 2-7y, 7-12y, 12-17y and > 17y;
- Eventual adaptation of some parameters (e.g. consumption habit,…).

The dose is calculated at the most unfavourable receiving points, taking into account the relevant exposure pathways and living habits, e.g. the consumption rates of different foodstuffs. On the basis of these assumptions and parameters used in the models, the radiation exposure to individuals cannot be underestimated.

2.5 Environmental norms and standards

The art. 34 of the RD of 20 July 2001 defines that liquid discharges in surface waters or sewer canalisations are forbidden when concentration in radionuclides, expressed in Bq/litre, exceeds one thousandth of the annual limit of intake by ingestion for an adult (annexe III D of the RD).

2.6 Monitoring programmes of discharges and environmental concentrations of radionuclides

Under the Royal Decree, the Federal Agency for Nuclear Control (FANC) is charged in particular with *monitoring the radioactivity of the territory and the doses received by the population* (Article 70) as well as organising the *monitoring of the population as a whole* (Article 71). It should also be noted that the Franco-Belgian co-operation agreement of 8 September 1998, relates to the Chooz nuclear power station situated on the Meuse in France close to the border with Belgium. This agreement ensures the full monitoring on Belgian territory of all radioactivity transfers around the nuclear site as well as the periodic exchange of results between states.

Between 2002 and 2004, the Agency reviewed its entire sampling and measurement programme in order to completely harmonise it with international requirements. The 1998 European Directive on drinking water had imposed:

- stronger controls, with new requirements in terms of control;
- the reporting of radiological surveillance data to the European Commission resulting from the application of Article 36 of the EURATOM treaty.

Finally, the OSPAR Convention (OSlo-PARis Convention, 1998 – ratified by Belgium) on the protection of the marine environment of the North-East Atlantic makes the development of monitoring and research programmes concerning the impact of radioactive discharges on the marine environment mandatory.

The programme for the radiological monitoring of the territory currently (2009-2010) relies on about 5,300 samples annually, which are subjected to almost 32,000 alpha, beta and gamma radioactivity analyses. This radiological monitoring programme includes radioactivity measurements carried out in:

- the Meuse and Sambre basins;
- the Scheldt and Nete basins;
- the marine zone;
- a reference zone (Brussels Capital region);

for the major parts of the biosphere (air, soil, water and biocenosis) as well as in the main constituents of the food chain, supplemented by the follow-up of the atmospheric and liquid discharges of the main nuclear sites and through dose rate measurements around these facilities.

Wastes releases from hospital will be also controlled in sewage purification plants by using submersible automatic gamma spectrometry probes. The goal is to qualify and quantify if possible the radioactivity that enters the environment at the outlet of the sewage plants. The *in-situ* controls of the hospital practices conducted by nuclear inspectors will be also linked with the obtained results. The final aim is to minimise the radioactivity levels of the hospital releases.

The discharges and environmental impact of some NORM and legacy sites are also monitored. This monitoring occurs either periodically or in the framework of a specific measurements campaign. These NORM sites belong to the phosphate and to the titanium dioxide production sectors. An environmental follow-up of a legacy site related to a former radium extraction facility is also performed.

2.7 National authority responsible for supervision of discharges

All licensing and supervision activities concerning construction and operation of nuclear facilities is carried out by the regulatory authority of the federal state (FANC) with the co-operation of authorised inspection and controlling bodies (Bel V, Controlatom, …). This is also the case for authorisation of radioactive discharges to the environment. FANC is under the authority of the Ministry of Interior.

2.8 Nature of inspection and surveillance programmes

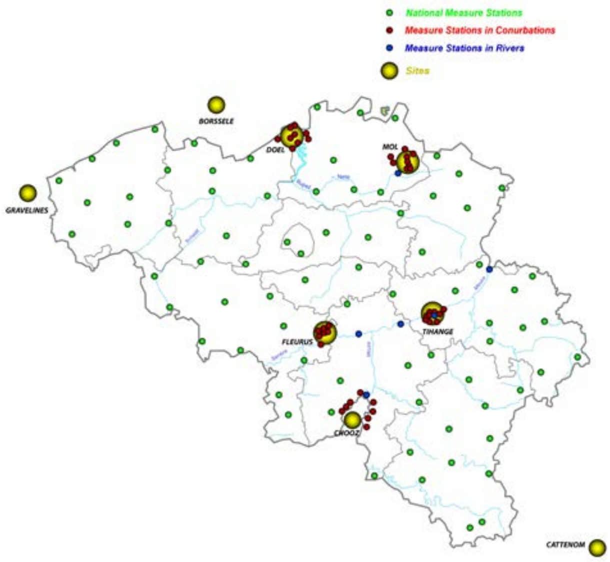
The nuclear installations are inspected several times each year by the federal authorities (FANC and authorised inspection and controlling bodies). The environmental monitoring programme is undertaken by special authorised laboratories under the co-ordination and the responsibility of the federal authority (FANC). Laboratories undertake analyses in accordance with internal Quality Control procedures also involving regular calibration of detectors and yearly comparison exercises. Therefore, the quality of environmental and discharge sample measurements, and the assessment of impact of discharges and emissions on members of the general public, is based on a independent national system of governmental bodies and experts.

The TELERAD network - automatic remote radioactivity measuring network in Belgium - was modernised in 2010. The network now comprises 218 stations, which constantly measure the radioactivity of the ambient air, river waters. The stations are distributed throughout the entire country for nationwide monitoring, in rings around the nuclear sites at Tihange, Doel, Mol, Fleurus and Chooz to monitor the installations, as well as in the urban areas close to these installations.

In addition, in selected sewage purification plants the radioactivity of waters are controlled *in-situ* with automatic (submerged) gamma spectrometry probes (see also 2.6).

The modernisation in 2010 comprised the replacement of all stations by stations of a new generation and with modern data communication links. To improve the nuclear sites surveillance, the ring stations (situated around the sites on the fence) have been equipped with a gamma spectrometry to make a quick identification of nuclides present in the ambient air of these stations. In addition, existing river stations are also modified and are now equipped with a gamma spectrometry with identification of present nuclides. Finally, new automatic gamma spectrometry probes are implemented upstream and downstream of the Doel NPP on the Scheldt river. The surveillance of the aquatic releases from NPPs are now directly done by automatic gamma spectrometry probes placed at the oultlet of the release channels of the NPPs (Tihange and Doel).

All stations are linked to a centralised system that is automatically alerted when detecting any abnormal rise in radioactivity levels or a nuclide is detected above a preset threshold on the ring stations. The cental systems has a full redundant set-up at a disaster recovery site.



2.9 Reporting

The results of discharge measurements performed by operators are reported monthly to the federal authority (FANC) and are also available through annual reports. Moreover, a new note from the FANC concerning the periodical reporting of radioactives releases (gas and liquid) is applicable since January 2011. The note transposes the requirements of the EU recommendation 2004/2/Euratom.

Belgium reports annually on the FANC website all the results obtained from the radiological surveillance programme of the territory (including TELERAD, foodchain, nuclear sites discharges, NORM and legacy sites…).

Belgium reports discharge data from nuclear installations annually to EURATOM (art. 35&36 of the treaty) and to the OSPAR secretariat.

Belgium also reports hourly the dose rate data from the TELERAD network to the European Commission (EURDEP).

3 Nuclear Power Plants (NPP)

Nuclear power currently accounts for about 57 % of Belgian’s electric energy production in 2009[1]. The nuclear power stations are located near Doel and Tihange. There are 7 operational pressurised water power reactors.

Discharge data are given for reactor sites. The activity concentrations of radionuclides in non-human biota of river water are so low that it is generally not possible to detect them.

Information to be submitted in accordance with the BAT Guidelines is given in Annex 1 referring to nuclear power plants for the period between 2006 and 2009.

[1] Rapport d'activités et développement durable 2009, Electrabel GDF SUEZ, 68 pages, juin 2010

For each installation, the information as defined in BAT Guidelines is given in tabular form:

- Name of facility
- Type of facility
- Date commissioned
- Location
- Installed electrical generation capacity
- Electricity generation
- Shut-down year
- Annual emissions and discharges, absolute and normalised according to actual output as compared to the UNSCEAR ranges
- Individual dose as compared to the national dose limits
- Waste treatment

The determination of individual dose covers all radionuclides discharged to the environment.

3.1 Sources of liquid effluent

The main sources of radioactive liquid effluent are reactor operations and small leaks from the reactor itself, associated plant, laundry and general cleaning processes. The principal radionuclides arising in liquid wastes are tritium and, to a much lesser degree, activation and fission products. See Annex 1.

3.2 Liquid effluent treatment

See 3.7.

3.3 Nuclide libraries

The radionuclides to be monitored are stipulated in the "licence to operate" of the NPP reactors under the responsibility of the federal authority (FANC).

3.4 Environmental impact

The environmental surveillance programme in the vicinity of nuclear power stations is performed by the FANC radiological monitoring programme. The analyses of environmental samples (sediment & water in rivers and north-sea, fauna & flora in freshwater and marine water, soil, air, rain, milk, foodchain, drinking water) show that there are no detectable α- and β-activity concentrations (excluding tritium) referring to radioactive discharges from NPP. Tritium discharges from pressurised water reactors can increase the tritium concentrations in surface water of rivers by 10 to 30 Bq/l (e.g. river Meuse).

3.5 Trends in discharge over the 1998-2009 period and summary evaluation (see annex 3)

Reactors have been operating steadily throughout this period, so liquid discharges have been fairly constant.

For tritium, the range for normalised liquid discharges during the whole period for the two NPP sites (Doel and Tihange) is 9.9 to 22.4 TBq/GWa with an average value of 14.9 TBq/GWa for Doel and 15.5 TBq/GWa for Tihange. No clear trend is discernible.

For beta/gamma emitters excluding tritium, the range for the whole period is 1.0 – 19.8 GBq/GWa with a mean value of 6.0 GBq/GWa for Doel and 13.1 GBq/GW for Tihange. Up to 2006, a clear decreasing tendency for Doel is noted. For tihange, up to 2004, no discernible trend can be noticed but for the following years a slight decrease is observed.

Comparisons with UNSCEAR ranges show that:

- Tritium discharges for both NPPs are **near the lower end limit** of the range;
- Non-tritium discharges into water are always **below** the level of the range for Doel and up to 2006, **near the lower end limit** for Tihange. From 2006, discharges from Tihange are **also below the lower end limit**.

For both nuclear installations, calculations made for liquid discharges under conservative assumptions show that the maximum effective doses to the population in the vicinity of the NPPs are well below the national limits of 1 mSv/a (maximum limit including all atmospheric and liquid contributions): from 2005 to 2009 for Doel ≤ 0.1% and from 0.28% in 2006 to 0.17% in 2009 for Tihange for liquid discharges. If we take into account the dose constraint (see 2.4), calculations show that effective doses represent: from 2005 to 2009 for Doel ≤ 0.5% and from 3.5% in 2006 to 2.1% in 2009 for Tihange.

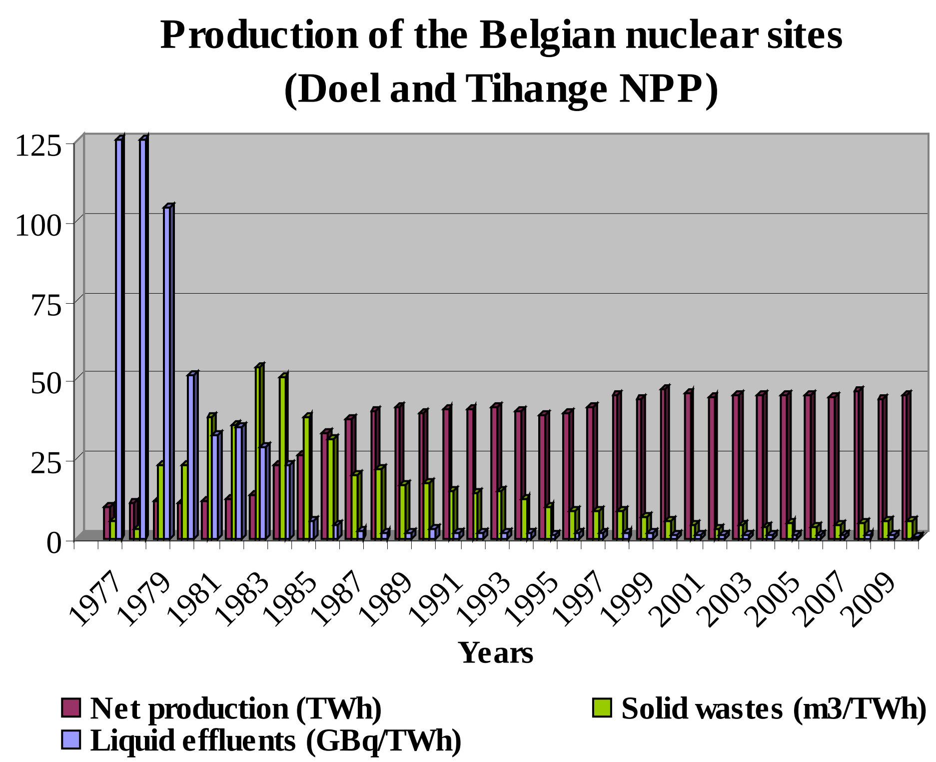
For both nuclear installations, calculations made for atmospheric discharges under conservative assumptions show that the maximum effective doses to the population in the vicinity of the NPPs are well below the national limits : ≤ 0.9% for the period 2005 - 2009 of the annual maximum limit of 1 mSv/a for Doel and around 2.3% in the period 2006 - 2009 for Tihange. If we take into account the dose constraint (see 2.4), calculations show that effective doses represent: from 2005 to 2009 for Doel ≤ 5% and around 12% in the period 2006 - 2009 for Tihange.

The low levels of radioactivity discharges and emissions from all nuclear power stations and low levels of radiation exposure in general show that the best available technology is being applied in Belgium.

Another interesting point to note concerns the quantity of liquid and solid waste generated by nuclear power stations (chart below). While the total production of electricity has remained more or less constant at around 45 TWh in recent years, the quantity of radioactivity discharged by the two NPP sites - excluding Tritium - in the liquid effluents has sharply declined from 44 GBq in 2005 (7.7 GBq/GWa) to 17.1 GBq in 2009 (2.9 GBq/GWa).

This observation is even more amplified when the volume of solid waste generated per TWh produced and removed for treatment and storage by the National Organisation for Radioactive Waste and Enriched Fissile Materials (ONDRAF - NIRAS) is considered: from 1985 a clear decreasing trend is observed up to the years 2001 (~ 3 m^3/TWh). From then on, volumes have increased slowly up to a value of 5.4 m^3/TWh in 2009. This increase of solid waste is related to the decrease of the produced liquid waste during that same period. That means that BAT are applied to reduce liquid discharges (more concentration/solidification).

This shows also the efforts made by Belgian NPPs to reconcile the objectives of optimising industrial operations, notably in reducing the volumes of waste produced and the related costs while, on the other hand, “reducing” the discharge of effluents as far as possible. These elements of assessment clearly demonstrate the application of the BAT concept with regard to liquid and solid waste.



3.6 Atmospheric wastes

3.6.1 Doel:

Origin: reactor building, space between the reactor building itself and the second containment, fuel building, nuclear auxiliaries building.

Treatment: all gas releases from hydrogenous circuits of the four reactors (primary circuit, …) or the WAB (water and waste treatment building) are sent to storage tanks. All gas from other sources (ventilation of the buildings, non-condensable gas, machinery rooms, demineralisation building, other WAB building areas, …) are continuously released through filters and monitored.

Waste management: Once the radioactivity of a full storage tank has sufficiently decreased, effluents are released through the chimney (presence of filters and continuous monitoring). All gas from other sources (ventilation of the buildings, non-condensable gas, machinery rooms, demineralisation building, other WAB building areas, …) are continuously released through filters and monitored. When "action" levels are exceeded, gas releases are by-passed through HEPA filters (High Efficiency Particulate Air filters). Filters and active carbon cartridges - trapping iodine - are analysed weekly (determination of iodine concentration and gamma spectrometry). Using monthly aliquots, beta and alpha measurements are conducted on filters; ^{85}Kr is determined on gas; tritium is determined on condensed gas.

3.6.2 Tihange:

Origin: 1) space between the reactor building itself and the second containment ("inter-space"), fuel building (spent-fuel pool), nuclear auxiliaries building (ventilation, machinery rooms, laundry building, demineralisation building, decontamination building, …); 2) Gaseous effluents from hydrogenous circuits (primary circuit, chemical and volumetric conditioning circuits); 3) atmosphere of each reactor building itself (70,000 m^3).

Treatment: all gas releases from 1) are continuously monitored, can be filtered and released (at a rate of 150,000 to 250,000 m^3/h). Gas releases from 2) are sent to storage / decay tanks. Venting of the atmosphere of the reactor building is done after monitoring and filtered if necessary.

Waste management: releases from 2) for each reactor (Tihange 1, Tihange 2 & Tihange 3) are sent to primary storage tanks. Once the radioactivity of a full storage tank has sufficiently decreased, effluents are released through the chimney at a maximum rate of 75 m^3/h (presence of filters and continuous monitoring). All gas from 1) is continuously released and monitored. When “action” levels are exceeded, gas releases are by-passed through HEPA filters (High Efficiency Particulate Air filters) and active carbon filters. Filters and active carbon cartridges - trapping iodine (excepted for laundry and decontamination buildings) - are analysed weekly (determination of iodine concentration and gamma spectrometry). Using monthly aliquots, beta and alpha measurements are conducted on filters; ^{85}Kr is determined on gas; tritium is determined by calculation taking into account flow rate and concentration.

3.7 Liquid wastes

3.7.1 Doel:

Origin: there are 4 reactors and in each reactor building there are 3 kinds of liquid wastes: recyclable waste waters (leakages from primary circuit) from the controlled areas called “primary waters”, non-recyclable waste waters (floor, laundry, lavatory, chemical, “demineralisation effluents” from steam generators) from the controlled areas and non-recyclable waste waters (floor, regeneration effluents from machinery, …) coming from other non-controlled areas.

Treatment: ion-exchange procedures, filtration and evaporation of waste waters (in evaporators, Tritium from the distillate is condensed and released as a liquid fraction). The concentrate phase is conditioned in the NPP itself as solid concrete waste.

Waste management: primary waters as non-recyclable waters coming from controlled areas are sent to the WAB (water and waste treatment building). Waters coming from other non-controlled areas are directly sent to the ELK (unique release collector to the Scheldt river after dilution) after control of the radioactivity concentration. In WAB, effluents are kept in a tank. After treatment, effluents are sent to a management building (L building) where they are diluted by secondary waters at a flow rate of 150 m^3/h. Diluted waters are then sent to the ELK building. There is a late dilution with tertiary cooling waters (at a flow rate of 150,000 m^3/h). Then waters are released to the Scheldt river if the radioactivity is below 0.1 MBq/m^3.

3.7.2 Tihange:

Origin: there are 3 reactors and for each reactor building there are 2 main categories of liquid wastes: recyclable waste waters (primary waters or hydrogenous waters) and non-recyclable waste waters (floor, laundry, lavatory, chemical such as labs decontamination component cooling systems, "demineralisation effluents" from steam generators, regeneration effluents from machinery, …).

Treatment: ion-exchange procedures, filtration and evaporation of waste waters (in evaporators, Tritium from the distillate is condensed and released as a liquid fraction). The concentrate phase is conditioned in the NPP itself as solid concrete waste.

Waste management: recyclable effluents are collected in their respective units (Tihange 1, 2 or 3) and then pumped to unit 2 where they are filtered (1 or 5 µm filters), demineralised (anionic, cationic and mixed bed resins), degassed (fission gas) and evaporated. The distillate (bore) is recovered, the filtrate (containing tritium) is sent to the RAR tank (storage tank before release to river) of the originating unit. The residue (containing residual non recovered bore) is eliminated as solid waste (cementation).

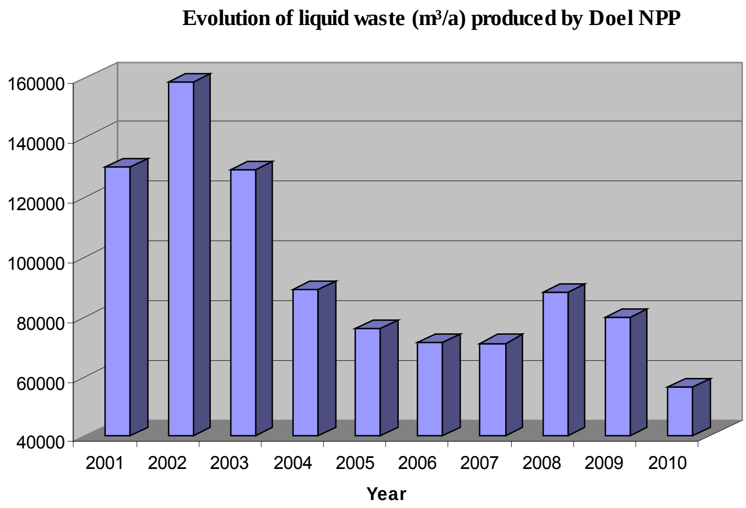
Non-recyclable effluents are identically collected in their respective units and are also pumped to unit 2. If the radioactivity is low, treatment will be conducted by filtration. If the radioactivity is higher, most of the effluents will be treated by evaporation or through filters and ion exchange resins. The distillate (evaporation) and/or filtrate (filtration) are treated as a low level activity effluents, analysed and repumped to the RAR tank (storage tank before release to river) of the originating unit. In either case, solid residues are treated as solid waste according ONDRAF procedures.

All effluents from the RAR, after second analyses, are pumped to their own end collector. There, they are mixed with and diluted by waters from raw water cooling system before being released to the Meuse river.

3.8 Other relevant information:

All liquid waste management and treatments are audited according to EMAS (Eco-Management and Audit Scheme) and ISO 14001 certifications.

For Doel NPP e.g., for the last ten years, following factors have influenced the reduction of radioactive liquid releases:



- more liquid wastes are evaporated to solid wastes instead of being released in the Scheldt river;
- replacement of the steam generators of reactor 2 (2004) allows to recover the “blow-down” waters which induced a significant decrease of liquid releases.
- Steam Generators and power uprate of reactor 1: by the replacement of the steamgenerators (2009) the risc of leaks form the primary to the secundairy circuit has decreased. Due to the power increase, the inventory of radioactive products present in the reactor core as in the primary circuit can raise to reach a possible maximum level proportional to the power increase factor. This doesn’t necessairy mean that releases towards the environment will rise and this is due to the dependence of plenty of other factors such as for example pH and mainly of the degree of leak tightness of all different barriers between the source of activity and its surroundings. Nevertheless, after the implementation, controle and surveillance showed that the actual dicharge limits - according to the Technical Specifications which remained the same as before – are still well respected and likewise amply meets the appropriate dose limits for the population.

3.9 IAEA Operational Safety Review Team (OSART):

At the request of the Government of the Belgium, an IAEA Operational Safety Review Team (OSART) of international experts:

- visited the site of Tihange Nuclear Power Plant (unit 1) from 7 May to 23 May 2007.
- visited Doel Nuclear Power Plant (units 1 & 2) from 8 to 25 March 2010.
- According to the request of the Federal Agency for Nuclear Control (FANC) oldest units were the main scope of the OSART review : unit 1 for Tihange and units 1 and 2 for Doel.
- The purpose of these missions was to review operating practices in the areas of Management organisation and administration; Training and qualification; Operations; Maintenance; Technical support; Operating experience, Radiation protection; Chemistry and Emergency planning and preparedness. In addition, an exchange of technical experience and knowledge took place between the experts and their plant counterparts on how the common goal of excellence in operational safety could be further pursued.

The main conclusions of the OSART team for Tihange were that the managers of Tihange unit 1 are committed to improving the operational safety and reliability of their plant and that good areas of performance were found, including the following:

- The plant has developed an ambitious programme for reducing fire hazards in improving fire fighting capability, staff behaviour, training, fire fighting equipment and facilities;
- The plant has equipped all exits of its radiological controlled area with sensitive exit gate monitors “IPM9” that are equipped with beta and gamma detectors;

- The plant has designed and installed seismically qualified fixed structures on which blankets of lead shielding can be quickly installed and dismantled for high dose rate worksites in places where workers carry out systematic maintenance;
- A document management database was created to meet deadline requirements for essential reports (e.g. ASME), for increased precision and completeness of the issued documents, for improving operating experience (OPEX), work records and to plan future work;
- Several tools were developed to increase the behaviour of employees in charge of responding an emergency situation at the plant (specific colour-stickers for cars, blue flash light to direct rescue teams and reflex form for each key position in the emergency plan);
- The plant has set up an organisation for the reception of personnel and families for managing a long accident period, in the “reception and fall-back center” in Les Awirs (Centre d’Accueil et de Repli des Awirs - CARA).

Besides this previous good areas of performance, the team found also some areas where improvement should be done such as:

- The work authorisation process and its coordination are not fully established and not always followed;
- Events are not always analysed in a timely manner and formal root cause analysis methodology is not always used;
- The application of the human performance tools does not always meet management expectations;
- Procedures for temporary modifications, personnel operational aids and tagging are not always adhered to in a rigorous manner;
- The plant operations managers and personnel did not develop and implement a sufficiently demanding programme for resolving minor deficiencies in the field, such as labeling, cleanliness, unmanaged storage and small leakages;
- Plant workers, in some cases, do not rigorously follow the plant requirements necessary to prevent their contamination and/or spread of contamination.

The OSART follow-up mission of January 2009 is being welcomed as another opportunity to verify that Tihange is on the right track in its quest for excellence. The OSART follow-up team received excellent cooperation from the Tihange NPP management and staff. The team was impressed with the sets of corrective actions taken to resolve the findings of the original mission. In a numerous domains improvement were noticeable:

- Human performance tools are promoted and utilised;
- A large sets of performance indicators were set-up to assess process at the department level, and are now tools for conducting improvement;
- Industrial safety practices are clearly reinforced;
- Lesson plans are systematically developed to improve training materials;
- Assessment of staff competencies are conducting to certification for work;
- Coaching on human behaviour at the simulator is in place;
- More rigour is applied on operational activities and for the start-up mode, procedures were efficiently revised;
- The status of the emergency shutdown panel has been enhanced;
- Management of the surveillance programme and its periodic review was reconsidered and enhanced;
- The event investigation is timely done and training has been improved;

- Chemistry control procedures and the practices were re-evaluated and improved;
- Numerous drills were organised in a comprehensive manner to practice the evacuation of personnel during emergency situations.

The original OSART team in May 2007 developed 10 recommendations and 12 suggestions to further improve operational safety at the plant. As at January 2009, 19 months after the mission, 73% of recommendations and suggestions were resolved and 27% were progressing satisfactorily. No recommendations/suggestions were found to have made insufficient progress. These results are outstanding.

The main conclusions of the OSART team for Doel were that the managers of Doel units 1 & 2 are committed to the principle of continuous improvement in the operational safety and reliability of their plants and that good areas of performance were found, including the following:

- Self assessment exercises are conducted at all levels, including workshop level, as well as at different process levels;
- Competency grades are used to measure safety culture and reduce errors due to human behavior;
- The defense-in-depth principle as a strategy for nuclear safety is integrated into all training courses and programmes;
- A training and assessment programme is performed to improve contractors' competency in Nuclear Safety Culture during outages;
- An intensive training program is used for maintenance work planners, leading to a formal accreditation;
- The fuel department has compiled a pocket size book that is easy to use and provides a short and easy to read description of tools, equipment and installations used for handling of fuel and core components.

Besides these previous good areas of performance, the team found also some areas where improvement should be done such as:

- Analyses for some events are not being performed to the required depth and rigor described in the plant programs, and are not being completed in a timely fashion;
- Outside of working hours, there is no-one required to be present at the site who has the responsibility or the authority to classify an emergency or to notify off-site authorities;
- Not all industrial safety related hazards and risks to workers' safety and health are identified and eliminated on an ongoing basis;
- The plant uses Probabilistic Safety Analyses to a limited extent for assessments and risk evaluations;
- Procedural guidance is not currently in place to ensure the control room environment remains habitable by operators with respect to oxygen content following an accident;
- There are weaknesses in the maintenance backlog management tool and the methodology for ensuring timely completion of maintenance works.

As for Tihange, an OSART follow-up mission is scheduled for Doel NPP units 1 & 2 in the beginning of 2012 to verify the implementation of the OSART team recommandations and suggestions. In anticipation of this follow-up, the current general conclusion pointed out at that the OSART experts acknowledged the given priority of Electrabel for its NPP safety.

4. Other nuclear sites

There are two other nuclear sites in Belgium: the Fleurus site (IRE-National Institute of Radioelements and MDS-Nordion) in Wallonia and the Mol-Dessel site (the Nuclear Research Centre SCK●CEN / Belgoprocess sites 1&2 (BP) / Belgonucléaire (stopped in August 2006, dismantling started in 2009 and to be completed in

2014) / FBFC International - Franco-Belge de Fabrication de Combustibles International / IRMM – Institute for Reference Materials and Measurements) in Flanders. The facilities at these sites carry out scientific, technical and commercial programmes in the nuclear field.

For the Fleurus site there are no liquid discharges: all liquid wastes are sent to the Belgoprocess site 1 for treatment. After treatment, eventual liquid discharges are released by the Belgoprocess site 2. All the liquid discharges produced by the Mol-Dessel site are also managed by the Belgoprocess facilities.

For Belgoprocess site 2 the information, as defined in BAT Guidelines, is given in tabular form (annex 2):

- Name of facility
- Type of facility
- Location
- Annual emissions and discharges
- Individual dose as compared to the national dose limits
- Waste treatment

The determination of individual doses covers all radionuclides discharged to the environment.

Belgoprocess site 1

4.1 Sources of liquid effluent

The radioactive liquid effluents are generated by the waste treatment unit of Belgoprocess 2. Liquid discharges are operated in the Molse Nete river with a limit set at 25 GBq/month and a maximum of 150 GBq/year according to the following weighting formulae:

2,5 [α total] + 0.4 [^{90}Sr-^{90}Y] + 2.5 10^{-5} [^{3}H] + [^{60}Co] + 1.5 [^{134}Cs] + 1.5 [^{137}Cs] + 0.1 [β] ≤ 25 GBq/month (150 GBq/year maximum with a concentration limit of 15 MBq/m³) in the river Molse Nete.

with [β] = [β total] – ([^{90}Sr-^{90}Y] + [^{60}Co] + [^{134}Cs] + [^{137}Cs])

The discharges from the site into the Molse Nete adequately comply with the limit set, even though they are not negligible. The principal radionuclides arising in liquid waste are tritium and, to a much lesser degree, activation and fission products. See Annex 2.

4.2 Liquid effluent treatment

See 4.7.

4.3 Nuclide libraries

The radionuclides to be monitored are stipulated in the licences of the nuclear sites under the responsibility of the FANC federal authority.

4.4 Environmental Impact

The environmental programme in the vicinity of the nuclear sites is performed by the FANC radiological monitoring programme. The analyses of environmental samples (sediment & water in rivers and north-sea, fauna & flora in freshwater and marine water, soil, air, rain, milk, foodchain, drinking water) show that there are no detectable α- and β-activity concentrations (excluding tritium) related to radioactive discharges from the sites.

4.5 Trends in discharge over the 1998-2009 period and summary evaluation (see annex 3)

The installations have been operating more or less steadily throughout this period, so liquid discharges have been fairly constant.

For tritium, since 2000, releases are more or less constant around 2-3 TBq per year. These releases are almost entirely due to the operation of the BR2 research reactor (PWR) situated on the SCK●CEN site. Observed fluctuations are linked to the number of working days durind a considered year. Since the power of this reactor is small (125 MWth), produced quantities of tritium are also limited.

For beta emitters excluding tritium, releases decrease exponentially from 2000 to 2009 (2.4 GBq to less than 0.2 GBq). For alpha emitters, releases have increased to a maximum of 98.7 MBq in 2001 and then decreased exponentially to 16.0 MBq in 2009.

4.6 Atmospheric waste

Origin: at Belgoprocess, gaseous wastes can be produced by burning solid and liquid wastes, by the gaseous and liquid waste treatments, by building ventilations, … The other nuclear installations, mentioned in §53, also produce atmospheric wastes but will not be further discussed in this report.

Treatment: filtration by HEPA filters before releases in the chimneys.

Waste management: after filtration, releases are continuously monitored and sampled.

4.7 Liquid waste

Origin: liquid wastes treated by BP are mainly produced by SCK•CEN and Belgoprocess installations. Beside that, there are also effluents coming from Doel and Tihange NPPs, Belgonuclaire, FBFC International, IRE, IRMM (production of calibrated/reference sources, cyclotron) sites and finally hospitals and research centres (universities, …).

Kind of effluents:

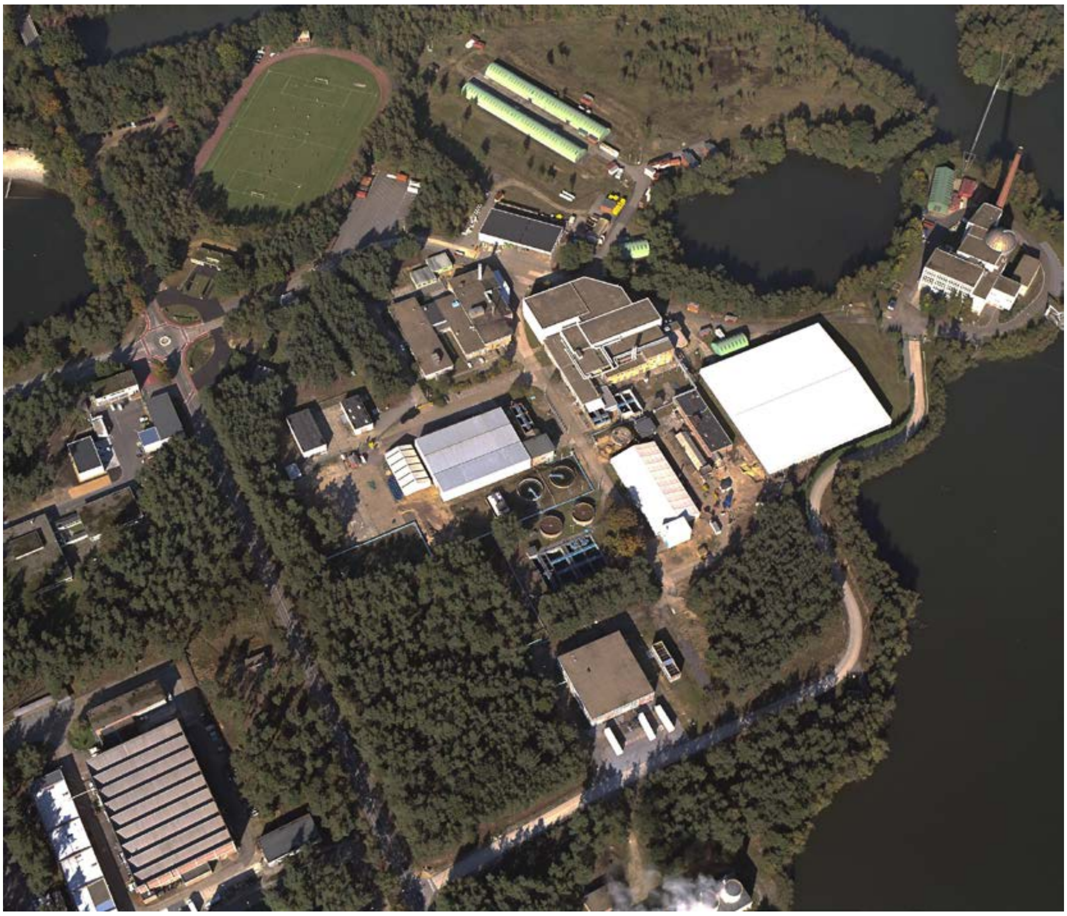
Relatively low activity effluents:

- *suspicious* effluents where activity is < 400 kBq/m^3 for beta/gamma emitters and < 40 kBq/m^3 for alpha emitters;
- *contaminated* effluents where activity is < 400 MBq/m^3 for beta/gamma emitters and < 800 kBq/m^3 for alpha emitters;
- *higher radioactive* effluents where activity is < 40 GBq/m^3 for beta/gamma emitters and < 80 MBq/m^3 for alpha emitters.

Medium activity effluents:

- with activity < 40 TBq/m^3 for beta/gamma emitters (i.e. liquid wastes of medium activity from the IRE site).

Belgoprocess site 2 (liquid waste treatment and releases)



Treatment: effluents are treated by sedimentation in decantation tank, the particulate phase is sent to a storage tank where other sedimentation/decantation processes occur. Depending on the radioactivity levels, the liquid phase is evaporated by BP.

Waste management: residues or solid phases are conditioned by BP cementation before storage (since 2005 bitumisation is not applied). Up to 1992, high solid wastes - coming from the former Eurochemic plant (dismantled now) - were vitrified and stored. Now these processes are stopped. Before liquid effluents are released into the Molse Nete river, the following limits have to be respected: concentration < 15 MBq/m^3 and < 25 GBq/month or 150 GBq/a according to the weighting formulae described in 4.1.

Annex 1 - NPPs

1. Site Characteristics

By: Claes Jurgen
Sombre Lionel

Name of facility	NPP Doel
Type of facility	PWR
Date commissioned	1975-1975-1982-1985
date of shut-down	2015-2015-2022-2025
Location	Belgium (Doel)
Receiving water	Scheldt

Installed capacity	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
MW[e]	2776	2776	2776	2776	2776	2776	2817	2817	2840	2840	2840	**2878**

Electricity generation (net)	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GWh	~21800				21801	21780	21404	21886	21627	22669	20500	**21167**

2. Discharge and emission data
annual liquid discharges, Bq/a

Radionuclide (TBq/a)	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Co-58	2,91E-03	9,32E-03	5,15E-03	8,43E-04	2,29E-03	5,09E-04	3,85E-04	0,00E+00	0,00E+00	7,24E-04	3,92E-04	5,69E-04
Co-60	5,30E-04	2,43E-03	1,37E-03	9,50E-04	1,21E-03	1,05E-04	2,17E-04	3,09E-04	2,84E-04	3,82E-04	5,54E-04	8,63E-04
Zn-65	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,20E-06	3,00E-07	3,00E-07	4,60E-06
Sr-90	2,20E-05	2,13E-04	1,33E-04	2,31E-05	9,20E-06	1,00E-06	0,00E+00	3,70E-06	6,60E-06	0,00E+00	0,00E+00	0,00E+00
Zr/Nb-95	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,59E-05	4,19E-05	3,33E-05	1,11E-04	9,89E-05
Ru-106	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,6E-05	2,29E-05	1,20E-04	3,22E-05
Ag-110m	1,80E-04	4,30E-05	5,18E-04	6,32E-05	3,68E-05	5,23E-04	1,31E-03	2,76E-04	1,78E-04	3,31E-04	6,56E-04	4,95E-04
Sb-125	1,94E-03	2,25E-03	2,13E-03	2,11E-03	1,98E-03	2,54E-03	1,14E-03	2,16E-03	4,19E-04	4,56E-04	4,11E-04	4,04E-04
Cs-134	3,08E-03	3,54E-03	6,57E-04	0,00E+00	2,50E-04	6,00E-05	5,80E-05	3,67E-05	8,60E-06	9,80E-06	1,74E-05	2,10E-06
Cs-137	6,67E-03	9,42E-03	3,49E-03	2,73E-03	3,62E-03	3,49E-03	1,40E-03	5,81E-04	1,01E-04	2,62E-04	2,64E-04	3,59E-04
Ce-144	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Total-Beta*	1,60E-02	2,78E-02	1,50E-02	6,70E-03	1,17E-02	8,41E-03	5,22E-03	4,52E-03	1,71E-03	2,54E-03	3,10E-03	3,53E-03
Total activity excluding H-3	3,13E-02	5,50E-02	2,84E-02	1,34E-02	2,11E-02	1,56E-02	9,73E-03	7,92E-03	2,79E-03	4,76E-03	5,63E-03	6,36E-03
H-3	4,71E+01	4,84E+01	3,09E+01	3,80E+01	2,75E+01	3,43E+01	4,21E+01	3,99E+01	4,61E+01	5,37E+01	4,17E+01	5,31E+01
Total-Alpha	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,20E-06	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total activity excluding H-3	3,13E-02	5,50E-02	2,84E-02	1,34E-02	2,11E-02	1,56E-02	9,73E-03	7,92E-03	2,79E-03	4,76E-03	5,63E-03	6,36E-03
Annual limit (TBq/a)	1,50E+00	1,50E+00	1,50E+00	1,50E+00	1,50E+00	1,50E+00	1,50E+00	1,50E+00	1,50E+00	1,50E+00	1,50E+00	1,50E+00
% of annual limit	2,1	3,7	1,9	0,9	1,4	1,0	0,6	0,5	0,2	0,3	0,4	0,4
Normalised to capacity (GBq/GWa)	11,3	19,8	10,2	4,8	7,6	5,6	3,5	2,8	1,0	1,7	2,0	2,2
UNSCEAR ranges (GBq/GWa)	14 - 140											
H-3	4,71E+01	4,84E+01	3,09E+01	3,80E+01	2,75E+01	3,43E+01	4,21E+01	3,99E+01	4,61E+01	5,37E+01	4,17E+01	5,31E+01
Annual limit (TBq/a)	1,04E+02	1,04E+02	1,04E+02	1,04E+02	1,04E+02	1,04E+02	1,04E+02	1,04E+02	1,04E+02	1,04E+02	1,04E+02	1,04E+02
% of annual limit	45,5	46,7	29,8	36,7	26,5	33,1	40,6	38,5	44,5	51,8	40,3	51,3
Normalised to capacity (TBq/GWa)	17,0	17,4	11,1	13,7	9,9	12,4	14,9	14,2	16,2	18,9	14,7	18,4
UNSCEAR ranges (TBq/GWa)	7,9 - 80											

3. Annual aerial emissions (Bq/a)

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
H-3 (TBq/a)	0,052	5,665	0,017	0,326	1,026	0,710	0,030	0,476	1,98	2,93	2,61	2,94
Normalised to capacity (TBq/GWa)	0,03	2,83	0,01	0,16	0,51	0,35	0,01	0,24	0,70	1,03	0,92	1,02

C-14 is not measured and estimated to 5,55E+02 GBq/a (according to literature** that mentions 5 Ci/a (18.5 GBq/a) for 1000 MWe installed)

4. Radiation doses to the public

Effective Dose (mSv/a)***	1992 to 2001	2002	2003	2004	2005	2006	2007	2008	2009
Water pathway	0,0023	0,0013	0,0010	0,0007	0,0006				
% of dose constraint	1,0	0,6	0,4	0,3	0,3		Waiting for data****		
% of dose limit (1 mSv/a)	0,23	0,13	0,1	0,07	0,06				
Air pathway	0,0087	0,0087	0,0086	0,0085	0,0086				
% of dose constraint	4,8	4,8	4,8	4,7	4,8		Waiting for data****		
% of dose limit (1 mSv/a)	0,87	0,87	0,86	0,85	0,86				

* Value of "other radionuclides" (= total Beta-Gamma) reported as mentioned in the 'instructions for the reporting format for liquid discharges of radioactive substances from nuclear installations' (point 8)

** Investigations into the emission of C-14 compounds from nuclear facilities, J. Schwibach, H. Riedel und J. Bretschneider, november 1978, Commission of the European Communities

*** Given for an adult. Calculated by NUREG 1.109

**** Since 2006-2009 discharges are ≤ previous years, doses are of same order of magnitude

1. Site Characteristics

By: Claes Jurgen
Sombre Lionel

Name of facility	NPP Tihange
Type of facility	PWR
Date commissioned	1975-1982-1985
date of shut-down	2015-2022-2025
Location	Belgium (Tihange)
Receiving water	Meuse

Installed capacity	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
MW[e]	2973	2973	2973	2973	2985	2985	2985	2985	2985	2985	2985	**3024**

Electricity generation (net)	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GWh	~23000				23186	23141	23495	23183	22597	23097	22740	**23674**

2. Discharge and emission data
annual liquid discharges, Bq/a

Radionuclide (TBq/a)	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Co-58	8,46E-03	6,21E-03	8,34E-03	2,06E-02	1,46E-02	1,37E-02	1,07E-02	8,40E-03	7,36E-03	4,55E-03	6,78E-03	9,09E-04
Co-60	4,60E-03	3,84E-03	3,78E-03	5,30E-03	5,32E-03	5,07E-03	8,33E-03	5,22E-03	1,02E-02	6,10E-03	6,90E-03	3,49E-03
Zn-65	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,42E-05	1,80E-05	0,00E+00
Sr-90	2,10E-05	5,75E-06	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Zr/Nb-95	1,59E-04	2,20E-04	2,35E-04	1,02E-03	6,93E-05	3,00E-04	5,28E-04	2,62E-04	2,00E-04	7,15E-04	6,74E-04	7,00E-05
Ru-106	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,25E-04	2,5E-05	0,00E+00	0,00E+00	0,00E+00
Ag-110m	1,87E-03	3,59E-04	8,40E-04	3,57E-04	8,27E-04	1,48E-03	1,44E-03	7,16E-04	7,85E-04	4,32E-04	7,33E-04	2,57E-04
Sb-125	1,58E-03	4,02E-04	2,70E-04	4,47E-04	1,02E-03	8,48E-04	1,95E-03	8,43E-04	6,72E-04	1,26E-04	6,75E-05	4,19E-06
Cs-134	2,47E-04	9,05E-05	5,10E-05	9,62E-05	2,99E-04	1,17E-03	2,08E-03	7,89E-04	1,05E-03	5,51E-04	1,97E-04	1,06E-04
Cs-137	1,05E-03	2,88E-04	3,50E-04	4,22E-04	5,36E-04	1,15E-03	2,10E-03	1,27E-03	2,03E-03	1,01E-03	4,83E-04	3,08E-04
Ce-144	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,50E-06	9,00E-06	2,90E-05	4,27E-06	0,00E+00	0,00E+00
Total-Beta*	2,00E-02	1,27E-02	1,57E-02	3,32E-02	2,66E-02	2,66E-02	3,13E-02	1,90E-02	2,41E-02	1,66E-02	1,77E-02	5,53E-03
Total activity excluding H-3	3,80E-02	2,41E-02	2,96E-02	6,15E-02	4,93E-02	5,03E-02	5,84E-02	3,66E-02	4,64E-02	3,01E-02	3,35E-02	1,07E-02
H-3	3,29E+01	6,66E+01	3,31E+01	4,10E+01	5,96E+01	4,35E+01	4,55E+01	4,60E+01	4,41E+01	5,71E+01	3,37E+01	5,34E+01
Total-Alpha	9,00E-07	9,00E-07	7,10E-07	1,20E-07	0,00E+00	9,10E-10	5,13E-09	2,11E-09	1,71E-09	2,60E-09	1,36E-09	1,27E-09

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total activity excluding H-3 (TBq/a)	3,80E-02	2,41E-02	2,96E-02	6,15E-02	4,93E-02	5,03E-02	5,84E-02	3,66E-02	4,64E-02	3,01E-02	3,35E-02	1,07E-02
Annual limit (TBq/a)	8,88E-01	8,88E-01	8,88E-01	8,88E-01	8,88E-01	8,88E-01	8,88E-01	8,88E-01	8,88E-01	8,88E-01	8,88E-01	8,88E-01
% of annual limit	4,3	2,7	3,3	6,9	5,5	5,7	6,6	4,1	5,2	3,4	3,8	1,2
Normalised to capacity (GBq/GWa)	12,8	8,1	9,9	20,7	16,5	16,9	19,6	12,3	15,6	10,1	11,2	3,5
UNSCEAR ranges (GBq/GWa)	14 - 140											
H-3 (TBq/a)	3,29E+01	6,66E+01	3,31E+01	4,10E+01	5,96E+01	4,35E+01	4,55E+01	4,60E+01	4,41E+01	5,71E+01	3,37E+01	5,34E+01
Annual limit (TBq/a)	1,48E+02	1,48E+02	1,48E+02	1,48E+02	1,48E+02	1,48E+02	1,48E+02	1,48E+02	1,48E+02	1,48E+02	1,48E+02	1,48E+02
% of annual limit	22,3	45,1	22,4	27,8	40,4	29,5	30,8	31,2	29,8	38,7	22,9	36,1
Normalised to capacity (TBq/GWa)	11,1	22,4	11,1	13,8	20,0	14,6	15,2	15,4	14,8	19,1	11,3	17,6
UNSCEAR ranges (TBq/GWa)	7,9 - 80											

3. Annual aerial emissions (Bq/a)

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
H-3 (TBq/a)	6,35	7,32	7,56	5,65	5,26	5,66	6,75	6,51	5,66	6,26	6,68	7,49
Normalised to capacity (TBq/GWa)	2,14	2,46	2,54	1,90	1,76	1,90	2,26	2,18	1,90	2,10	2,24	2,48

C-14 is not measured and estimated to 5,55E+02 GBq/a (according to literature** that mentions 5 Ci/a (18.5 GBq/a) for 1000 MWe installed)

4. Radiation doses to the public

Effective Dose (mSv/a)***	1992 to 2001	2002	2003	2004	2005	2006	2007	2008	2009
Water pathway	0,0024	0,0025	0,00226	0,00295	0,00213	0,0028	0,00237	0,00182	0,00165
% of dose constraint	3,0	3,1	2,8	3,7	2,7	3,5	3,0	2,3	2,1
% of dose limit (1 mSv/a)	0,24	0,25	0,226	0,295	0,213	0,28	0,24	0,18	0,17
Air pathway	0,0225	0,0224	0,0228	0,0227	0,0226	0,0226	0,0228	0,023	0,0227
% of dose constraint	11,8	11,8	12,0	11,9	11,9	11,9	12,0	12,1	11,9
% of dose limit (1 mSv/a)	2,25	2,24	2,28	2,27	2,26	2,26	2,28	2,3	2,27

* Value of "other radionuclides" (= total Beta-Gamma) reported as mentioned in the 'instructions for the reporting format for liquid discharges of radioactive substances from nuclear installations' (point 8)

** Investigations into the emission of C-14 compounds from nuclear facilities, J. Schwibach, H. Riedel und J. Bretschneider, november 1978, Commission of the European Communities

*** Given for an adult. Calculated by NUREG 1.109, DCF ICRP-72

Annex 2 - Other Nuclear Sites (BP)

1. Site Characteristics

By: Claes Jurgen
Sombre Lionel

Name of facility	Belgoprocess (BP)
Type of facility	Wastes treatment and storage centre
Location	Belgium (Mol-Dessel)
Receiving water	Molse Nete

2. Discharge and emission data
annual liquid discharges, Bq/a

Year		1998	1999	2000	2001	2002	2003 [7]	2003 [8]
Tritium	[1] MBq	1300000	3343600	2341300	2287900	2162100	494600	1516800
	[2] MBq	1.30	3.34	2.34	2.29	2.16	0.49	37.92
Total-α	[1] MBq	33.6	21.3	80.8	98.7	83.2	5.9	53.6
	[2] MBq	168.2	106.5	404.1	493.4	416.0	29.5	134.0
Total-β	[1] MBq	2316.3	1430.0	2438.1	2110.4	1373.1	233.6	281.8
	[2] MBq	2316.3	1430.0	2438.1	2110.4	1373.1	233.6	28.2
Co 60	[1] MBq							43.0
	[2] MBq							43.0
Sr/Y 90	[1] MBq	178.7	149.9	108.6	111.6	63.0	18.4	73.9
	[2] MBq	1340.3	1124.3	814.5	837.0	472.5	138.0	29.6
I 131	[1] MBq	3.5	5.1	8.0	3.3	4.2	1.7	
	[2] MBq	10.6	15.2	23.9	10.0	12.5	5.0	
Cs 134	[1] MBq							18.0
	[2] MBq							27.0
Cs 137	[1] MBq							383.0
	[2] MBq							574.5
Ra 226	[1] MBq	0.030	0.032	0.032	0.032	0.033	0.011	
	[2] MBq	8.9	9.5	9.7	9.5	9.9	3.4	
GBq released	per annum [3]	1.30E+03	3.35E+03	2.34E+03	2.29E+03	2.16E+03	4.95E+02	1.52E+03
TBq released	per annum [4]	3.845	2.689	3.693	3.463	2.286	0.410	0.230
		[5]	[5]	[5]	[5]	[5]	[5]	[6]

Year		2003 [9]	2004	2005	2006	2007	2008	2009
Tritium	[1] MBq	2011400	2204000	2372800	2493400	1888900	2700000	2290000
	[2] MBq	38.41	55.10	59.32	62.34	47.22	67.50	57.25
Total-α	[1] MBq	59.5	46.4	41.5	8.6	11.1	14.5	16.0
	[2] MBq	163.4	116.0	103.7	21.5	27.8	36.3	40.0
Total-β	[1] MBq	515.4	281.8	213.9	129.4	155.1	151.4	187.9
	[2] MBq	261.8	28.2	21.4	12.9	15.5	15.1	18.8
Co 60	[1] MBq	43.0	63.0	109.0	26.0	99.0	4.0	9.0
	[2] MBq	43.0	63.0	109.0	26.0	99.0	4.0	9.0
Sr/Y 90	[1] MBq	92.3	117.6	69.1	57.1	65.6	33.8	20.5
	[2] MBq	167.6	47.0	27.6	22.8	26.2	13.5	8.2
I 131	[1] MBq	1.7						
	[2] MBq	5.0						
Cs 134	[1] MBq	18.0	19.0	56.0	15.0	0.0	0.0	0.0
	[2] MBq	27.0	28.5	84.0	22.5	0.0	0.0	0.0
Cs 137	[1] MBq	383.0	324.0	315.0	22.5	0.0	0.0	0.0
	[2] MBq	574.5	486.0	472.5	33.8	0.0	0.0	0.0
Ra 226	[1] MBq	0.011						
	[2] MBq	3.4						
GBq released	per annum [3]	2.01E+03	2.20E+03	2.37E+03	2.49E+03	1.89E+03	2.70E+03	2.29E+03
GBq released	per annum [4]	0.640	0.246	0.212	0.120	0.117	0.132	0.124
		[5] + [6]	[6]	[6]	[6]	[6]	[6]	[6]

[1]	Amount of the radionuclide in MBq
[2]	Weighted Amount of the radionuclide in MBq being [1] multiplied by its weighting coefficient
[3]	Being the total amount of activity in TBq released
[4]	Being the total amount of ponderated activity in TBq released
[5]	Total Weighted Amount in TBq according former formula 1 E-06 [H3] + 5[α] + 1[β] + 7,5[Sr90] + 3[I131] + 300[Ra226] **applicable until March 2003**
[6]	Total Weighted Amount in TBq according actual formula 2.5 E-05 [H3] + 2,5[α] + 0,1[b] + 1[Co60] + 0,4[Sr/Y90] + 1,5[Cs134] + 1,5[Cs137] with [b] = total beta ([β]) activity - [[Sr/Y90] + [Co60] + [Cs134] + [Cs137]] **applicable from April 2003**
[7]	Activity values for the months January, February and March calculated according formula [5].
[8]	Activity values for the months April until December calculated according formula [6].
[9]	Sum of the activities [7] and [8], being the amount for the whole year 2003.

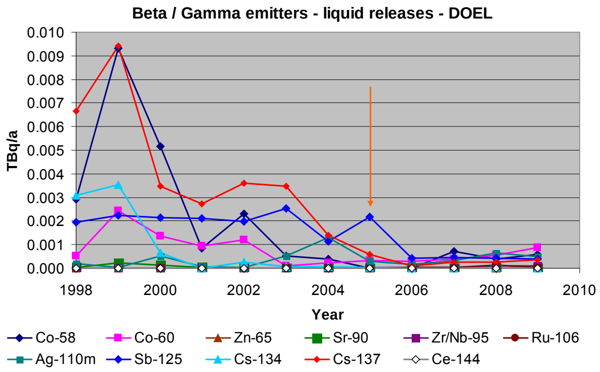
3. Radiation doses to the public

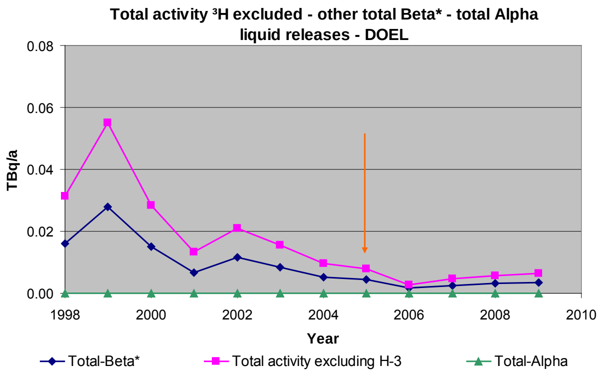
Effective Dose (mSv/a)	2001	2002	2003	2004	2005	2006	2007	2008	2009
Water pathway*	8.75E-05	6.83E-05	6.32E-05	6.16E-05	6.71E-05	5.68E-05	4.74E-05	6.11E-05	5.19E-05
% of dose limit (1 mSv/a)	0.009	0.007	0.006	0.006	0.007	0.006	0.005	0.006	0.005
Air pathway**	1.0E-03	1.2E-02	1.3E-02	2.5E-02	2.1E-02	1.6E-02	1.5E-02	1.3E-02	9.0E-03
% of dose limit (1 mSv/a)	0.1	1.2	1.3	2.5	2.1	1.6	1.5	1.3	0.9

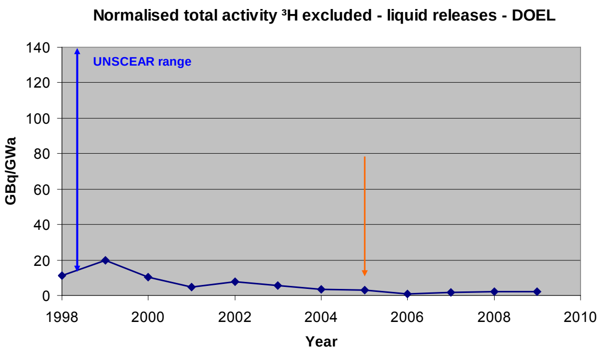
* given for an adult. Calculated by the NRPB-231 (1990)
** for the total site Mol-Dessel (Belgoprocess, SCK•CEN, FBFC, Belgonucléaire, IRMM)
given for an adult. Calculated by NUREG 1.109, DCF ICRP-72 (from 2002)

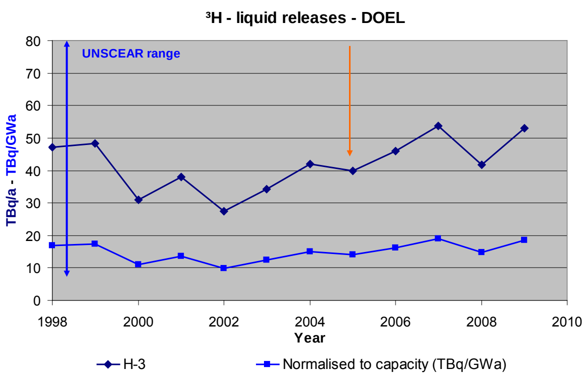
Annex 3 - Trend line figures

DOEL NPP

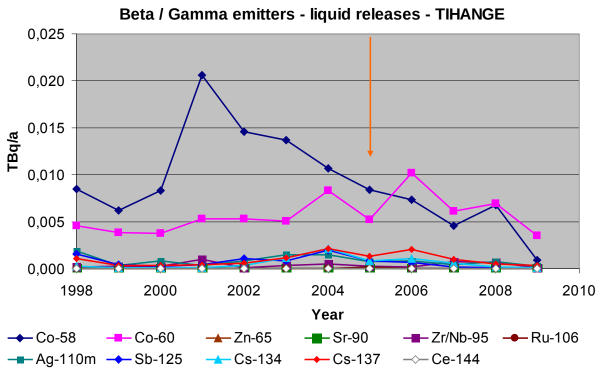


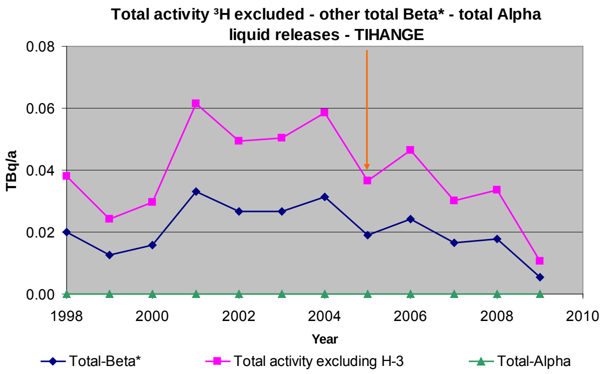


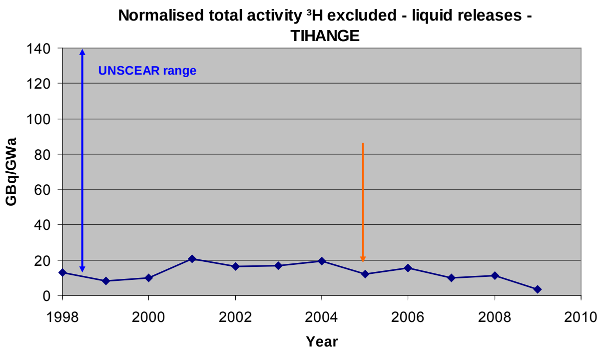


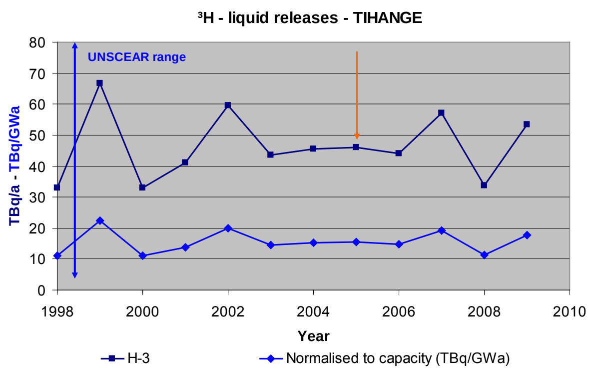


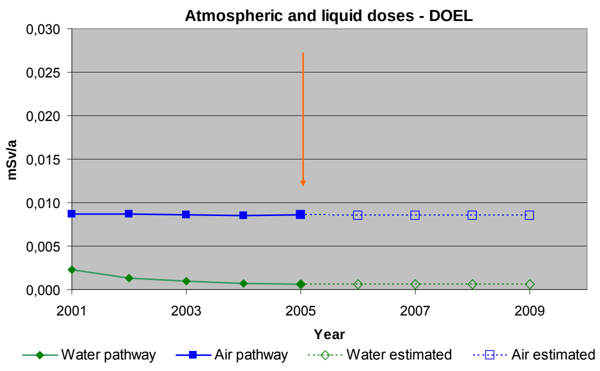
TIHANGE NPP

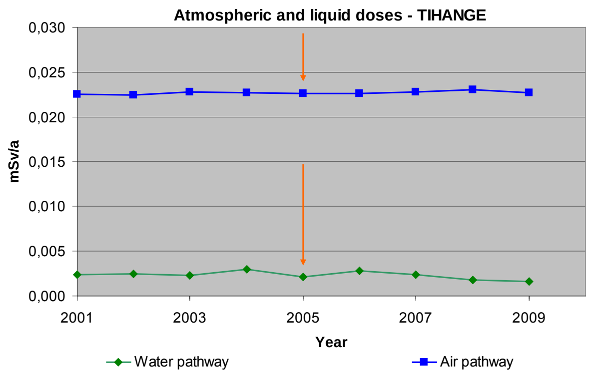


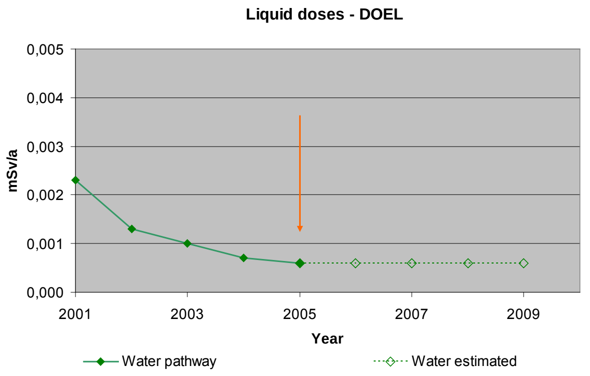


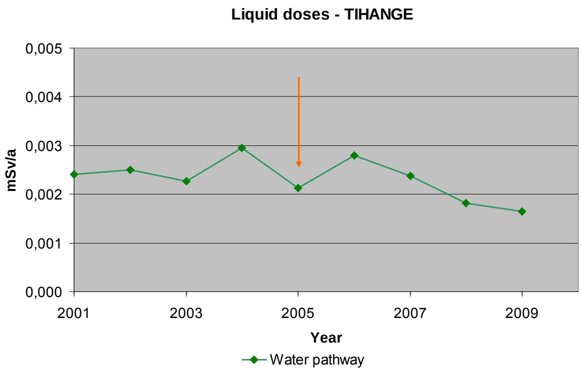




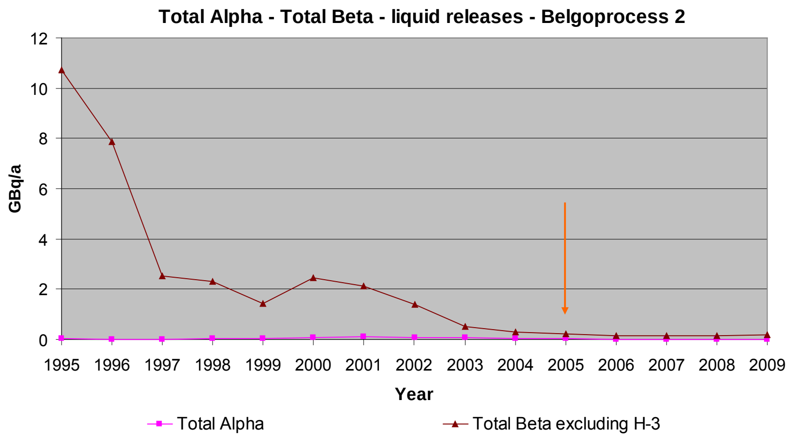

Atmospheric and liquid doses - DOEL
mSv/a
0,030
0,025
0,020
0,015
0,010
0,005
0,000
2001
2003
2005
2007
2009
Year
Water pathway
Air pathway
Water estimated
Air estimated

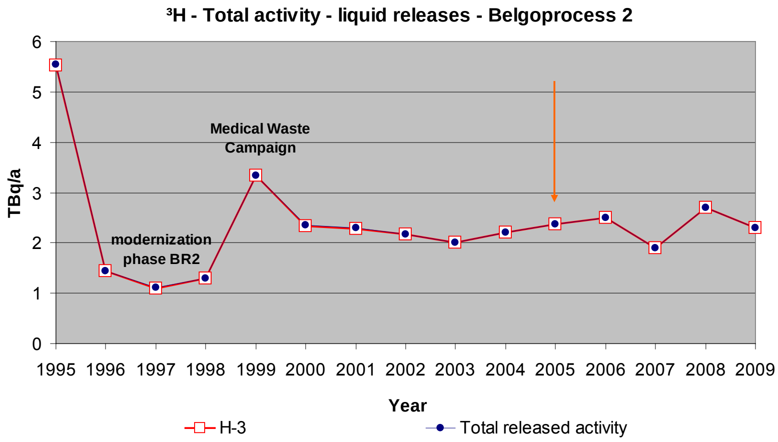

Atmospheric and liquid doses - TIHANGE
mSv/a
0,030
0,025
0,020
0,015
0,010
0,005
0,000
2001
2003
2005
2007
2009
Year
Water pathway
Air pathway

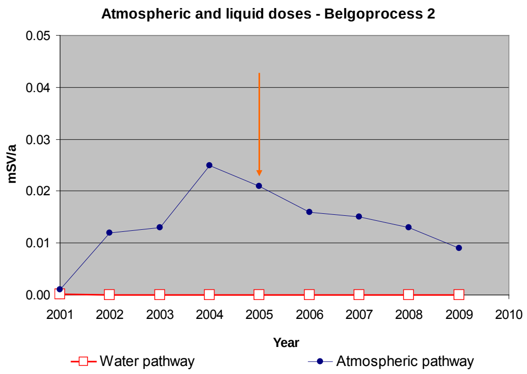

Liquid doses - DOEL
mSv/a
0,005
0,004
0,003
0,002
0,001
0,000
2001
2003
2005
2007
2009
Year
Water pathway
Water estimated

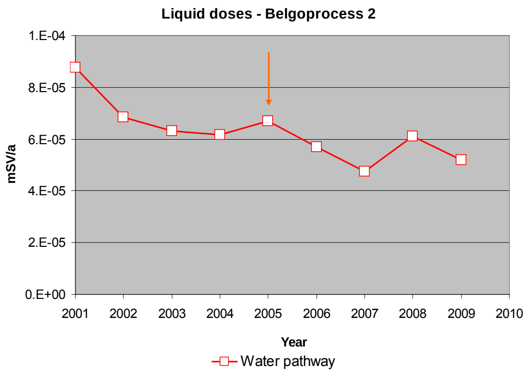

Liquid doses - TIHANGE
mSv/a
0,005
0,004
0,003
0,002
0,001
0,000
2001
2003
2005
2007
2009
Year
Water pathway

BELGOPROCESS 2









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