

KINGDOM OF BELGIUM



**SIXTH MEETING OF
THE CONTRACTING PARTIES
TO THE CONVENTION ON NUCLEAR SAFETY**

NATIONAL REPORT

August 2013

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This report is produced by the Federal Agency for Nuclear Control on behalf of Belgium. Contributions to the report were also made by "Bel V", "Electrabel", "Tractebel Engineering" and "SCK•CEN".

Table of Contents

I.	Introduction	1
I.A.	Content of the Present Report.....	1
I.B.	History of Nuclear Energy Development in Belgium	2
I.C.	Developments since the last report (2010).....	5
I.C.1.	Follow-up – Barsebäck	5
I.C.2.	Development of the PSA.....	5
I.C.3.	Use of INES	5
I.C.4.	New safety diesel generators for units Doel 1 & 2	6
I.C.5.	Beyond design basis flood diesels at Tihange.....	6
I.C.6.	Repair of concrete structure of secondary containment of reactor building Tihange 2..	6
I.C.7.	Flaw indications in reactor pressure vessel of Doel 3 and Tihange 2	7
I.C.8.	The Government decision on the confirmation of shutdown of Doel 1 & 2 and on lifetime extension of the Tihange 1 nuclear power plant	9
I.C.9.	Long Term Operation of Tihange 1.....	9
I.C.10.	Application of a new methodology for the Periodic Safety Reviews.....	10
I.C.11.	OSART follow-up mission at Doel	10
I.C.12.	IRRS mission planned in Belgium and self-assessment action plan	11
I.C.13.	Status of WENRA Action Plan.....	11
I.C.14.	Incorporation of the WENRA Reactor Harmonization Working Group (RHWG) Reference Levels into the Belgian legal framework	11
I.C.15.	Long Term Operation approach for the research reactors	11
I.C.16.	MYRRHA research reactor pre-licensing activities	12
I.D.	Summary of the follow-up of the 2012 extraordinary meeting of the Convention on Nuclear Safety. 13	
I.D.1.	Topic 1: External Events.....	13
I.D.2.	Topic 2: Design Issues	15
I.D.3.	Topic 3: Severe accident management and recovery (on-site)	15
I.D.4.	Topic 4: National organisations	15
I.D.5.	Topic 5: Emergency preparedness and response (off-site).....	17
I.D.6.	Topic 6: International cooperation	18
II.	General Provisions	21
II.A.	Article 4. Implementing Measures	21
II.B.	Article 6. Existing Nuclear Installations.....	22
II.B.1.	Nuclear Power Plants (NPPs)	22
II.B.2.	Research Reactors	23
II.C.	Article 7. Legislative and Regulatory Framework.....	26
II.C.1.	Introduction.....	26
II.C.2.	The Law of 15 April 1994.....	26
II.C.3.	The Royal Decree of 20 July 2001	28
II.C.4.	The Royal Decree of 30 November 2011.....	29
II.C.5.	The Royal Decree of 17 October 2003 on Emergency Planning	32
II.C.6.	The Law of 31 January 2003 on the Phase-out of Nuclear Energy	33
II.C.7.	The Licensing regime for nuclear installations	34
II.C.8.	Conclusions regarding the Provisions of Article 7	35
II.D.	Article 8. Regulatory Body.....	37
II.D.1.	Mandate and Function of the Regulatory Body	37
II.D.2.	Powers and Attributions of the Regulatory Body.....	39
II.D.3.	Structure of the Regulatory Body, Financial and Human Resources	39
II.D.4.	Position of the Regulatory Body in the Governmental Structure.....	43

II.D.5.	Relations between the Regulatory Body and the Organisations in Charge of Nuclear Energy Promotion and Use.....	43
II.D.6.	Relations between FANC and Bel V	43
II.D.7.	International relations	45
II.D.8.	Conclusion.....	45
II.E.	Article 9. Responsibility of the Licence Holder.....	46
II.F.	Article 10. Priority to Safety	47
II.F.1.	NPPs Licensee Safety Policy and Safety Culture.....	47
II.F.2.	Research Reactors	52
II.F.3.	Regulatory Body	53
II.G.	Article 11. Financial and Human Resources	55
II.G.1.	NPPs	55
II.G.2.	Research Reactors	59
II.G.3.	The Belgian education programme in nuclear engineering	59
II.H.	Article 12. Human Factors.....	61
II.H.1.	NPPs Licensee (Electrabel) Human Performance Programme	61
II.H.2.	Research Reactors	63
II.H.3.	Safety Culture Observations by the Regulatory Body	64
II.I.	Article 13. Quality Assurance.....	65
II.I.1.	NPPs	65
II.I.2.	Research Reactors	68
II.I.3.	Activities of the Regulatory Body.....	68
II.J.	Article 14. Assessment and Verification of Safety.....	69
II.J.1.	NPPs	69
II.J.2.	Research Reactors	72
II.K.	Article 15. Radiation Protection	74
II.K.1.	Regulations	74
II.K.2.	Design.....	74
II.K.3.	NPP Operation	74
II.K.4.	Research reactors	78
II.K.5.	International Exchanges	80
II.L.	Article 16. Emergency Preparedness.....	81
II.L.1.	Regulatory Framework	81
II.L.2.	Implementation of Emergency Organisation in the Event of an Emergency.....	81
II.L.3.	SCK•CEN (research reactors).....	89
II.M.	Article 17. Siting.....	90
II.M.1.	NPPs	90
II.M.2.	SCK•CEN (research reactors).....	92
II.N.	Article 18. Design and Construction	94
II.N.1.	NPPs	94
II.N.2.	Research Reactors	97
II.O.	Article 19. Operation.....	98
II.O.1.	NPPs	98
II.O.2.	Research Reactors	102
II.O.3.	Generation of Radioactive Waste.....	103
II.O.4.	Temporary Storage of Used Fuel.....	103
III.	Appendix 1 - Description of the Nuclear Installations: Power Plants	105
IV.	Appendix 2 : Description of the BR1 and BR2 Research Reactors.....	107
V.	Appendix 3 : List of Acronyms	109
VI.	Appendix 4 : List of the Web Sites of the Different Nuclear Actors in Belgium.....	111
VI.A.	Regulatory Body.....	111

VI.B. Licences, Architect-engineers, Research Centres	111
VI.C. Associations	111
VI.D. Others	111
VII. Appendix 5 : Subjects examined during the Periodic (ten yearly) Safety Review	113
VII.A. Subjects examined during the First Safety Reviews of the Doel 1 & 2 and Tihange 1 Units 113	
VII.B. Subjects examined during the First Safety Reviews of the Doel 3, 4 and Tihange 2, 3 Units, and Second Safety Review of Tihange 1	114
VII.C. Subjects examined during the Second Ten-yearly Safety Reviews of Doel 1 and 2	116
VII.D. Subjects examined during the Second Safety Reviews of Doel 3 and Tihange 2, subjects to be examined during the Second Safety Reviews of Doel 4 and Tihange 3, and subjects to be examined during the Third Safety Reviews of Doel 1 & 2, and Tihange 1	117
VIII. Appendix 6 – Belgian Action Plan as a result of the European Stress test process	119

I. Introduction

I.A. Content of the Present Report

This Belgian national report, submitted to the sixth review meeting of the contracting parties to the Convention on Nuclear Safety, is based on its previous editions and has a similar structure. For each article of the Convention, relevant descriptions and explanations are provided on how the principles of the Convention are translated into the Belgian legal framework and how they are applied to its nuclear installations. In addition, in order to highlight relevant evolution since the last review meeting, section I.C focuses on new developments since 2011, including developments related to the follow-up of the fifth review meeting.

Section I.D gives an overview of specific actions in the frame of the Fukushima Daiichi accident, according to the 6 topics structure of the extraordinary meeting of the contracting parties to the Convention on Nuclear Safety which took place in August 2012.

The report addresses the issues raised during the Belgian presentation at the last review meeting.

When drafting this report, due account was taken of the appropriate guidelines in INFCIRC/572/Rev.3 (28 September 2009).

On a voluntary basis, information about the Belgian research reactors is included in the present National Report. The post-Fukushima actions for the research reactors are also described.

In order to keep the report to a reasonable size, rather than identifying for each Article the particularities and characteristics of the Belgian power plants, it was found preferable to give in in Appendix 1 a detailed description of the power reactors, highlighting their original design and the major modifications brought to them during the periodic safety reviews which are mandatory under the Belgian regulations. Appendix 2 contains similar information about the BR1 and BR2 research reactors.

The principal nuclear Belgian actors have participated in its drafting:

- FANC, the Federal Agency for Nuclear Control, the safety authority,
- Bel V, the technical subsidiary of the FANC,
- Electrabel as the operator of the seven nuclear power plants,
- Tractebel Engineering, the engineering support organisation to the NPP's operator,
- SCK•CEN as the operator of the research reactors in Belgium.

Together, the above-mentioned organizations encompass the legal and practical competencies necessary to collect and to structure the information required to elaborate the national report.

The report is available on different Belgian web sites such as www.fanc.fgov.be, www.belv.be.

A list of the acronyms used in the present Report is given in Appendix 3.

Appendix 4 gives the web site addresses of Belgian organisations playing an important role in the nuclear field.

Appendix 5 lists the subjects which have been examined during the 10-yearly safety reviews of the Doel and Tihange units, and indicates topics to be examined during the next 10-yearly safety reviews.

A new appendix 6 gives an overview of the action plan as a result of the European stress test process.

I.B. History of Nuclear Energy Development in Belgium

Before the Second World War, Belgium was the world's largest radium producer, which gave rise not only to the related metallurgy, but also, in collaboration with the academic circles, to the development of metrology techniques. In the universities a number of teams worked on the latest discoveries in the field of particle physics and maintained close contact with their counterparts abroad.

By 1945, a Scientific Commission in Belgium examined the possibilities of civil applications of nuclear energy, and the "Institut Interuniversitaire de Physique Nucléaire" was created in 1947 in order to support the existing university laboratories and co-ordinate their activities. In parallel with nuclear physics research, this Institute also supported some related activities such as production of graphite and high-purity metallic uranium.

From 1950 onwards, Belgian engineers were trained in the UK and in the USA.

The Atomic Energy Commission was formed in 1950.

In 1952, a number of personalities of Belgium's scientific and industrial circles set up a private non-profit organisation -the "Centre d'Etude des Applications de l'Energie Nucléaire"-, which was to give birth to the "Centre d'Etude de l'Energie Nucléaire" (SCK•CEN) at Mol (i.e. the Nuclear Research Centre), and which became a public interest organisation in 1957.

Research reactors were built in Mol and became operational between 1956 and 1963. These are the BR1, a uranium/graphite reactor similar to the British experimental pile (BEPO), the materials test reactor BR2 (fuel assemblies with highly enriched uranium placed in a beryllium matrix shaped as an hyperbolic paraboloid, which ensures at the same time a high neutron flux and an easier access to the experiments from the top and the bottom of the reactor) and the 11.5 MWe BR3 which was the first Westinghouse-type pressurised water reactor built in Europe. This reactor, which went critical in 1963, served to develop the technology (e.g. reactivity control by boron dissolved in the water of the primary circuit, introduction of MOX and gadolinium fuel rods as early as 1963) and to train the first operators of the Belgian nuclear power reactors. This plant is now nearly totally dismantled.

From 1950, the private industry has also invested in nuclear technology and participated in the construction of reactors. The "Ateliers de Constructions Electriques de Charleroi" acquired the Westinghouse licence; "Métallurgie et Mécanique Nucléaires" manufactures enriched uranium fuel assemblies, and was later on a part of the "Franco-Belge de Fabrication de Combustibles" (FBFC).

As regards the fuel cycle, the Mol Centre investigated several reprocessing techniques and, as a result of which the Eurochemic Consortium, formed under the aegis of the OECD, built its pilot reprocessing plant (adopting the PUREX process) in the Mol-Dessel region. This plant ceased its operations in 1975 and is now mostly dismantled. Dismantling operations should be completed by 2013.

A consortium of industries was formed in 1954 to develop the nuclear technology; later giving birth to Belgonucleaire which developed the plutonium fuel technology.

Belgonucleaire manufactured the first commercial MOX fuel (Mixed Oxides fuel) batch for the French PWR power station Chooz A in 1986.

After having produced MOX fuel during 20 years, for both PWR and BWR reactors, Belgonucleaire definitively stopped its activities in mid-2006 Belgonucleaire produced more than 660 tons of MOX fuel for commercial nuclear power reactors. The dismantling of the MOX fuel fabrication plant at Dessel has started in 2009 and is currently on-going.

The Belgian power utilities and their architect/engineers closely followed-up the evolution in nuclear technology and, confident with their BR3 experience, they decided to take a 50 % stake in the construction of EdF's "Centrale des Ardennes" at Chooz, connected to the grid in 1967. Seven Belgian units, spread over the Doel and Tihange sites, were put into service between 1974 and 1985.

In 1971, the "Institut des Radioéléments" (IRE) was built in Fleurus, manufacturing mainly radioisotopes for use in medicine.

The "Organisme National des Déchets Radioactifs et des Matières Fissiles Enrichies" – "Nationale Instelling voor Radioactief Afval en verrijkte Spleijstoffen" (ONDRAF/NIRAS) (i.e. the national organisation for radioactive waste and enriched fissile materials) was created in 1981, and waste treatment and storage activities were performed at the Mol-Dessel site through its subsidiary BELGOPROCESS .

This brief historic overview shows that, in addition to the nuclear power plants which are the subject of the present National Report, various aspects of the fuel cycle are or were present in Belgium. A full description of the nuclear sector in Belgium can be found in the book published by the Belgian Nuclear Society in 1995 "Un demi-siècle de nucléaire en Belgique" (i.e. Half a century of nuclear activities in Belgium: ISBN 90-5201-405-1) as well as in "Histoire du nucléaire en Belgique, 1990-2005" (Nuclear history in Belgium 1990-2005, ISBN 978-90-5201-377-0).

Specific information on the safe management of spent fuel and on the safe management of radioactive waste may be found in the Belgian report presented to the fifth review meeting of the Joint Convention, Vienna May 2012, available on the FANC and ONDRAF/NIRAS web sites.

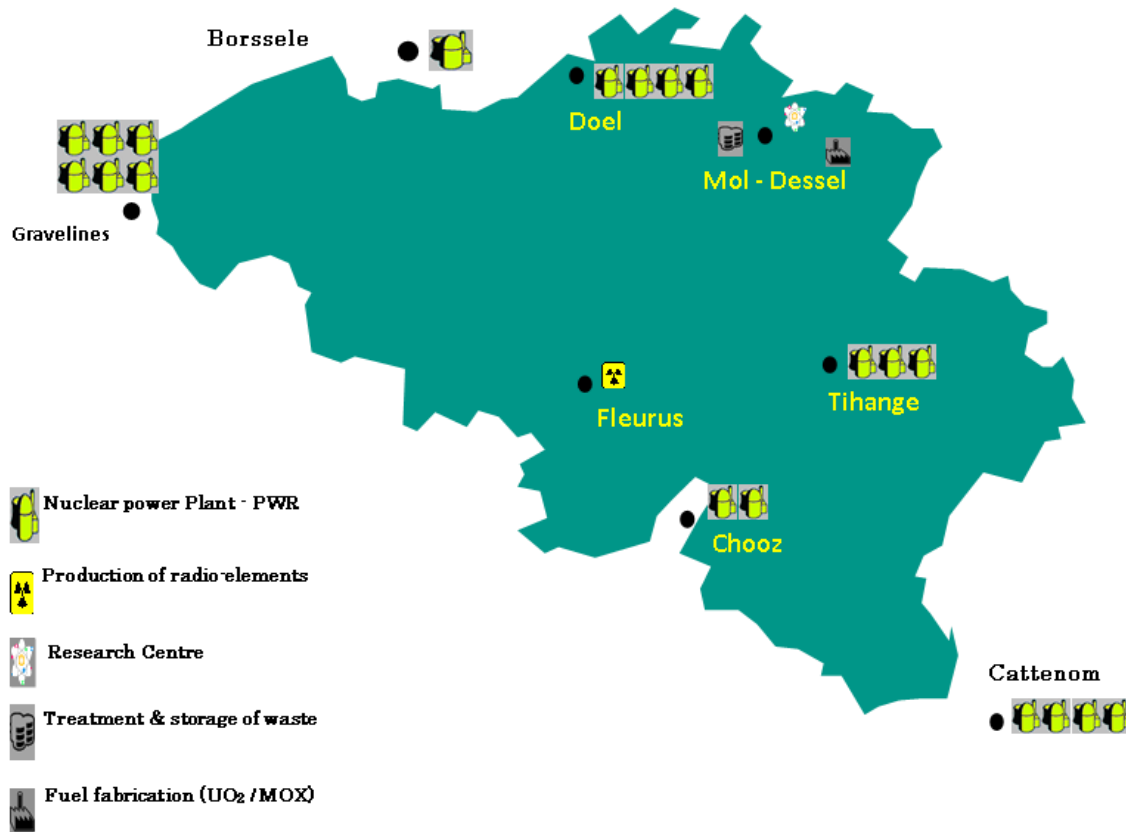


Figure 1 : Nuclear sites in and near Belgium

Units	Type	Thermal power (MWth)	Date of first criticality	Containment building characteristics	Steam generator replacement	Fuel storage pool capacity	Designer
Doel 1	PWR (2 loops)	1 312	1974	Double containment (steel and concrete)	2009	664 positions	Westinghouse
Doel 2	PWR (2 loops)	1 312	1975	Double containment (steel and concrete)	2004		Westinghouse
Doel 3	PWR (3 loops)	3 064	1982	Double containment with inner metallic liner	1993	672 positions	Framatome
Doel 4	PWR (3 loops)	3 000	1985	Double containment with inner metallic liner	1997	628 positions	Westinghouse

Table 1 : Main characteristic of the units located at the Doel Site

Units	Type	Thermal power (MWth)	Date of first criticality	Containment building characteristics	Steam generator replacement	Fuel storage pool capacity	Designer
Tihange 1	PWR (3 loops)	2 873	1975	Double containment with inner metallic liner	1995	324 positions + 49 removable positions	Framatome / Westinghouse
Tihange 2	PWR (3 loops)	3 054	1982	Double containment with inner metallic liner	2001	700 positions	Framatome
Tihange 3	PWR (3 loops)	2 988	1985	Double containment with inner metallic liner	1998	820 positions	Westinghouse

Table 2 : Main characteristic of the units located at the Tihange Site

I.C. Developments since the last report (2010)

This part intends to highlight the main evolutions that have occurred since the last report, including those realized in the frame of the follow-up of the fifth review meeting, in particular:

- Follow-up – Barsebäck OEF
- Development of the PSA
- Use of INES
- New safety diesel generators for units Doel 1 & 2
- Beyond design basis flood diesels at Tihange
- Repair of concrete structure of secondary containment of reactor building Tihange 2
- Flaw indications in reactor pressure vessel of Doel 3 and Tihange 2
- The Government decision on the confirmation of shutdown of Doel 1 & 2 and on lifetime extension of the Tihange 1 nuclear power plant
- Long Term Operation of Tihange 1
- Application of a new methodology for the Periodic Safety Reviews
- OSART Follow-up mission at Doel
- IRRS mission planned in Belgium and self-assessment action plan
- Status of WENRA Action Plan
- Incorporation of the WENRA Reactor Harmonization Working Group (RHWG) reference levels into the Belgian legal framework
- Long Term Operation approach for the research reactors
- MYRRHA research reactor pre-licensing activities

I.C.1. Follow-up – Barsebäck

As planned, new recirculation filters have been installed at the units Doel 1 & 2 and Tihange 1. Resolution strategy of the sump clogging issue with regard to the units Doel 3, Doel 4, Tihange 2 and Tihange 3 has been modified in 2012. Reasons for this change are long-standing issues regarding the downstream effects, and more specifically the in-vessel effects and the lessons learned from the new filter test campaigns for the units Doel 1 & 2 and Tihange 1. Priority has been given to ensuring in a robust and test-based manner that potential recirculation filter clogging will not impede long-term recirculation. As a result, new filters will be installed for these four units. All units will be backfitted by the end of 2014

In order to reinforce the recirculation function at Tihange 1, low pressure safety injection pumps have been replaced in April 2013.

I.C.2. Development of the PSA

A full Level 2 analysis (including analysis of the source term) is performed (being finalised for some plants; planned or on-going for the others), as well for power as for shutdown states. The evaluation of the results is in progress.

Probabilistic Safety Assessments for internal hazards (fire and flooding) are in progress (in response to the WENRA Action Plan).

In the framework of the periodical safety review, a peer review by an external consultant of the PSA approach used for the Doel and Tihange nuclear power plants was performed in 2011. Opportunities for improvements were identified in 2012. The selection of the more relevant improvements is on-going.

I.C.3. Use of INES

INES (International Nuclear and Radiological Event Scale) has been used in Belgium for about 20 years now. In the early years, the scale was only used for the NPPs, but was rapidly extended to all major nuclear facilities, including nuclear research institutes as well as fuel cycle facilities.

The use of INES is implemented via a convention between the licensees, the FANC and Bel V. This convention stipulates in which circumstances and how INES is to be used. The licensee has to perform the INES-analysis according to the latest INES manual, and this level has to be approved by Bel V and the FANC. Depending on the INES-level, a specific notice is issued. For events of level 1 or higher, the FANC publishes a short notice on its website (<http://www.fanc.fgov.be/fr/page/ines-un-outil-de-communication/221.aspx>). For events of level 2 or higher, besides the notice on the website

of the FANC, the licensee has to issue a press release about the event and the INES National Officer notifies the IAEA.

As of April – May 2010, the use of the INES-scale was extended to all activities involving the use radiation sources and the transport of radioactive materials.

In 2010, 2011 and 2012, the NPP Licensee reported respectively 17, 6 and 11 events classified at level 1. One level 2 event was reported in 2011 for the Doel 4 unit. This event was related to the unavailability of an emergency auxiliary feed water pump.

For the research reactors, respectively 1, 1 and 0 events classified at level 1 have been reported during the same period.

I.C.4. New safety diesel generators for units Doel 1 & 2

The four diesel generators of the first level of protection (essentially internal accidents) of the twin unit Doel 1 & 2 have been replaced by five new generators, in a new safety diesel generator building (DGG).

Operating margins with regard to diesel load were impacted by successive upgrade. In order to restore an acceptable margin with regard to load capacity, the decision was taken to replace the four existing generators by five new generators, the fifth one being a swing generator able to be lined in case of planned unavailability of any of the 4 other ones.

The commissioning of the building and the new safety diesel generators was completed in September 2012.



Figure 2 : Installation of the new safety diesel generators in the DGG of units Doel 1 & 2

I.C.5. Beyond design basis flood diesels at Tihange

Three beyond design basis flood diesels have been installed at the Tihange NPP. The generator for the Tihange 1 NPP is housed in a new diesel building. The diesel generator for the Tihange 2 and Tihange 3 NPPs are housed in a common new building. These new structures have been placed at a height exceeding the new design basis flood level that was defined during the latest periodic safety review (see section I.D.1 b). Each diesel has sufficient capacity to provide the electrical power that is required to maintain two NPPs in safe shutdown during a flooding event, and cross connections have been made accordingly.

I.C.6. Repair of concrete structure of secondary containment of reactor building Tihange 2

In 2007, during in-service inspection of the concrete engineered structures, Electrabel, the operator of the Tihange nuclear power plant, observed extended degradations of concrete apparent on the external surface of the secondary containment building of the Tihange 2 reactor. Typical degradation depths were 3 to 5 cm. This secondary containment is designed to protect the reactor building against external hazards, in particular aircraft crash.

In 2009, two main mechanisms of concrete degradation were identified by means of physico-chemical and mineralogical analyses performed on concrete cores. A deeper than expected and extended carbonation front was developing on the whole structure while concrete at the top of the containment

building (upper 6 m) was also affected by the alkali-silica reaction (ASR). Delayed ettringite formation (DEF) was also sometimes observed in association with ASR.

In 2010, Electrabel began to repair the concrete surface of the external containment building, but the works were more important than initially foreseen and also delayed because of poor weather conditions.

In 2012, Electrabel had repaired more than 50 % of the total containment surface. In some places (5 % of the surface), the depth of the degraded concrete scrapped for repairs reached 30 cm (of a total thickness of 120 cm). The resistance of the repairs tested on concrete cores also appeared to be lower than anticipated.

Because of the unexpected importance of the repair works and given the depth of some altered zones (especially affected by ASR at the top of the containment) and the difficulties encountered to demonstrate the good adhesion of the repairs to the base concrete, in 2012, Electrabel decided to assess the structural integrity of the containment building. This was required to exactly determine the potential impact of the degradations on the ability of the containment to withstand extreme external loads and to validate the quality of repair works.

A more robust technique (with a steel reinforcement mesh mechanically anchored into the base concrete) was also developed to continue the repair works. This was needed (1) to improve the shear strength of the reparations in case of airplane crash, and (2) to allow model simplification for the calculations of the structural integrity of the containment. The repair works are on-going and the new technique will also be applied to the first repaired zones.



Figure 3 : Zone affected by the alkali-silica reaction (ASR) awaiting repair at the top of the external containment building of Tihange-2 unit (photograph: Bel-V).

I.C.7. Flaw indications in reactor pressure vessel of Doel 3 and Tihange 2

In June 2012, during an ultrasonic in-service inspection intended to detect under-clad defects and conducted for the first time in Belgium, several thousands of flaw indications were detected in the base metal of the Doel 3 reactor pressure vessel, located mainly in the upper and lower core shells. As a precaution, similar inspections were conducted in September 2012 on the Tihange 2 unit, whose reactor pressure vessel is of identical design and construction. Flaw indications were detected as well, but to a lesser extent.

The figure below displays a typical example of data recorded in the lower core shell of Doel 3. Left: an axial section, with indications appearing as colour spots. Right: the indications, all detected in a 20° sector of the shell, are cumulated on the figure plane (333 sections).

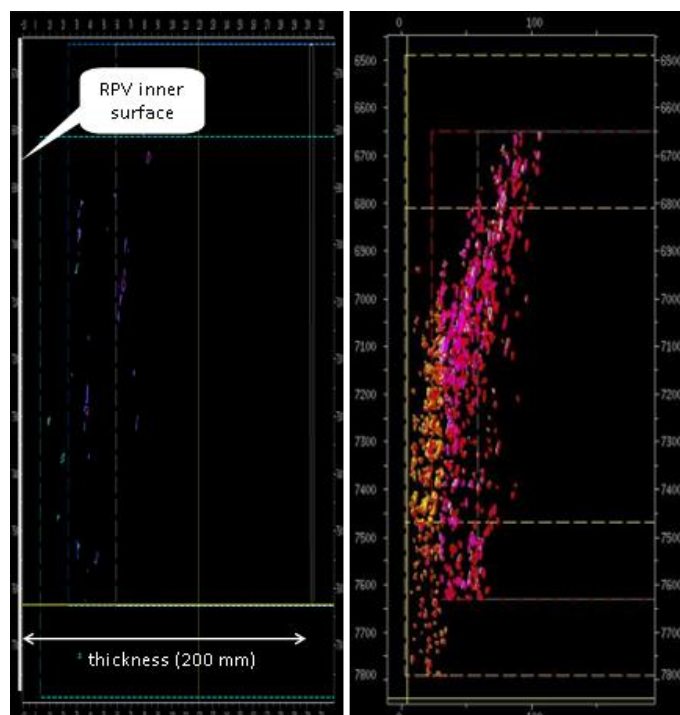


Figure 4 : data recorded in the lower core shell of the Doel 3 reactor pressure vessel

The pressure vessel is a key-component in a reactor unit, and its failure is not covered by safety studies. As a result, the licensee decided to keep both units in cold shutdown state, core unloaded, until in-depth analyses have been achieved and submitted to the Federal Agency for Nuclear Control in view of a possible restart.

With the support of internal and external experts, the licensee started an investigation of the precise nature and origin of these indications, and built its own analysis to determine whether or not the reactor units in question could safely resume operation in spite of the detected flaws. The most likely origin of the indications identified in the Doel 3 and Tihange 2 reactor pressure vessels is hydrogen flaking due to the manufacturing process. This assumption is supported by the number of flaws, their shape, orientation, and location in zones of suspected macro-segregation.

The safety demonstration of the licensee was recorded in two safety case reports (submitted to the FANC in December 2012) and backed by a number of technical documents, leading the licensee to conclude that both Doel 3 and Tihange 2 were eligible for immediate restart. In parallel, the licensee also proposed several additional measures intended to further increase the safe operation of the units, to monitor the pressure vessels state along time or to extend its initial material testing programme.

Meanwhile, the FANC set up a dedicated organisation and commissioned several national and international expert groups to seek scientific and technical advice in order to elaborate an independent, founded and balanced judgement about the issue.

Along the assessment process, the expert groups raised a number of questions that were discussed with the licensee and its technical supports. From those discussions, a number of open issues were raised about the manufacturing of the reactor pressure vessels, the suitability of the in-service inspection technique, the possible evolution of the flaws during future operation, the characterization of the material properties, and the structural integrity of the reactor pressure vessels under penalizing loadings.

Taking into account the advice of the different expert groups, the FANC issued in January 2013 its provisional evaluation report on the issue, which stated that in the current state of knowledge and given the available data, the identified open issues did not represent conditions that require a definitive shutdown of Doel 3 and Tihange 2. However, these open issues lead to some uncertainties that might reduce the conservatism of the licensee's safety demonstration and hence impair the level of confidence in the safe operability of the units in question. As a consequence, the Federal Agency for Nuclear Control considered that, in the current state, Doel 3 and Tihange 2 may only restart after

the requirements listed in its provisional evaluation report are met by the licensee. These requirements include for example further validation of the ultrasonic inspection methods, completing the proposed material testing program (including large scale specimen tests) and the performance of a load-test on both reactor pressure vessels.

In response, the licensee elaborated an action plan to meet those requirements, including a methodology and associated acceptance criteria where applicable. This action plan was implemented in the first semester of 2013.

Once the licensee implemented its action plan, the FANC, together with Bel V and AIB-Vinçotte, evaluated whether all the safety concerns at the origin of the requirements are solved and whether the related reservations can be lifted. On this basis, on May 17th, 2013, the FANC considered that Doel 3 and Tihange 2 could be restarted safely. Consequently Doel 3 and Tihange 2 resumed operation in June 2013.

All files related to the flaws indication issue, including the final evaluation report are available on the FANC web site (in English):

<http://www.fanc.fgov.be/fr/page/dossier-pressure-vessel-doel-3-tihange-2/1488.aspx?LG=1>

The FANC also asked the licensee Electrabel to speed up the planned ultrasonic inspections on the other Belgian units.

Given the recent governmental decision to extend the operation of Tihange 1 by ten years, the FANC has already asked that the same inspection be conducted on this unit early 2013. During the inspection, done in April - May 2013, no flaws were detected.

For Tihange 3 this inspection is planned by the end of 2013.

For Doel 4 and Doel 1 & 2 the specific ultrasonic investigations aimed at detecting potential flaws in the reactor vessel are planned as follows:

- For Doel 4, in 2015, as initially scheduled;
- For Doel 1 & 2, these inspections are no longer planned (initially scheduled in 2015) given the fact that both units will then be definitively shut down.

I.C.8. The Government decision on the confirmation of shutdown of Doel 1 & 2 and on lifetime extension of the Tihange 1 nuclear power plant

According to article 4 of the law of 31 January 2003 on nuclear phase out, the lifetime of the Belgian NPPs is limited to 40 years. In the short term, the NPPs concerned are Doel 1 & 2 and Tihange 1 which have been commissioned in 1975

Article 9 of this law is an exception clause. In case of force majeure, the federal government may take exceptional measures to guarantee the supply of electricity. In case of force majeure the King, after deliberation of the Council of Ministers and on advice of the Commission of Electricity and Gas Regulation (CREG), can take the necessary measures, including a modification of the nuclear phase-out, to ensure the electricity supply.

On the 4th of July 2012, the government decided to confirm the shutdown of the Doel 1 & 2 NPPs in 2015 while allowing a lifetime extension of 10 year for the Tihange 1 NPP, which should be shut down in 2025. The government also decided to propose the deletion of article 9 of the phase out law, prohibiting thereby any future exception on the phase out law decided by the federal government.

I.C.9. Long Term Operation of Tihange 1

The operating licenses of the nuclear power plants in Belgium were issued without time limitation. Every 10 years, a periodic safety review is performed by the licensee and submitted to the regulatory body.

For the three oldest units (Doel 1 & 2 and Tihange 1), the FANC and Bel V issued in 2009 a strategy note on Long Term Operation (LTO) which defined the regulatory approach for a possible operation after 40 years. As described in this note, the safety assessment of LTO is to be integrated in the fourth periodic safety review of Doel 1 & 2 and Tihange 1 and consists in an anticipated assessment of some safety factors of this periodic safety review (in particular the safety factors related to design evaluation and ageing management).

In this way it is ensured that these safety factors raise no major issues and in addition the necessary safety improvements are fully known before a decision on the possibility of a long term operation will

be made. This means that in addition to a final periodic safety review report planned for 2015, a first assessment of the safety factors dealing with aspects directly related to the LTO was submitted to Bel V and the FANC at the end of 2011.

A detailed review and assessment of these licensee LTO reports were performed by Bel V. Where needed, additional information was requested to evaluate the need and feasibility of some complementary design improvements. In June 2012, Electrabel has provided additional information and proposed further improvements. These issues were the subject of final discussions with the FANC and Bel V which resulted in a proposal for an "agreed design upgrade". Some examples of this design upgrade for the Tihange 1 unit include the installation of a filtered containment vent, the addition of a new emergency building ("SUR Etendu") and the installation of a fully representative simulator for the Tihange 1 unit.

Mid 2012, the FANC and Bel V issued their final conclusions on the LTO reports of the licensee (available on the FANC website). The licensee approach and the LTO improvement plan are considered to be adequate to ensure the safety in case of operation beyond 40 years. The proposed design upgrade measures clearly improve the safety of the Tihange 1 unit.

I.C.10. Application of a new methodology for the Periodic Safety Reviews

The current periodic safety reviews (PSR) of the Belgian NPP's (3rd review for Doel 3, Doel 4, Tihange 2 and Tihange 3, and 4th review of Doel 1 & 2 and Tihange 1) are based on the IAEA safety guide NS-G-2.10. A report describing the scope and the method for the PSR has already been submitted by the Licensee (Electrabel) to the Regulatory Body. The periodic safety review evaluates 14 safety factors, as defined in the IAEA safety guide.

The Doel 3 NPP was the first unit assessed using the new methodology. The Doel 3 PSR was completed in August 2012. The assessments of the fourteen safety factors identified both Strengths and Opportunities for Improvement (OFIs). The OFIs are weighted according to a resources/safety relevance scale (in accordance with the new international standards) to select the most relevant actions to be taken. Approximately 50 OFI's were selected for further action.

The Tihange 2 PSR will be completed in June 2013 according to the new methodology. Regarding the PSRs that began in 2012 in the other units, the FANC requested to take into account the lessons learned during the first assessments performed with the new approach (PSRs of Doel 3 and Tihange 2).

For Tihange 1, evaluations and results related to ageing and design upgrade have been submitted 3 years before the 4th PSR deadlines. The LTO is to be considered as part of the 4th PSR for this unit and consists in an anticipated evaluation of some safety factors. For Doel 1 & 2 the Belgian government has decided to end its operation after 40 years. A PSR will be executed for Doel 1 & 2 to cover the time frame from the end of its operation until start of dismantling under the new dismantling licence.

I.C.11. OSART follow-up mission at Doel

During the first three weeks of March 2010, the OSART-team (*Operational Safety Review Team*) from the International Atomic Energy Agency (IAEA) carried out an in-depth audit at units 1 and 2 of the Doel nuclear power plant. At that time, the OSART-team issued 5 recommendations and 10 suggestions to further improve the operational safety at the plant. The Doel NPP set up an action plan in order to improve some areas identified by the OSART team.

In March 2012, an IAEA team carried out a follow-up mission to the Doel NPP to examine the manner how the operator has taken into account the recommendations and suggestions made in the March 2010 OSART mission. According to the IAEA, the Doel NPP has since then performed good work to comply with the recommendations and suggestions made. Ten of the 15 recommendations or suggestions have been implemented. Those 10 items are prevention in industrial safety, on-the-job-training support reinforcement, reinforcement of control room inhabitability in case of emergency, effective use of PSA, reducing backlogs, limiting safety review duration, rapid sharing of operational experience feedback, formal agreements with public fire brigade, selection of adequate coatings and surface with regard to decontamination in restricted areas and on-shift emergency personnel. The five remaining follow-up items are in progress, but not yet completed. Those items are cable trays loading, local identification of chemicals, material condition and safety report update. No recommendations/suggestions were found to have made insufficient progress.

The IAEA has also considered as a good practice the decision of the licensee not to confine the OSART action plan to only the Doel 1 & 2 units, but to implement the improvements also on the Doel 3 and 4 units.

I.C.12. IRRS mission planned in Belgium and self-assessment action plan

According to the European Directive 2009/71/EURATOM on the Nuclear Safety and to the IAEA action plan, Belgium requested an IRRS mission in May 2012.

A self-assessment took place between June 2011 and September 2012, and led to an action plan comprising some 60 actions. The implementation of this action plan started in September 2012 and is currently on going. The IRRS mission itself will take place in December 2013. According to the European Directive, the IRRS report and the action plan will be made public. This mission will be a "full scope" IRRS, covering all regulatory activities of the FANC and Bel V.

I.C.13. Status of WENRA Action Plan

In 2006, the WENRA Reactor Harmonisation Working Group (RHWG) published an extensive study to compare the national nuclear safety requirements for the operating NPPs with several hundred reference levels, grouped in 18 issues.

In the field, many of these reference levels were already implemented by the licensee of the Doel and Tihange NPPs. For the gaps and deltas that have been identified, an action plan was drawn up by the licensee. This action plan was approved by the Regulatory Body in 2007 and a follow-up of this action plan has been performed in close collaboration between the licensee, Bel V and the FANC. The implementation of this action plan is scheduled according to a strict time schedule, in particular since the WENRA reference levels were transposed in the Belgian regulatory framework at the end of 2011.

A formal structure for the follow-up of the implementation of the licensee's action plan has been put in place. This WENRA Consultative Committee is composed of experts of the regulatory body (the FANC and Bel V) and of the licensee (GDF Suez - Electrabel) and its architect-engineer (Tractebel Engineering). This Committee meets about every three months. At each meeting the status of implementation of the action plan is reviewed and the progress and status of some specific actions are discussed in detail.

In 2013, almost all of the actions of this action plan have been completed. Most of the remaining actions are to be fully implemented only by 2016: these actions are all related to the implementation of the probabilistic safety assessment (PSA) policy.

I.C.14. Incorporation of the WENRA Reactor Harmonization Working Group (RHWG) Reference Levels into the Belgian legal framework

The "Royal Decree on the Safety Requirements for Nuclear Installations" (referenced SRNI-2011 in this report) has been signed by the King on the 30th of November 2011 and has been published in the official journal of the 21st of December, 2012. This Royal Decree incorporates all the WENRA RHWG reference levels into the Belgian regulations. This Royal decree has a wider scope than the NPPs, as some reference levels were found applicable to other nuclear facilities (for example, the obligation to proceed to periodic safety reviews, to have a Safety Analysis Report, to have an integrated Management system, ...). This Royal decree is currently being completed with specific safety requirements for waste disposal facilities, for waste storage facilities and for decommissioning of nuclear installations. More information is given in section II.C of the present report.

I.C.15. Long Term Operation approach for the research reactors

Currently the lifetime of the Belgium research reactors is not limited by regulation nor by the operating license (unlike the lifetime of the Belgium nuclear power plants, which is limited). Through their operating license, research reactors are however, subject to Period Safety Reviews (PSR) and ageing is one of the subjects that needs to be evaluated as part of the PSR. The relative importance of this subject is increasing due to the increasing age of the research reactors.

For SCK•CEN the next PSR will take place in 2016 and its preparation has recently started. One of the aspects to be evaluated is long term operation (LTO) and in 2012 the FANC issued its expectations through a strategic note partially based on a similar note issued for the nuclear power plants.

The expectations issued through the FANC strategic note notably include ageing and design. With regards to ageing it is expected that a systematic and thorough ageing management programme is implemented for all safety relevant structures, systems and components. This programme needs to be implemented on a continuous basis and will be subject to regular evaluation during the remaining operating lifetime of the research reactors. With regards to design it is expected that a gap-analysis is performed relative to the most recent regulations and standards to identify potential design improvements and enhancements. This should result in an agreed plan for design upgrade to be implemented.

I.C.16. MYRRHA research reactor pre-licensing activities

The Belgian Nuclear Research Centre in Mol has been working for several years on the design of MYRRHA, a multipurpose flexible irradiation facility intended to replace in the future the ageing BR2, a multipurpose materials testing reactor (MTR), in operation since 1962.

MYRRHA, aimed at replacing the BR2, is a flexible fast spectrum research reactor and is conceived as an accelerator driven system (ADS), able to operate in sub-critical and critical modes. It contains a proton accelerator of 600 MeV, a spallation target and a multiplying medium with MOX fuel, cooled by liquid lead-bismuth (Pb-Bi). Since February 2011, the Belgian Nuclear Research Centre has engaged in a "pre-licensing" process with the regulatory body for an estimated period up to end 2014.

Hence, the FANC and Bel V have to perform the safety assessment in view of the licensing of the MYRRHA facility developed by the SCK•CEN. Looking at the overall licensing process, two phases could be distinguished: a pre-licensing phase and a licensing phase.

A pre-licensing phase does not belong as such to the regulatory framework. Their objectives should provide a sound view of the expected safety, radiation protection and security argumentations that have to be developed by the applicant during the licensing phase. They provide also a well-defined framework for future exchanges between the future applicant and the regulatory body.

I.D. Summary of the follow-up of the 2012 extraordinary meeting of the Convention on Nuclear Safety.

From 27 to 31 August 2012, the IAEA convened an extraordinary meeting of the Convention on Nuclear Safety intended to review and discuss the lessons learned to date from the Fukushima-Daiichi accident. The debates were held within 6 working groups in charge of producing conclusions in topical reports as follows:

- topic 1: external events (earthquake, flooding, extreme weather conditions),
- topic 2: design issues,
- topic 3: severe accident management and recovery (on site),
- topic 4: national organizations,
- topic 5: emergency preparedness and response and post-accident management (off site),
- topic 6: international cooperation.

The meeting led to a number of high level safety recommendations for the licensee (topics 1 to 3), and for the relevant national authorities (topics 4 to 6).

For the topics 1 to 3, most recommendations were already covered by the planned actions that were derived from the stress tests programme and further ENSREG activities.

The majority of the key issues identified for the topics 4 to 6 are already addressed in Belgium. However, complementary actions were identified through self-assessments conducted as part of the continuous improvement process.

As member of the European Union, Belgium participated in the "**Stress Tests**" programme initiated by the European Commission after the Fukushima-Daiichi accident. The main milestones of the "Stress Tests" programme developed by ENSREG are listed below:

- Technical definition of the "stress tests" by WENRA : May 2011
- Stress test report by the Licensee: October 2011
- National stress test report : December 2011
- Peer review organized by ENSREG of the stress tests report : April 2012
- ENSREG action plan : August 2012
- Publication of the National action plans : December 2012
- European peer review organized by ENSREG of the national action plans : April 2013

The various reports that have been issued by or for Belgium are available on the following ENSREG website : <http://www.ensreg.eu/EU-Stress-Tests/Country-Specific-Reports/EU-Member-States/Belgium> (in English) and on the FANC website : <http://www.fanc.fgov.be/fr/page/stress-tests-nucleaires/1411.aspx> (in Dutch and French).

As result of the stress tests, the ENSREG action plan and the peer review and findings of the extraordinary meeting of the CNS in 2012, a Belgian national action plan was issued in December 2012. Nearly 300 individual actions have been identified, and are currently being implemented.

This Belgian National action plan is available on the ENSREG web page: <http://www.ensreg.eu/node/694> (in English). The follow-up of this action plan is closely monitored by the Regulatory Body. **Appendix 6 gives a detailed overview of this action plan, mentioning the issue, the site(s) concerned, the action type and the target implementation date.**

I.D.1. Topic 1: External Events

a) Earthquake

During the stress tests evaluations for the Belgian NPP an SMR evaluation was carried out with the support of international seismic experts to evaluate the margins regarding a beyond-design earthquake. Therefore, a Review Level Earthquake (RLE) was determined based on a short term conservative PSHA study made by the Royal Observatory of Belgium (ROB).

Considering the limited time period in which the PSHA was executed, new detailed investigations were not performed.

Therefore, it was decided to launch with ROB a new detailed study to assess the validity and adequacy of the design base earthquake at the sites of the nuclear power plants in Belgium.

This re-evaluation will take into account data of the SHARE-project (Seismic Hazard harmonization in Europe) and more recent ground motion prediction equations (GMPE's) or Cumulative absolute velocity filtering (CAV).

Furthermore, deeper and more thorough Geotechnical evaluations will be performed to rule out uncertainties discovered during the preliminary PSHA.

Based on this study an UHS (Uniform Hazard Spectra) will be determined and, considering the sites material properties, new spectra at surface level aiming to conclude regarding the validity of the design basis earthquake for Belgian NPP's.

The whole process will be done with independent reviewers and international experts to assess the final results.

b) Flooding

The consequences of a flooding are different for the two Belgian sites. They depend on the specific characteristics of the sites.

The Doel power plant is built alongside the estuary of the river Scheldt subjected to tidal motion.

As part of the Stress Tests, the revaluation done concluded that the existing dike was sufficient to prevent flooding of the site even in beyond design conditions. Additional measures were proposed such as the strengthening of the dike with concrete slabs and the implementation of a maintenance programme in cooperation with the local government to ensure the long term resistance of the dike.

As a defence in depth measure in case of dike breach, combined with the highest water level in case of a severe storm, mobile dams are available on site and can be installed if needed.

Extreme weather conditions are another cause for flooding. A re-evaluation of the sewage system has been executed, considering beyond design rain showers, followed by a safety analysis of the impact of local and temporary flooding on site following the showers.

The Tihange power plant is located on the bank of the river Meuse. As part of the Ten-Yearly Safety Review before the stress test study, a study to re-evaluate the design basis flood has been launched in combination with an action plan to improve the flooding protection of the site. In the stress test framework, the beyond design flooding has been evaluated regarding the potential consequences for the site. Based on these analyses two main actions to further improve the robustness of the site against the risk of flooding have been identified:

The construction of a peripheral wall to protect the site against a 10000-year flood. The construction of the wall is on-going and is expected to be completed by the end of 2014.

The installation of a beyond design protection system, containing additional diesels, pumps, procedures and a reinforced emergency organisation to be able to get and maintain the plants in a stable and controlled condition in case of a long term (1 week) beyond-design flooding of the site.

As for the Doel Power Plant, a revaluation of the sewage system has been carried out to assure the capability of the system to handle beyond design rain showers.

c) Extreme weather conditions

In addition to heavy rains, beyond design wind velocities are being considered for the oldest units (the newer units Doel 3 and 4 and Tihange 2 and 3 being designed to a wind velocity of 107.3m/s).

This evaluation is currently on-going, based on an evaluation of the impact of beyond design wind conditions on the plant safety functions.

An action plan will be set up if modifications are necessary.

Furthermore, an update and reinforcement of the lightning protection is carried out to comply with the European Standards.

Finally, an evaluation of the resistance of beyond design snow loads on the roofs of safety buildings was performed. Procedures have been put into place to evacuate snow if margins are deemed insufficient.

The Belgian Nuclear Power Plants licensee actively participates in the ENISS working groups on the subjects mentioned under this topic.

I.D.2. **Topic 2: Design Issues**

Although several improvements to increase the global robustness of the units have been proposed as conclusions of the stress tests, the evaluations carried out did not reveal any deviation regarding the design of the installations.

I.D.3. **Topic 3: Severe accident management and recovery (on-site)**

In the framework of the Belgian Stress Tests, several actions have been executed or are still on-going to take into consideration the return of experience of the Fukushima Daiichi accident:

- Regarding procedures:
 - A modification of the Severe Accident Management Guidelines, following the input of the PWROG.
- regarding organisation and means of communication:
 - The reinforcement of on-site radiation monitoring and radioprotection means.
 - The installation of back-up communication network through satellites to reinforce communication means on site and with corporate headquarters.
 - The erection of a Nuclear Logistical Support Cell on a corporate level with dedicated communication means to enhance communication and collaboration in case of an event.
 - The development of new radiation and contamination dispersion models in case of multi-unit events.
 - The improvement of the Emergency Preparedness Plans e.g. to include extra personnel, an alert phase in case of imminent flooding risk, etc.
- Regarding hardware:
 - The installation of a new On Site Operational Centre at Tihange to improve the coordination in case of a multi-unit event on site (the current centre not being able to remain functional after a beyond design base earthquake).
 - The installation of a Containment Filtered Venting System on all units that will remain in operation beyond 2015 in order to prevent containment failure following a slow pressurization in case of a severe accident.
 - A prefeasibility study considering means to control the pH in post-accident conditions.
 - A feasibility study for the reinforcement of containment spray and sump flooding (Tihange only) in severe accident conditions.

I.D.4. **Topic 4: National organisations**

a) *Revision of regulations*

All the reference levels of the WENRA reactor harmonization group (RHWG), based mainly on IAEA requirements have been incorporated in the Belgian regulations: The Royal decree of 30 November 2011 (SRNI-2011) is dedicated to the safety requirements applicable to the nuclear installations and in particular to the NPPs. Relevant sections of this regulation deal in particular with requirements related to the design of existing reactors, the emergency procedures and severe accident management guidelines. Furthermore, the FANC has, on the basis of the relevant WENRA reference levels, drafted proposals of specific requirements for decommissioning and for storage of waste and spent fuel, to be incorporated in the royal decree of 30 November 2011. These drafts are currently submitted to the stakeholders for comment.

A proposal of Law on "interventions and remediation" has been drafted and submitted to the FANC's supervising Minister. This law deals primarily with the remediation of contaminated sites from past activities but covers also remediation of contaminated sites following a nuclear accident.

b) *IRRS mission in Belgium*

In 2012, the FANC requested an IRRS mission to identify possible improvement opportunities in the organization and activities of the regulatory body. The IRRS mission is expected to be a full scope mission covering all activities of the FANC and Bel V. In particular, the new "Fukushima" module has been explicitly requested, in order to benchmark the FANC regulatory framework with the latest Fukushima insights in view of the identification of possible improvement.

On the other hand, Belgian experts volunteer to participate in foreign OSART or IRRS missions, namely in the frame of the European Expert Pool set up by ENSREG and made available for

performing the peer review missions requested by the European Directive 2009/71/Euratom on Nuclear Safety.

c) Research and development

(1) Earthquake Issue

In close collaboration with Bel V and with the Royal Observatory of Belgium, the FANC drafted in 2012 specific guidance on the assessment of the seismic hazard, using deterministic and probabilistic methods and input data that are available. The international practices are also considered in the process. This guidance is intended to be applied for the seismic design of the new nuclear facilities in Belgium.

(2) Core melt issues

Following the Fukushima Daiichi accident, Bel V has been involved in several R&D programmes related to severe accident (core modelling and melting scenario calculations), and fission products and hydrogen behaviour and management.

An overview of some relevant Bel V activities included in their 2013 R&D programme is given below:

- **Severe Accidents Progression** : Bel V intends to develop expertise in the area of severe accident analysis:
 - Obtain the MELCOR code from USNRC and install it on appropriate hardware at Bel V to make it available for simulations. Develop MELCOR input decks for the Belgian plants.
 - In support of Bel V's activities related to the filtered containment venting system analysis, in the framework of the "Belgian Stress Tests" (BEST) action plan, continued participation to meetings of the OECD WGAMA (Working Group on Analysis and Management of Accidents) Task Group on Filtered Containment Venting .
 - In support of Bel V's activities related to the spent fuel pool behaviour, Bel V will participate to the preparation of the status report on "Spent Fuel Pool (SFP) under loss of cooling accident conditions" in the framework of the OECD/WGAMA and OECD/WGFS activities.
- **Fission Products and Aerosols Behaviour**: Bel V intends to investigate the behaviour of fission products (in particular iodine) and aerosols in the containment after core melt accidents in the frame of participation in the OECD BIP-2 project.
- **Residual power computations**: Up to now, the residual power of a reactor core was computed using 1D or 2D models, but recent progress in computer performances allow at present more complex 3D calculations. The objective of this R&D project is to perform 3D calculations of the residual power for a typical Belgian reactor core, in collaboration with IRSN. The objective is also to obtain the burnup code VESTA, and to provide a benchmark for verification and validation of this code.
- **Seismic Hazard Assessment**: Earthquakes are important threats to nuclear installations and should therefore be thoroughly considered during the lifetime of such installations. In this frame, our knowledge has to be updated with new data and take into account new technical developments. A new reassessment will be conducted in cooperation with the FANC, based on data provided by the Royal Observatory of Belgium (ROB). Updated seismic hazard of the four Belgian nuclear sites (Tihange, Doel, Fleurus and Mol/Dessel) is expected. Reassessment with a deterministic approach will be conducted by Bel V. Probabilistic approach will be conducted by the ROB, as was done for the Stress Tests.
- **Emergency Preparedness**: The main objectives are to strengthen its expertise and competence in emergency preparedness, through participation in existing organisations and programmes, and R&D collaboration with experienced partners. Since 2012, Bel V is sponsoring an R&D project in the University of Brussels, related to the "Cognitive radio for nuclear power plants". Follow-up of this R&D programme will be ensured, with regular progress reports. In 2012, Bel V has acquired JRODOS, an atmospheric dispersion code developed by ITU, Karlsruhe (Germany). In 2013, it is expected to finalize the testing of the JRODOS-software in order to confirm the first results and impressions concerning the possible use by CELEVAL or the FANC/Bel V Internal Crisis Centre.

d) Extensive valorisation of experience feedback

As a result of the Self-assessment conducted in view of the IRRS mission in Belgium, the regulatory body is developing an internal process intended to better benefit from, and contribute to, the national and international experience feedback.

This joint process involving the FANC and Bel V will improve the procedures currently in force and will help the regulatory body to seek, capture and feed back into the regulatory process the relevant data regarding operating experience, research and development findings, evolution of standards and regulations, and other safety related matter.

Wherever relevant, the nuclear operators settled in Belgium will be informed of the learnings resulting from the process, in addition to their own in-house experience feedback system.

e) Transparency

Transparency is a key value of the regulatory body. As such, the different stress test reports and the post stress test national action plan are released in full to the public and media through the FANC website (<http://www.fanc.fgov.be>).

The FANC publishes on its website information on safety issues on NPPs and also results of the OSART missions and outcomes of Periodic Safety Reviews.

In addition, a full information file on the stress tests program is available on the FANC website to remind the context and perspectives on a higher level.

Flash messages are also published on the website's homepage if important information needs to be released to the public and media. The public is encouraged to interact with the FANC about the stress tests national action plan, and more generally for all nuclear safety related matters. A single point of contact is available at the FANC to collect and evaluate all demands and provide answers to all relevant requests. Questions can be asked via postal mail, e-mail, telephone, fax, or through the FANC website (<http://www.fanc.fgov.be/fr/page/point-de-contact/1056.aspx>) by filling an electronic query form. All relevant questions get an answer within 14 calendar days.

f) Operator liability

The law of 13 November 2011 modified the law of 22 July 1985, which made the conventions of Paris and Brussels and their additional protocols applicable, and in particular the protocols of February 2004, by increasing the maximum amount of the operator's liability for the damage to some Euro 1.2 billion per site and per nuclear accident. This modification entered into force on the 1st of January, 2012.

I.D.5. Topic 5: Emergency preparedness and response (off-site)

a) Participation in European initiatives

Following the European stress tests programme, ENSREG identified that emergency preparedness should be improved at the European level, and included this subject in its activities. The European Commission ordered specific studies on this issue that will be useful for further orientation. The FANC will actively participate in these activities.

b) Reinforcement of the regulatory body's preparedness

The self-assessment conducted by the regulatory body as part of the preparation of the IRRS mission resulted in the following improvement actions:

- establishment of individual profiles for critical functions within the FANC and Bel V in an emergency situation,
- review of training and refresher training programmes for the staff involved,
- introduction of procedures for recording and monitoring of the training and the participation to emergency drills, in order to maintain knowledge and skills of the FANC / Bel V staff,
- optimization of the collaboration between the FANC, Bel V and the national coordination and crisis centre.

c) Enhancement of the national crisis organization and structure

Several actions involving the national coordination and crisis centre (CGCCR) were decided to further improve the emergency preparedness with respect to Fukushima-like accidents:

- review and update (where needed) of the procedures and instructions related to CELEVAL (evaluation cell of the CGCCR), to CELMES (measurement cell of the CGCCR), and to the FANC/ Bel V internal crisis centre,
- installation of a videoconferencing system at the FANC / Bel V internal crisis centre that will be compatible with those installed in the CGCCR and on nuclear sites (not yet operational),
- introduction of arrangements and mechanisms to provide officials and local authorities with advice and information on radiation protection,
- introduction of an information brochure for the intervention staff explaining the concepts and provisions related to a radiological emergency, radiation exposure and dose levels.
- Development of operational approach for the slicing of the planning zones in predefined blocks to reach a common understanding at all levels (evaluation, decision, implementation and communication).
- Development of a web-based application to facilitate and speed up the exchange of information and advises on protective actions for the population and emergency workers between the evaluation cell and the management cell. This web-based application includes the above mentioned operational slicing of the planning zones.

d) Upgrade of the TELERAD national network

The early warning and radiation monitoring network (TELERAD) benefited from a large-scale modernization programme in 2010-2012. No specific new action is currently envisaged with respect to this monitoring network as a result of the Fukushima Daiichi accident.

Finally, the Nuclear Emergency Preparedness and Response plan will be updated, based on the experience feedback of previous emergency exercises. It will also take into account the future developments from the WENRA and HERCA dedicated working groups set up after the Fukushima Daiichi accident. The review and development of the new national plan has started in May 2013 and is expected to be pursued up to 2014

I.D.6. Topic 6: International cooperation

Belgium signed the main international conventions dealing with nuclear safety and is actively represented in numerous organizations and cooperation programmes, most of them implying activities related to the Fukushima Daiichi accident.

a) Cooperation at international organisations level

Belgium is a contracting party to the following international conventions:

- the Convention on Nuclear Safety,
- the Joint convention on the safety of spent fuel management and on the safety of radioactive waste management,
- the Convention on assistance in the case of a nuclear accident or radiological emergency,
- the Paris convention on nuclear third party liability and the Brussels supplementary convention, and subsequent amendments,
- the Convention on early notification of a nuclear accident,
- the European ECURIE system,
- the Convention on physical protection of nuclear material.

The FANC and Bel V are also actively involved in other international activities:

At the **IAEA** level, the FANC has a representative in the Commission on Safety Standards (CSS) and, with Bel V, participate in the Nuclear Safety Standards Committee (NUSSC), the Waste Safety Standards Committee (WASSC), the Transport Safety Standards Committee (TRANSSC) the Radiation protection Safety Standards Committee (RASSC) and the INES advisory committee.

In this regard, it can be considered that the FANC and Bel V actively participate in the development and the promotion of the IAEA Safety Standards and will continue these activities in the future.

At the **OECD** level, the FANC also participates in the steering committee of the OECD NEA and in the activities of the following NEA committees: the radioactive waste management committee (RWMC), the Committee on Radiation Protection and Public Health (CRPPH), the Committee on Nuclear Regulatory Activities (CNRA) and the Committee on the Safety of Nuclear Installations (CSNI).

Bel V participates also in the activities of the following NEA committees and working groups:

CNRA, CSNI, the Nuclear Science Committee (NSC), the Working group on inspection practices (WGIP), the Working group on operating experience (WGOE), the Working group on fuel cycle safety (WGFCs), the Working group on risk assessment (WGRISK), the Working group on analysis and management of accidents (WGAMA), the Working group on human and organisational factors (WGHOE), the Working group on integrity of components and structures (WGIAGE), the Working group on fuel safety margins (WGFSM) and in various NEA projects.

Bel V is the national coordinator for the incident reporting system (IRS) of the NEA, the incident reporting system for research reactors (IRSRR) of the IAEA, and the fuel incident notification and analysis system (FINAS) of the IAEA.

The FANC has a national coordinator for the International nuclear and radiological event scale (INES), allowing the exchange of information on significant nuclear safety and radiation protection events occurring in all types of industrial facilities.

The FANC and Bel V will continue these activities and participations in the future.

b) Cooperation at European level

At the European level, the FANC is an active member of the ENSREG (European Nuclear Safety Regulators group). Belgian representatives are members of the different working groups set up by ENSREG. The working group on external cooperation is currently chaired by a FANC representative.

The FANC and Bel V are also members of the **WENRA**, the Western European Nuclear Regulators' Association, and participate in the various WENRA activities and working groups. The Fukushima Daiichi accident impacted significantly the work of WENRA under the impulse of ENSREG, namely for developing and harmonizing new approaches for safety requirements and emergencies management.

The FANC and Bel V have representatives and actively participate in the following sub-workings groups (non-exhaustive list) of the RHWG (WENRA Reactor Harmonization Working Group) dealing with different technical issues:

- External Events
- Accident Management
- Containment integrity
- Emergencies, in collaboration with HERCA

In addition, FANC is an active member of **HERCA** (Heads of Radiation Protection Authorities) which brings together 49 radiation protection Authorities from 31 European countries. In June 2011, HERCA decided to set up of a new Working Group Emergencies (WGE)". This working group is in charge of two issues:

- developing an action plan concerning accidents happening at more remote sites, the objectives of which are : to consider the experience already gained from the Fukushima Daiichi accident, to identify the most urgent needs for further harmonisation of the reactions in European countries to any such remote event and to propose practical solutions to achieve it.
- developing an action plan with regard to accidents originating within the boundaries of the HERCA member countries, the objectives of which are to come up with practical and operational recommendations enabling a uniform way of protecting people in the directly affected area during any serious radiological emergency situation, regardless of national borders.

Furthermore, as a recent initiative, the regulatory body (the FANC and Bel V) participates in the European clearinghouse on nuclear power plants experience feedback, set up to share and analyse international experience feedback at European level.

Finally, Bel V is also an active member of ETSO (the European Technical Safety Organisations Network) and of EUROSAFE and has a cooperation agreement with IRSN.

c) Cooperation at bilateral level

At the bilateral level, several bilateral agreements are in force and the FANC has extended collaboration with foreign regulatory bodies, in particular with his neighbouring countries (France, the Netherlands and Luxembourg). Among others, this cooperation includes sharing of information, technical meetings, attendance at inspections on the field, and exchange of experts

With respect to emergency planning and response, the Belgian provincial authorities are also regularly involved in foreign emergency exercises for the nuclear power plants that are close to the Belgian

border. Exchanges of observers with the French Safety Authority (ASN) for emergency planning exercises are organized on a systematic basis, as well as participation of inspectors to cross-inspections.

II. General Provisions

II.A. Article 4. Implementing Measures

Each Contracting Party shall take, within the framework of its national law, the legislative, regulatory and administrative measures and other steps necessary for implementing its obligations under this Convention.
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After being adopted by the Belgian Parliament, the law endorsing the Convention on Nuclear Safety of Vienna of 20 September 1994 was signed by the King on 26 November 1996 and published in the "Moniteur belge" (i.e. Belgium's Official Journal) of 22 August 1997. As a result, the Convention is incorporated in the Belgian national legislation.

After the ratification, the national legislator decided that the existing legislative and regulatory framework was sufficient to implement the Convention, without adaptations or completions deemed necessary. This does not alter the fact that the efficiency and effectiveness of the regulations are permanently evaluated by the public bodies involved and that they will be improved if necessary, in order to take into account the scientific, technological and social evolutions or to be in compliance with obligations resulting from other international conventions. Since the ratification of the Convention, the nuclear laws and regulations have undergone important modifications, among other things, as a consequence of the operational start-up of the Federal Agency for Nuclear Control (see art. 7 and 8), the adoption of the Law of 31 January 2003 concerning the phasing-out of nuclear energy and the promulgation of the royal decree with safety requirements for nuclear installations.

II.B. Article 6. Existing Nuclear Installations

Each Contracting Party shall take the appropriate steps to ensure that the safety of nuclear installations existing at the time the Convention enters into force for that Contracting Party is reviewed as soon as possible. When necessary in the context of the Convention, the Contracting Party shall ensure that all reasonably practicable improvements are made as a matter of urgency to upgrade the safety of the nuclear installation. If such upgrading cannot be achieved, plans should be implemented to shut down the nuclear installation as soon as practically possible. The timing of the shutdown may take into account the whole energy context and possible alternatives as well as the social, environmental and economic impact.

II.B.1. Nuclear Power Plants (NPPs)

Belgium's seven nuclear power units in operation are equipped with pressurised water reactors built either by Westinghouse or by Framatome, each time in partnership with Belgian manufacturers for the major equipment of the primary and secondary systems. These units were put into service between 1974 and 1985. More details on the seven nuclear power plants can be found in Table 1 in Section I.B and in appendix 1 of this report.

The process applied for the licensing of these installations was described in previous reports for the Convention. Since the process would no longer be the same today and since many organisations and committees that played a role in this process have been replaced by other organisations and committees, it was deemed no longer appropriate to describe this historic information in this report. However, if needed, the reader can find the information in the 2007 Belgian report for the Convention (in particular in paragraphs II.B, II.D en II.J.1), available on the FANC web site.

After the licensing of the plants, the safety of the installations was continuously reviewed through different processes.

The most important and systematic process is the series of periodic safety reviews (PSR) that have been performed for all seven nuclear power plants. The PSRs are imposed through the operating license of the facilities and now by the Royal Decree of 30 November 2011 (SRNI-2011). The current status of the PSRs is described in section I.C.9 of the present report.

In addition, many other projects with important modifications have been executed, amongst others steam generator replacements at all units, in some cases accompanied by power increase. A table with a more complete overview of important projects (besides the PSR) is given below:

Summary of the main projects and modifications to the installations		
Year	Unit	Description
1993	Doel 3	Replacement of the 3 steam generators + power increase
1994	Tihange 2	Introduction of MOX fuel
1994	Doel 3	Introduction of MOX fuel
1994	Tihange 2	Power increase
1995	Tihange 1	Replacement of the 3 steam generators + power increase
1996	Doel 4	Replacement of the 3 steam generators
1998	Tihange 3	Replacement of the 3 steam generators
1999	Tihange 1	Replacement of the pressure vessel head
2001	Tihange 2	Replacement of the 3 steam generators + power increase
2004	Doel 2	Replacement of the 2 steam generators + power increase
2009	Doel 1	Replacement of the 2 steam generators + power increase

Table 3 : overview of important projects for the NPPs

Some important projects for the safety assessments of the installations took place in an international context. We refer in particular to the OSART missions undertaken at the Tihange site in 2007 and at the Doel site in 2010. All Belgian plants are also subject to a so-called WENRA Action Plan. This plan

results from the WENRA RHWG self-assessments and benchmarking project, for which the results were published early 2006 (see WENRA website). This action plan covers design as well as operational issues.

As mentioned in section II.C.6, a law relating to the phase-out of nuclear energy was voted by the Belgian parliament in January 2003. In July 2012 a governmental decision was taken to close Doel 1 & 2 in 2015 and to allow Tihange 1 to operate until 2025. An action plan has been drawn up for the improvement of Tihange 1, based on the safety assessment report established by the licensee and reviewed by the Federal Agency for Nuclear Control (FANC) and Bel V. Furthermore the licensee has to develop an action plan for the end of operation of Doel 1 & 2 and their future decommissioning and dismantling.

The technical characteristics of each unit are described in detail in Appendix 1 to this Report. The original design is described together with the main modifications made since their construction.

A particular characteristic of the Belgian nuclear power plants, that merits to be described in some more detail, is their high level of protection against accidents of external origin. Indeed, for the four most recent units, it was requested at the licensing stage that accidents of external origin had to be taken into account, such as an aircraft (civil and military) crash, a gas explosion, a major fire and the effects of toxic gases. These requirements resulted in a duplication of a significant number of safety systems, installed in bunkered structures to withstand an aircraft crash, which is the most demanding loading case. Moreover, explosive or toxic gases detection systems isolate the ventilation systems in a redundant way in order to prevent the introduction of such gases in the control rooms and of explosive gases in the bunkered part of the installations.

This high protection against accidents of external origin resulted in a greater redundancy or diversity in some cases, of the protection and engineered safety systems. For example, the Doel 3 and 4 units, as well as Tihange 2 and 3, are three loop plants equipped with 3 independent and redundant safety trains (each train having its own safety diesel group in a non-bunkered building) and with 3 emergency trains to mitigate accidents of external origin (each train with a diesel located in a bunkered area and built by a manufacturer different from the one of the normal safety diesels, ensuring diversity). The safety trains and the emergency trains are not designed to cope with the same accidents (of internal origin or of external origin respectively) but the emergency trains provide an equipment diversity which can be very useful even for some accidents of internal origin, according to the probabilistic safety studies results.

Afterwards, the protection against external accidents for the older units (Doel 1 & 2 and Tihange 1) was also considerably improved, amongst others by adding dedicated and bunkered systems to these plants.

Following the Fukushima Daiichi accident, the licensee was asked to conduct stress tests. Safety assessment reports for the Doel and Tihange sites have been established by the licensee and reviewed by the FANC and Bel V and external experts. Action plans have been developed. Various modifications were made to the facilities or are in the process of implementation. Specific inspections are carried out at Doel and Tihange to monitor the implementation of these modifications. One of the most important ones is the strong improvement of the protection of the Tihange NPP against external flooding.

As a conclusion, the permanent in-service monitoring and inspection of the installations, combined with the periodic safety reviews during which the changes in regulations and practices and the systematic use of feedback of operating experience are also taken into account, ensures that the safety of the installations is maintained and even improved where possible. Ageing is systematically investigated in order to ensure the availability of all safety systems during the next decade.

II.B.2. Research Reactors

Several research reactors were operational in Belgium (5 at the Nuclear Research Centre SCK•CEN and 1 at the University of Gent). At this moment 3 of these reactors are still in operation. The BR1 and BR2 research reactors are included in this report. A detailed description of BR1 and BR2 is given in appendix 2. The other research reactors are:

- VENUS: a zero power critical facility, mainly used for experiments to validate nuclear calculation codes. In 2008-2009, a major overhaul of VENUS was performed to allow for experiments to study the coupling between an external neutron source and a fast spectrum

reactor core. This core consists of uranium and lead. The neutrons are produced by a deuterium accelerator, with a tritium target. The project is part of the feasibility study of an accelerator driven system.

- BR02: a zero power nuclear model of BR2. It was used to study various core configuration of the BR2 reactor. Since the years eighty, more powerful calculation methods were available and validated. BR02 was no longer needed. It was dismantled in the early nineties. The beryllium core was used for the second replacement of the BR2 beryllium core in 1996.
- BR3: a PWR with an electrical power of about 12 MW. In its early years BR3 was used as a spectral shift reactor, using a mixture of light and heavy water for burn up compensation. Later the reactor was used for testing MOX and gadolinium fuel types. BR3 was definitively shut down in 1989 and served since then as a pilot project for dismantling of nuclear power reactors. The dismantling is nearly completed and still on-going.
- THETIS: a small pool type research reactor at the University of Gent, with a thermal power of 250 kW. The reactor was mainly used for neutron activation experiments. THETIS was definitively shut down in 1999 and is currently being dismantled. The spent fuel has been evacuated to an interim storage facility at BELGOPROCESS.

Following the Fukushima Daiichi accident, SCK•CEN was asked to conduct stress tests as well as other nuclear installations. Safety evaluation reports, among others for the research reactors in operation, have been established by the licensee and reviewed by the FANC and Bel V. The FANC National report was issued on April 16, 2013. Update of the SCK•CEN action plans is expected for July 1, 2013. Action plans will have to be developed and implemented.

a) BR1

The BR1 is a natural uranium graphite reactor, comparable to the reactors ORNL X-10 (USA) and BEPO (Harwell, UK). The reactor went critical for the first time in 1956. The core is composed of a pile of graphite blocks thus forming a cube with ribs of 7 meter. The reactor is air cooled. The fuel is metallic natural uranium with an aluminium cladding. Its design thermal power is 4 MW. However, since the start of BR2 this high power was no longer needed and since 1963 the BR1 is operated at a maximum thermal power of 1 MW using only the auxiliary ventilation system. Due to its very well thermalized neutron spectrum, the reactor is mainly used for neutron studies, such as neutron activation analysis and instrument calibration. Neutronography is also possible.

No significant modifications have been made to the reactor. The original fuel is still loaded. The burn up is still low and the fuel can be used far beyond the lifetime of the reactor. In 1963, after the period of operation at high power, the fuel was unloaded and the graphite matrix was heated in order to release the Wigner energy. In the actual operating regime, using only the auxiliary ventilation, the graphite temperature is relatively high compared to the fast neutron dose, such that the Wigner energy is still decreasing.

b) BR2

The BR2 is a heterogeneous thermal high flux test reactor, designed in 1957 for SCK•CEN by NDA [Nuclear Development Corporation of America - White Plains (NY - USA)]. It has been built on the site of the SCK•CEN in Mol. Its first criticality dates from 1961 and operation of the reactor started in January 1963.

The reactor is cooled and moderated by pressurised light water in a compact core of highly enriched uranium positioned in and reflected by a beryllium matrix. The maximum thermal flux approaches 10^{15} neutrons / (cm².s) and the ultimate cooling capacity, initially foreseen for 50 MW, has been increased in 1971 to 125 MW by replacement of the primary heat exchangers.

The reactor was originally designed for material and fuel testing. A test loop for irradiation under PWR conditions is available. This still is an important activity. However during the last years isotope production (Mo-99, Ir-192 and others) have become important. Besides this, two irradiation facilities for silicon doping are available.

The beryllium matrix swells under neutron irradiation due to the formation of gas (helium and tritium). This swelling causes cracking of the beryllium which is a brittle material. Furthermore, the build-up of the helium-3 isotope results in neutron poisoning. Due to these effects the lifetime of the beryllium matrix is limited. Two replacements have already taken place. The first one took place in 1979 and the second one in 1996. For the second replacement the beryllium blocks of the BR02 were used.

During the lifetime of the reactor, continuous modernization projects have been executed. Various systems have been completely renewed, such as nuclear instrumentation, non-nuclear instrumentation and compressed air supply. On the occasion of the second beryllium matrix replacement, a full refurbishment programme was realized. In addition to the reactor vessel inspection, a vessel follow-up programme was defined, including the irradiation of material samples. In 2010 the cadmium control rods, which were end of life, were replaced by hafnium rods. Also in 2010, test irradiations were started for the conversion from highly enriched uranium fuel to lowly enriched fuel, using uranium molybdenum fuel plates.

Presently different studies have been initiated in view of continuing operation after 2016 such as the replacement of the beryllium matrix foreseen in 2014.

II.C. Article 7. Legislative and Regulatory Framework

- 1) Each Contracting Party shall establish and maintain a legislative and regulatory framework to govern the safety of nuclear installations.
- 2) The legislative and regulatory framework shall provide for:
 - (i) the establishment of applicable national safety requirements and regulations
 - (ii) a system of licensing with regard to nuclear installations and the prohibition of the operation of a nuclear installation without a licence
 - (iii) a system of regulatory inspection and assessment of nuclear installations to ascertain compliance with applicable regulations and the terms of licences
 - (iv) the enforcement of applicable regulations and of the terms of licences, including suspension, modification or revocation

II.C.1. Introduction

The basic Belgian legal texts regarding the safety of nuclear installations covered by this Convention are:

- the Law of 15 April 1994 on the protection of the population and the environment against the hazards of ionizing radiation and on the Federal Agency for Nuclear Control (amended for the last time in 2012),
- the Royal Decree of 20 July 2001 laying down the "General Regulations regarding the protection of the public, the workers and the environment against the hazards of ionising radiation (GRR-2001, amended for the last time in 2012).
- The Royal Decree of 30 November 2011 on the Safety Requirements for Nuclear Installations (SRNI-2011)

Besides these, other legal texts relate to some aspects covered within the Convention, such as:

- The legislation with respect to Emergency Planning and Preparedness,
- The law with respect to the Phase Out of Nuclear Energy
- The legislation on nuclear liability

The scope of the GRR-2001 is very wide and covers practically all human activities and situations which involve a risk due to the exposure to ionizing radiation, and this at the level of the protection of the workers as well as at the level of the protection of the public and the environment. In particular, the risks associated with the natural radiation (e.g. radon) are integrated in the regulations. These regulations ensure the transposition of all the European directives regarding radiological protection, in particular the 1996 and 1997 directives reinforcing considerably the standards protecting the public, the workers and the environment, and, in particular, the protection of the patients in the frame of medical exposures.

The GRR-2001 enforces many articles of the Law of April 15th 1994 and made **the Federal Agency for Nuclear Control (FANC)**, created by that Law, operational. The organisation of this public agency is explained under Article 8. This agency, which is endowed with wide competences, **constitutes the Safety Authority.**

The texts of the regulations now in force can be consulted on the website of the FANC (<http://www.jurion.fanc.fgov.be>). An English version of some of these texts will be available (in October 2013) on the FANC website: <http://www.fanc.fgov.be/fr/page/reglementation/11.aspx>.

A summary of the legislation is given below for each main topic. The texts referred to are not frozen, in the sense that they are likely to be replaced, completed or modified at any time by further regulations that amend the original texts, so as to limit the volume of texts to be referred to.

Information concerning the national framework for the management of spent fuel and radioactive waste can be found in the last National Report for the "Joint Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management", available on the FANC and IAEA web sites.

II.C.2. The Law of 15 April 1994

The Law of 15 April 1994 on "the protection of the population and the environment against the hazards of ionizing radiation and on the Federal Agency for Nuclear Control" constitutes the basic law

that sets out the basic elements for protecting the workers, the public and the environment against the adverse effects of ionising radiation. The same law also creates the FANC as the Safety Authority.

- **Chapter 1** defines a number of terms used and clearly establishes (Art. 2) the “Federal Agency for Nuclear Control”, abbreviated as “FANC” as the public interest organisation having legal personality to become the Safety Authority.
- **Chapter II** gives more detail regarding the competent authority. The King is the competent authority for all activities involving sources of ionising radiation, including transport. The King may take all measures aimed at protecting the public and the environment in case an unforeseen event presents a danger. The King also nominates the persons in charge of supervising the compliance with this law and its implementing decrees dealing with the medical surveillance of the workers and the health conditions at work (Art. 7-11). These persons are considered as judiciary police officers, auxiliaries of the King’s Attorney and, as such, they have specific enforcement powers. They trace and record infractions to this law; they can issue warnings and set deadlines for corrective actions; they have at any time access to the nuclear installations; they can proceed to the seizure of equipment or sources;
- **Chapter III** enumerates the various missions of the FANC. Those missions comprise a.o.
 - Control and supervision activities;
 - To perform all acts contributing to this law and to create legal entities contributing to his law;
 - To perform safety and security assessment of nuclear facilities and conduct inspections in those facilities;
 - To examine the license applications for nuclear facilities; to grant licenses for specific facilities, except those with the highest risk (class I facilities); the verification of compliance with license conditions;
 - Radiological surveillance of the territory;
 - To provide technical assistance to the Ministry of Home Affairs in case of nuclear emergencies;
 - To propose and prepare new regulations related to this law;
 - To gather a scientific and technical documentation in the field of nuclear safety; the stimulating and coordination of R&D;
 - To issue neutral and objective information to the public.
- **Chapter IV** deals with the delegation of some of the missions of the FANC.
 - The FANC can delegate some of its missions to organisations that it has recognized or to legal entities that it has created to that end.
 - The delegation relates to certain missions of the health physics department that each licensee has to set up as well as the supervision of loading, transport and delivery of fissile material.
 - The recognition of those organisations is based on criteria defined by the FANC.
 - The missions delegated to the legal entities that the FANC created, are specified by the King who also determines the way of financing the entity as well as how the FANC can control the mission entrusted to this entity
- **Chapter V** deals with the funding of the FANC, which is based on
 - annual taxes on license holders or future license holders (e.g. the projects for disposal of radioactive waste); the amounts and the procedure for paying are fixed in this chapter;
 - fees on the occasion of the application for a license, recognition or registration; the amounts are to be fixed by Royal Decree and are adapted annually to the price index;
 - administrative fines; amounts and procedures are detailed in articles 53 to 64 of the law;
 - fees for special (control) activities;
 - gifts and legacies;
 - subsidies.
- **Chapter VI** describes the basic management mechanisms of the FANC
 - FANC is directed by a Board, whose members are appointed by Royal Decree.
 - The Scientific Council, whose composition and duties are fixed by Royal Decree, is established as an advisory body to the FANC.

- The FANC must be organised in such a way that the regulation development function and the control and supervision functions are carried out independently.
- Day-to-day management of the FANC is entrusted to the General Manager
- **Chapter VII** describes some of the enforcement powers that the FANC can use such as administrative fines.
- **Chapter VIII** describes some final clauses and some transitional arrangements

II.C.3. The Royal Decree of 20 July 2001

This Royal Decree provides the basic nuclear safety and radiological protection regulations. Amendments are regularly proposed by the Safety Authority in order to take account of scientific and technical developments, to transpose the European directives, etc.

The GRR-2001 introduces the concept of clearance and strict rules concerning the reuse and the recycling of very low level solid waste that also has an important impact on the design, the operation and the dismantling of the nuclear installations concerned by the Convention.

An outline of the GRR-2001 and the provisions that are most relevant in the context of the Convention are given below.

- Chapter I – General Provisions
 - Definition of the scope and field of application of the GRR-2001
 - Definition of physical terms.
- Chapter II – Categorised Facilities.
 - Facilities are categorised from Class I (the nuclear fuel cycle facilities, representing the highest risk) down to Class IV (very low quantities of radioactive material).
 - Prior licensing is mandatory for facilities from Class I to III.
 - Art. 6 describes the licensing system of the class I facilities and is described at the end of this section.
 - Art. 12 and 13 deal with the licensing issues due to modifications to the facility or the additional license conditions that can be proposed by the FANC or its scientific council.
 - Decommissioning of Class I facilities is also subject to prior licensing.
 - The competent authority may withdraw or suspend the license when the regulations and/or license conditions are not complied with
- Chapter III – General Protection.
 - The limitation of individual or collective doses is based on the fundamental radiological protection principles: justification of practices, optimisation of protection and individual dose limits. Art. 20 sets out those limits for occupationally exposed people, trainees and students, and for members of the public. It also addresses concerted exceptional exposure, accidental exposure and emergency exposure of the workers.
 - Art. 23 describes the role and duties of the Health Physics Department (HPD) that each license holder of a facility or operator of a transport company must establish. The HPD is in charge, in a general way, of the verification of compliance with the regulations, the conditions set in the licence. Specific tasks of the HPD are listed in Art. 23. Experts in health physics control must be recognised by the FANC according to specifications set out in Art. 73.
 - Art. 24 and 26 deals with the medical surveillance of workers and with the requirements with respect to their training and obligations of the workers to comply with instructions and regulations.
 - Art. 27 to 32 deal with the general protection equipment and arrangements, including individual protection equipment, dosimetry and the use of warning signs.
 - Art. 33 to 37 deal with radioactive waste (solid, liquid and gaseous)
 - Art. 37 bis to 37quinquies deal with the access to nuclear facilities and with the protection of external workers when they are working in a radiation controlled area.
- Chapter IV - Import, Transit and Distribution of Radioactive Substances
 - This chapter has been withdrawn and replaced by the Royal Decree of 24 March 2009 regulating import, transit and export of radioactive material. This decree also

transposes Directive 2006/117/Euratom on the supervision and control of shipments of radioactive waste and spent fuel.

- **Chapters V and VI** deal with **medical applications** of ionising radiation and are not reported under this convention.
- Chapter VII – Transport
 - Transport of radioactive material is subject to a licence granted by the FANC.
 - This chapter describes the licensing procedure as well as the information that the licensee has to provide to FANC on a regular basis.
- Chapter VIII – Nuclear Propulsion
 - Construction of any ship or vehicle which is powered by nuclear energy is subject to prior authorisation by the King
 - Ship remaining in Belgian waters or passing through are subject to prior licensing
- **Chapter VIII – Bans and Authorisations** deal with specific prohibitions or special licenses for using ionising radiation (e.g. sterilisation of medical equipment)
- Chapter IX – Exceptional Measures
 - Art. 66 deals with the measures against the loss or theft of radioactive substances.
 - Art. 67 deals with the measures relating to accidents, concerted exceptional exposures and accidental exposures.
 - Art. 68 deals with decontamination and,
 - Art. 69 deals with the contaminated mortal remains.
- **Chapter X** - Surveillance of the Territory, the Population and Emergency Planning
 - Article 70 deals with radioactivity monitoring of the territory, and of the doses received by the population, which is taken care of by the FANC.
 - Article 71 deals with the (radiological) monitoring of the population as a whole, the collection of all the data, including those from occupationally exposed workers.
 - Article 72 deals with the emergency response planning for nuclear risks and the information of the population.
 - Article 72bis deals with interventions in cases of lasting exposure.
 - Article 72ter deals with interventions in case of discovery of orphan sources.
 - A specific Royal Decree of 17 October 2003 has laid down the general Emergency planning organisation in case of nuclear/radiological accident (see also II.C.5).
- Chapter XI - Recognition of Experts, Physicians and of Inspection Organisations
 - Article 73 sets all the conditions for the recognition of experts in health physics control.
 - Article 74 deals with the Authorized Inspections Organizations (AIOs).
 - Article 75 deals with the recognition of doctors in charge of the medical surveillance of occupationally exposed workers.
- Chapter XII – HASS Sources
 - This chapter has been added in 2006 as part of the transposition of Directive 2003/122/Euratom on the control of high-activity sealed radioactive sources and orphan sources

II.C.4. **The Royal Decree of 30 November 2011**

The Royal Decree of 30 November 2011 on the Safety Requirements for Nuclear Installations (SRNI-2011) is the result of the WENRA-harmonisation activities with respect to regulation. It also ensures the transposition of the European Directive 2009/71/Euratom on nuclear safety. The SRNI-2011 is composed of several chapters so that it is possible to add specific chapters for specific installations. The following chapters are available:

- **Chapter 1- General Provisions** sets the scope of the Decree and defines terms.
 - The SRNI-2011 applies to nuclear facilities of Class I.
- **Chapter 2 – Generic Safety Requirements** is applicable to all nuclear facilities covered by this decree.
 - Section I – Nuclear Safety Management
 - The licensee shall formulate and communicate to all personnel a safety policy with primary importance to nuclear safety and including a commitment to monitor and to continuously improve nuclear safety (Art. 3)

- Art. 4 states that the organisational structure has to be documented and that nuclear safety management should follow a graded approach to ensure a safe operation of the facility by sufficiently qualified people. The human resources management must take into account the long-term objectives as well as retirement and other cutbacks.
 - An integrated management system (Art. 5) giving priority to safety shall be established, implemented, assessed and improved on a continuous basis. This management system shall cover all the activities and processes which can have an impact on the nuclear safety of the facility, including the activities carried out by the subcontractors or suppliers.
 - Art. 6 sets out the requirements with respect to training and formal qualification of the personnel.
- Section II – Design
 - Art. 7 sets the requirements related to the design basis of the facility. These requirements comprise a.o. the defence in depth concept, the identification of normal operating conditions, anticipated operational occurrences as well as accidents from postulated initiating events (internal and external), fail safe principle,... The design shall also include some provisions for future decommissioning purposes.
 - Art. 8 requires that a specific process for the classification and qualification of structures, systems and components is in place and that their design, fabrication and maintenance requirements are commensurate with their classification.
- Section III – Operation
 - Art. 9 sets the requirements related to operational limits and conditions. The operational limits and conditions form an integral part of the safety report and shall be reviewed and modified when needed. The limits shall be determined in a conservative manner. In case the operational limits and conditions cannot be complied with, suitable corrective measures shall be implemented and reported to the regulatory body.
 - Art. 10 deals with ageing where both the ageing (physical and economic) as well as the ageing management programmes need to be addressed. This ageing management programme shall be reviewed at least during each periodic safety review.
 - Art. 11 imposes the licensee to have an operational feedback process in place for collecting, analysing and documenting events that occur in his facility as well as in other similar facilities. This process shall also document the analysis methodologies, notification and distribution of relevant information as well as the process for continuous improvement.
 - Art. 12 sets the principles, preparation and implementation of the maintenance-, test-, monitoring- and inspection programmes for structures, systems and components important to safety.
- Section IV – Verification of Nuclear Safety
 - A safety analysis report shall be prepared by the licensee during the licensing phase (Art. 13). The SAR reflects the installations and the activities that are carried out there. This safety report will serve as a basis for addressing the impact on nuclear safety due to modifications and will be updated on a regular basis, according to a specific procedure
 - Art. 14 sets the requirements for the periodic safety reviews (PSRs). The main objective of the PSR is to perform a systematic assessment of the nuclear safety of the facility taking into account not only the ageing or modifications made to the facility, but also developments related to regulation and experience feedback. The PSR is to be carried out following a systematic and documented method and shall address various safety topics. A summary report shall be transmitted to the regulatory body that includes the analysis for each safety topic as well as the safety improvement actions and the schedule for implementing these actions.

- Modifications shall be managed as to guarantee as a minimum the same level of safety as before the modification. Art. 15 details what changes are to be considered as a modification and sets some additional requirements with respect to the safety assessment and the execution of the modification.
 - Section V – Preparation for Emergencies
 - Art. 16 sets the requirements related to the internal emergency plan that the licensee has to implement. It specifies the objectives, the preparation and organisational issues. It also states that adequate emergency infrastructure needs to be provided and that the internal emergency plan needs to be exercised at least once per year.
 - Art. 17 sets the requirements for the protection against internal fires. The design basis should take already into account the main elements of the fire protection and has to be documented via a fire hazard analysis. The fire detection and alarm systems need to be in place as well as passive or active fire extinguishing systems and those systems will be regularly inspected and well maintained.
- Chapter 3 sets the specific Safety Requirements for Nuclear Power Plants
 - Section I – Nuclear Safety Management
 - Art. 18 imposes an organisational entity within the licensee’s organisation that is responsible for independent assessments.
 - Art. 19 stipulates specific requirements for operators working in the control room, such as an initial and yearly refresher training on a representative simulator and their authorization.
 - Section II – Design
 - Art. 20 deals with the design basis of existing reactors demanding a defence in depth approach to ensure the basic safety functions: control of reactivity, heat removal and confinement of radioactive materials. It specifies some internal and external events that have to be taken into account. The safety demonstration shall apply sufficient conservatism (e.g. use the most penalising single failure). The design of the safety functions must be such that an operator action is not required for the first 30 minutes. Instrumentation systems shall be used to measure the main parameters. A fall-back control room shall be provided, physically and electrically separated from the main control room. The safety systems shall provide sufficient redundancy and diversity to guarantee that no single failure will cause the loss of the safety system and that the shutdown of one component or one line will not cause the loss of minimum required redundancy. Emergency power supplies have to be available, capable of providing the necessary power.
 - Art. 21 deals with the design extension, i.e. beyond design basis accidents and severe accidents (involving core damage). Specific instrumentation shall be provided for managing those accidents in both the main control room and the fall back control room. For specified beyond design accident, the containment must be maintained as much as possible.
 - Art. 22 states that interfaces shall be present to prevent that a failure of structure, system or component of one class induces a failure on a system of a higher class.
 - Section III – Operation
 - Art. 23 imposes operational limits and conditions to cover all operational states of the nuclear power plants and that the personnel of the control room and the supervising personnel has sufficient knowledge of the limits and their technical basis.
 - The licensee shall develop an ageing management programme (Art. 24) that takes into account a.o. the operational conditions and load cycles. The main systems, structures and components shall be monitored to detect effects due to ageing in a timely manner to allow for preventive or corrective measures.
 - Art. 26 defines the minimal requirements for the leak tests of the reactor primary circuit and to verify the integrity of the containment.

- The licensee shall complete a set of accident management procedures (including severe accidents). Accident management procedures are to be used during accident conditions when there is no damage to the core and their main objective is to restore safe conditions, restore or compensate the loss of safety functions and to prevent or delay core damage. In severe accident conditions, or when there is damage to the core, the severe accident management procedures are to be used, with the aim to limit further core damage, preserve as much as possible the integrity of the vessel, limit the release of radioactive substances and to restore controlled conditions. The accident management procedures shall be developed on the basis of realistic scenarios, using deterministic and probabilistic analysis techniques. They shall be available, easy to identify and to use, and the transition from accident management procedures to severe accident management guidelines is clearly identified. They shall be inspected and validated, as well as updated periodically. Personnel that could be concerned by those procedures shall receive adequate initial training and refresher training.
 - Section IV – Verification of Nuclear Safety
 - Art. 28 defines the minimal content (16 chapters) of the safety analysis report.
 - A level 1 and level 2 probabilistic safety assessment shall be performed for each reactor and for each operating mode (Art. 29). For level 2 the PSA could use however a representative unit. The PSA shall use realistic assumptions and shall take into account aspects such as internal fire hazard, external events, human interventions and human errors. Level 1 PSA shall include a sensitivity and uncertainty analysis, level 2 PSA at least sensitivity analysis. The PSA results shall be used during the design and operation of the power plant for e.g. decision making aid or to check adequacy of modifications.
 - Art. 30 sets the frequency of the periodic safety reviews at a minimum of 10 years.
 - Section V – Preparation for Emergencies
 - A coordination centre for managing on-site events shall provide communication equipment to the control room, the fall-back control room and with all major locations on the site, as well as with on-site and off-site emergency organisations (Art. 31).
 - Art. 32 specifies specific requirement for protection against internal fires. These requirements include e.g. a fire PSA and the maintenance of the safety function during and after a fire occurrence.
- **Chapter 4** is intended to set specific **safety requirements for radioactive waste disposal facilities**. The draft has been notified to the European Commission by virtue of article 33 of the Euratom Treaty.
- Chapter 5 contains some Final Provision and transitional arrangements

II.C.5. The Royal Decree of 17 October 2003 on Emergency Planning

The law of 15 May 2007 defines the notion of Civil Safety and describes the roles and missions of the different entities involved. The Royal Decree of 16 February 2006 organises the planning and interventions during emergency situations. The Royal Decree of 17 October 2003 lays down the nuclear and radiological emergency response plan and the tasks of each of the parties involved.

According to article 18 of the SRNI-2011, it is mandatory for nuclear installation operators to set up an internal emergency plan and to get it approved by the Regulatory Body. This plan shall be tested regularly to address possible accidents. The intervention of the Authorities outside the affected installations takes place under the authority of the Minister of Home Affairs, who supervises the Civil Safety.

This nuclear and radiological emergency plan for the Belgian territory aims at co-ordinating the actions towards protection of the population and the environment in the event of a nuclear accident or any other radiological emergency situation that could lead to an overexposure of the population or to a significant contamination of the environment.

This document will serve as a guide for the protective actions to be implemented, should a radiological emergency occur. It establishes the tasks that the various departments and organisations would have to accomplish if the case arises, each within their legal and regulatory competences.

The provisions of the emergency plan apply in the cases where there is a risk of significant radiological exposures to the population in any of the following ways:

- external irradiation due to air contamination and/or deposited radioactive substances;
- internal irradiation by inhalation of contaminated air and/or ingestion of contaminated water or food.

The Nuclear and Radiological Emergency Plan for the Belgian Territory is mainly designed for emergency situations in the major Belgian nuclear installations: the nuclear power plants of Tihange and Doel, the Nuclear Research Centre in Mol, the Institute for Radioelements in Fleurus, the fuel fabrication factory Belgonucléaire (now in dismantling phase) and the waste treatment and storage installations of Belgoprocess in Dessel. This plan is also activated for other emergency situations, which can occur either on the Belgian territory (accident during the transport of radioactive materials or radiological emergency resulting from a terrorist attack or events occurring in other Belgian nuclear installations for instance) or nearby (EdF nuclear power plant of Chooz for instance).

In case of an emergency, the off-site operations are directed by the "Governmental Crisis and Coordination Centre" (CGCCR), under the authority of the Minister of Home Affairs. The implementation of the actions decided at the federal level and the management of the intervention teams are under the leadership of the Governor of the Province concerned.

The plan describes the overall organisation. It has to be completed by concrete internal plans based on the intervention, at various intervention levels, of:

- the provincial authorities;
- the municipal authorities;
- all the intervening institutions.

Belgium is contracting party to both the Convention on Early Notification of a nuclear accident and the Convention on Assistance in the case of a nuclear accident or radiological emergency.

It is worthwhile noting that this plan is intended to be revised during the two coming years (2013-2014) to cope with the lessons learned from the exercises, the recent events, the revision of international standards and the changes in the structure and responsibilities of federal and regional authorities.

II.C.6. The Law of 31 January 2003 on the Phase-out of Nuclear Energy

On 31 January 2003, a law on the phase-out of nuclear energy was promulgated. It stipulates amongst others:

- No new nuclear power plants for industrial generation of electricity from nuclear fission shall be constructed or commissioned (Article 3).
- Article 4:
 - § 1. Nuclear power plants for industrial generation of electricity from nuclear fission are shut down definitively forty years after the date of their industrial commissioning and shall no longer generate electricity from that moment on.
 - § 2. Every individual license for the industrial operation and generation of electricity from nuclear fission, granted by the King with no limitation in time
 - a) in accordance with the Law of 29 March 1958 concerning the protection of the population against the hazards of ionising radiations and under article 5 of the GRR-1963, which remain valid according to article 52 of the Law of 15 April 1994 (article 66 in current amended version) ;
 - b) under article 16 of the Law of 15 April 1994 and under articles 5 and 6 of the GRR-2001;comes to an end forty years after the date of the industrial commissioning of the generating facility.
- If the electricity supply is threatened, the appropriate measures can be taken by royal decree, in accordance with articles 3 to 7 of this law, except in circumstances outside one's control (Article 9).

II.C.7. The Licensing regime for nuclear installations

Since 2001, the new licensing process for facilities of class I comprises two phases, each one ending with a Royal Decree.

The license application consists of three parts:

- The first part consists mainly of administrative information, defining amongst others responsibilities, names and legal status of the applicant, ...
- The second part consists of a preliminary safety analysis report containing amongst others:
 - the safety principles that will be applied for the construction, the operation and the design basis accidents,
 - the already available probabilistic safety analysis,
 - the qualification of the mechanical and electrical equipment,
 - the principles that will be applied for quality assurance,
 - the expected quantities of waste and their management, including those related to the dismantling,
- The third part of the application consists of an environmental impact assessment report, including as a minimum the general data referred to in the recommendations of the European Commission on the application of Art. 37 of the Euratom Treaty (99/829/Euratom); this report must also comply with the European directive 85/337/EEC on the assessment of the effects of certain public and private projects on the environment (as amended).

Belgium is a federal state composed of three Regions being legally competent for environmental protection on their territory (radiological impact excluded). Future cooperation agreements are being discussed in order to avoid work duplications and incompatibilities and to streamline the licensing procedures

The licence application is examined by the FANC and then presented for advice to the Scientific Council of the FANC. A mandatory international consultation (application of Article 37 of the Euratom Treaty on the trans-boundary impact) and/or a voluntary consultation of the European Commission may take place. Following the advice of the Scientific Council, the file is submitted to a public enquiry and to the municipal authorities concerned for advice, and then to the executive of the provinces concerned. The completed file is then sent to the Scientific Council for final advice. A positive advice of the Scientific Council is necessary for a positive decision. The Scientific Council can also propose particular conditions to be attached to the license, related to the commissioning of the installations or in view of ensuring the safety and the wholesomeness of the future installation. This construction and operating licence allows the applicant to build the installations in conformity with the licence.

The second phase aims at confirmation of the construction and operation licence. The Federal Agency for Nuclear Control (FANC) or Bel V acting on behalf of the FANC proceeds to the delivery of the installations before the start up and the introduction of radioactive substances. A fully favourable acceptance report leads to the confirmation decree allowing the operation of the facility.

Partial confirmation decrees are possible, each based on a fully favourable delivery report. The confirmation decree can also modify or complete the conditions attached to the initial license.

The licensing scheme is illustrated in the figure below.

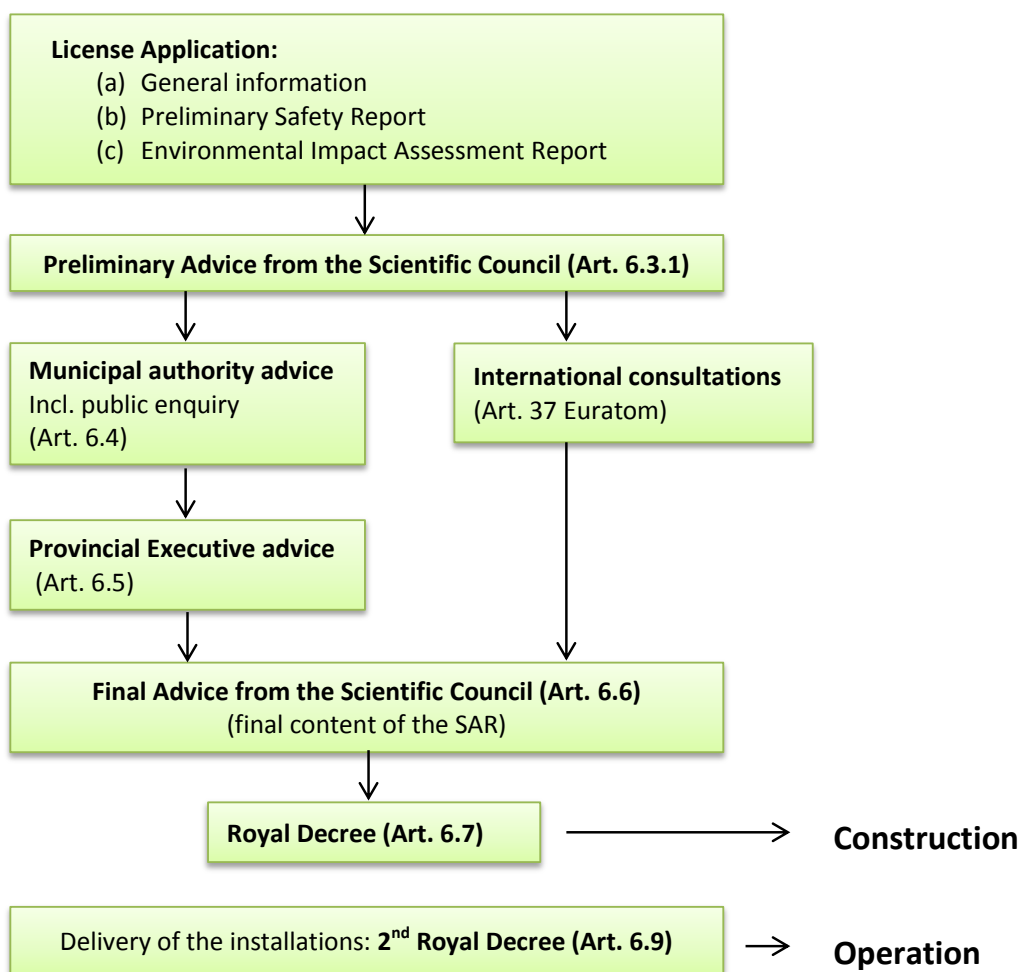


Figure 5 : Licensing scheme for Class I Facilities

Appeal against the FANC decisions and authorisation decrees.

The construction and operation licence of class I facilities is granted by royal decree on the proposal of the Minister of Home Affairs. Like any decree, anybody can introduce an action for cancellation of the decree, during 60 days after the publication of the decree.

The administration in charge of treating the appeal against the administrative decision is the "Council of State". If the situation is urgent or if it is needed, on request of the applicant, the council of state can suspend immediately the administrative decision.

Modification of the license:

The licence and the conditions attached to the license can be modified in two ways:

- At the initiative of the operator. According to article 12 of GRR-2001, any project to modify the facility must be notified to the FANC. If the proposed modification has a significant impact, the FANC can decide whether the license or the conditions attached to it, have to be amended.
- At any moment, at the initiative of the FANC or at the initiative of its Scientific Council, according to article 13 of GRR-2001.

In these cases, the process for modification of the license is similar to the initial licencing process. Derogations from administrative formalities are possible, but advice of the Scientific Council is always mandatory.

II.C.8. Conclusions regarding the Provisions of Article 7

By becoming fully operational in September 2001, the FANC has taken over the tasks performed previously by the DTVKI/SSTIN (Ministry of Labour and Employment) and by the DBIS/SPRI (Ministry

of Public Health and Environment) aiming at the enforcement of the Law of 15 April 1994 and its implementing decrees, in view of the radiological protection of the public, the workers and the environment.

In Belgium, there is a legal and regulatory framework for safety of nuclear installations for almost 50 years.

The laws and royal decrees are regularly updated, and completed or, if necessary, amended (for instance to take into account the Euratom Directives, the international treaties signed by Belgium, etc.).

The legislative and regulatory framework comprises:

- (i) a set of laws and regulations (cf. description in II.C. above), including safety requirements based on the WENRA reference levels (which are based on the IAEA safety standards),
- (ii) a licensing regime for nuclear facilities and activities, and the prohibition to operate an installation without a licence (cf. GRR-2001 and, among other, its articles 5, 6, 15, 16, 79 as well as all the Articles detailing the technical stipulations),
- (iii) a regulatory inspection and assessment system of the nuclear facilities and activities, to verify compliance with the regulatory provisions and conditions attached to the licence (cf. GRR-2001, among other its Articles 6, 12, 13, 15, 16, 23, 78),
- (iv) Measures intended to enforce compliance with the relevant regulatory provisions and the conditions attached to the licence, including the suspension, amendment or withdrawal of licences (cf. GRR-2001, among other its Articles 5, 12, 13, 16).

II.D. Article 8. Regulatory Body

- 1) Each Contracting Party shall establish or designate a regulatory body entrusted with the implementation of the legislative and regulatory framework referred to in Article 7, and provided with adequate authority, competence and financial and human resources to fulfil its assigned responsibilities.
- 2) Each Contracting Party shall take the appropriate steps to ensure an effective separation between the functions of the regulatory body and those of any other body or organisation concerned with the promotion or utilisation of nuclear energy.

Since 1 September 2001 the supervision of nuclear activities is within the responsibility of the Federal Agency for Nuclear Control (FANC), which constitutes the Safety Authority. This mission has been given to the FANC by the Law of 15 April 1994. According to articles 14bis and 28 of this law (as amended), the FANC may call upon the assistance of recognised bodies for health physics control, or on legal entities especially created to assist it in the execution of its missions. The FANC has made use of this provision and, in the case of the nuclear installations covered by this National Report (nuclear power plants), created Bel V in September 2007, a subsidiary with the statute of a so-called 'foundation' as defined in Belgian law. Bel V is given a mandate to perform regulatory missions that can be legally delegated by the FANC, without consulting the public market. The FANC delegates different tasks to Bel V, a.o. on site routine inspections. Other class I facilities (including the Research Reactors) are controlled in a similar way by Bel V.

It is through the association of the FANC on one side, and Bel V on the other that the function of regulatory body as stipulated in article 8, is ensured.

The staff of Bel V is composed of experts from the former recognized body (Authorized Inspection Organisation) AVN and is carrying out all the regulatory activities since April 2008, including the surveillance activities, previously performed by AVN. Background elements regarding AVN and the statute of "Authorized Inspection Organisation" can be found in the 2007 edition of this national report, available on the FANC web site.

A control structure with 3 levels is in place : first by the licensee's Health Physics Department (HPD), then by Bel V which performs by delegation of the FANC a number of inspections and regulatory tasks, and finally by the Safety Authority. This structure is illustrated below:

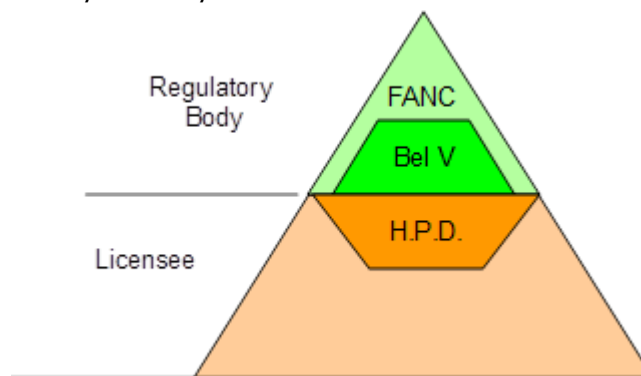


Figure 6 : 3-level control structure

The descriptions in this article focus on the tasks relating to the installations covered by the National Report, and consequently are not an exhaustive overview of all the regulatory functions assumed by the various organisations.

II.D.1. Mandate and Function of the Regulatory Body

The GRR-2001 stipulates that the King is the competent Authority who grants the licenses for Class I nuclear facilities (which include nuclear power plants and research reactors), it also specifies a number of tasks to be performed by the Federal Agency for Nuclear Control, which may delegate tasks to Bel V to perform supervision activities of Class I facilities.

In this way, the regulatory work, and in particular the supervision and inspection of the operating organisation, is performed at two levels:

a) At the level of regulations and supervision:

The FANC is in charge of updating the regulations, of transposing the European directives, international treaties, and of maintaining the internal coherence of the regulations. To that effect, it makes proposals to its supervising minister (of Home Affairs).

As regards the general supervision of the operating organisation, the FANC and Bel V are informed of the organisation's operational issues and projects through the meetings of a "Contact Committee" composed of representatives from the regulatory body and the operator. This Committee meets twice a year on average.

The regulatory body also systematically holds a control meeting at the end of each core refuelling period, to evaluate the activities and results of that shutdown period. Unexpected visits are also performed. In case of significant operational problems (e.g. deformation of fuel assemblies, possible contamination of transport containers, ...), or in case of safety issues raised for example by international OEF, specific meetings are held between the regulatory body and the operator in order to assess the technical problems and to consider and decide remedial action; these actions are in this way approved by the Safety Authority.

The FANC can also act as an arbitrator in cases where the operator deems that the technical demands of Bel V are unreasonable: after having heard the various technical standpoints the FANC can resolve about what is finally required.

b) At the level of the detailed technical analysis and the permanent supervision of the operator as required by the regulations.

When a licence for a modification of a nuclear power plant is applied for, Bel V is requested to review the Safety Report presented by the applicant, and to present its conclusions to the FANC. Using this safety review, the FANC can also propose additional conditions for operation that the Scientific Council may endorse. In this case, these operating conditions will be included in the licence (by Royal decree). The FANC and Bel V present the content of the safety review and the legal aspects, including proposals for additional conditions for operation, to the Scientific Council. If judged useful, the licensee concerned can be requested to provide specific information to the Scientific Council and respond to the latter's questions.

Before the installations are put into operation, the initial license must be confirmed by a second royal decree (see article 6 of GRR-2001), provided that the installations are subject to a fully favourable delivery, i.e. an in-depth verification of its conformity with the existing regulations, its license and the Safety Analysis Report, according to Article 6.9 of the GRR-2001. The delivery inspections and conformity checks are performed by Bel V, on behalf of the FANC.

Throughout the operation of the installation, the operator's Health Physics Department supervises nuclear safety and radiological protection, the department's performance being permanently supervised by Bel V (GRR-2001 - Article 23).

This permanent supervision in practice consists of systematic and periodic inspections devoted to defined subjects (operation, periodic tests, chemical control, radiological protection ...) and specific items follow-up inspections, examination of modifications and incident analysis. An inspection report is written following each visit.

The Bel V inspection reports of the nuclear power plants are systematically transmitted to the FANC.

After each core refuelling, Bel V verifies that the new configuration is acceptable, and follows-up the start-up tests, assesses their results, and authorises (through its delivery report) operation at nominal power.

All modifications are notified to Bel V. However, Bel V and the FANC will follow-up only the safety-related modifications.

Major modifications (power increase, use of MOX fuel, steam generator replacement ...) may require, under the appreciation of the FANC, a procedure similar to that of the initial licensing, and sanctioned by a new Royal Decree amending the initial license.

Less important modifications are implemented by the licensee under the supervision of its Health Physics Department (HPD). Bel V is in charge of approving the final delivery of the modification proposed by the HPD. The Safety Analysis report is updated accordingly.

II.D.2. Powers and Attributions of the Regulatory Body

Bel V is delegated by the FANC to permanently supervise whether the operator complies with the regulations in force and with the conditions attached to the licence.

The findings of the inspection visits and the observations made are recorded in the reports established by Bel V and transmitted to the operator; the latter implements then any necessary corrective action.

At this stage Bel V has only the power to make recommendations but should the operator violate the conditions set in the licence and fail to correct that situation, or should the operation evolve towards an unsafe situation, this would be referred to the FANC, who can then propose to suspend or withdraw the licence (GRR-2001, Article 16).

The FANC inspectors have the status of police officers, adjunct to the Public Prosecutor. They have the powers of enforcement inspectors; they can also intervene on the request of Bel V inspectors. The FANC inspectors can take any measure they consider necessary to reduce or eliminate hazards for workers, the public and the environment. These measures can include warnings, requests for corrective actions with a delay not exceeding 6 months (article 9 of the Law of 15 April 1994).

Another possibility to strengthen safety is foreseen in article 13 of the GRR-2001: the Safety Authority (The Scientific Council or the FANC services in charge of the supervision) can, on its own initiative and at any moment, propose additional conditions to be included in the License with the aim of improving safety.

II.D.3. Structure of the Regulatory Body, Financial and Human Resources

a) Safety Authority

The Federal Agency for Nuclear Control is an autonomous public institution with legal personality. The Agency is directed by a 14-headed Board of Directors; its members are appointed by the Federal Government on the basis of their particular scientific or professional qualities. In order to guarantee the independence of these directors, their mandate is incompatible with certain other responsibilities within the nuclear sector and within the public sector. The Agency is supervised by the Federal Minister of Home Affairs via a government Commissioner who attends the meetings of the Board of Directors. The Board delegates the management of the FANC to the General Manager.

In order to perform its tasks, the Agency is assisted by a Scientific Council [established by article 37 of the law of 15 April 1994]; the composition and the competences of this Council are fixed by Royal Decree. The Council consists of experts within the field of nuclear energy, nuclear safety and radiological protection.

The Agency exercises its authority with regard to the nuclear operators through one-sided administrative legal acts (the consent of the involved operators is not required) such as the granting, refusal, modification, suspension and withdrawal of licences, authorisations, recognitions or approvals. It organises inspections to verify the compliance with the conditions attached to the licences, recognitions and approvals. The Agency can claim any document in whatever form, from the facilities and companies under its supervision. Infractions with regard to the decisions of the Agency can be sanctioned.

The operation of the Agency is entirely and directly financed by the companies, organisations or persons to whom it renders services. In practice this is done through non-recurrent fees and annual taxes at the expense of the applicants or holders of licences or recognitions. The amount of the taxes is set in article 30bis of the law of 15 April 1994, the amount of the fees is fixed by Royal Decree, as foreseen in article 30quater of the law of 15 April 1994. The receipts and expenditures of the Agency have to be in equilibrium.

The above-mentioned statute confers to the Agency the indispensable independence to enable it to impartially exercise its responsibilities as a regulator of the nuclear activities - as prescribed in art. 8 of the Convention on Nuclear Safety.

More information is available on the website: www.fanc.fgov.be

Within the Board an audit Committee and a strategy Committee have been set up to prepare certain decisions. Below the General Manager, the FANC is organized in five departments: the Department "Regulations, International Affairs and Development", the Department "Facilities and Waste", the

Department "Security and transport", the Department "Health and environment" and the Department "Support".

The organisation chart of the FANC must take into account the law of 15 April 1994 and in particular article 43 which requires the regulation development missions and the supervision missions be carried out independently.

The present organisation of the FANC has been prepared beginning of 2007 and came into force on 1 September 2007. The FANC organisation chart can be drawn as follows:

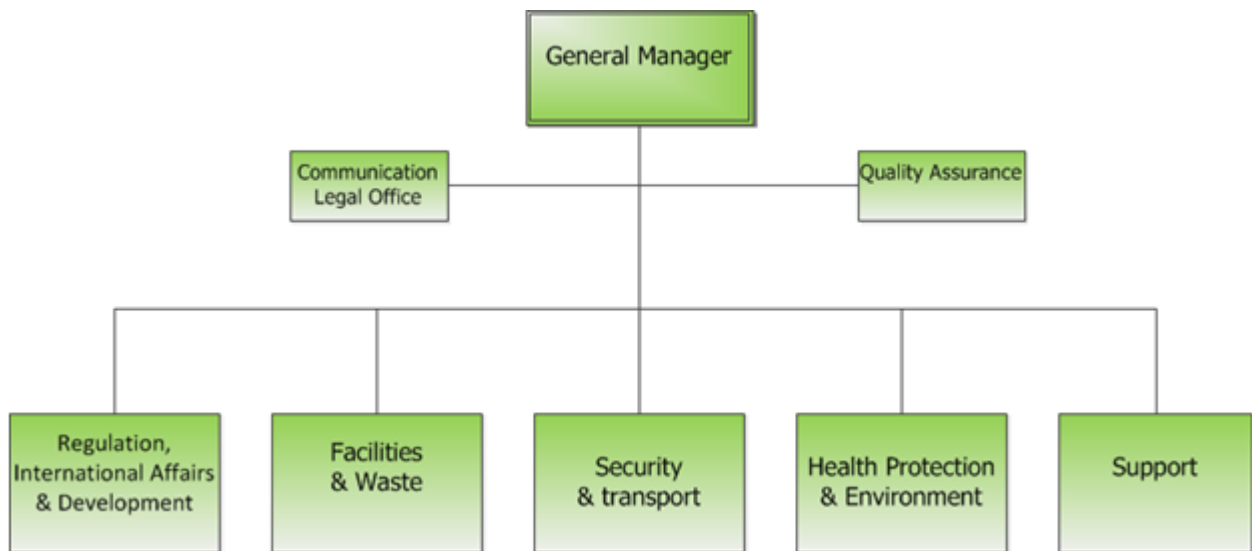


Figure 7 : Organisational chart of FANC

The department 'Regulation, International Affairs and Development' is in charge of

- the development of regulations,
- stimulating, following and carrying out the studies and the developments necessary in all fields to improve safety and the radiological protection of the population,
- managing, maintaining and developing a high level of knowledge,
- the coordination of FANC projects,
- international affairs,
- activities requiring the collaboration between several departments (horizontal activities).

The missions of the department 'Facilities & Waste' are specifically related to the nuclear industrial facilities, the management of the radioactive waste, the recognition of qualified experts in health physics control as well as the supervision of the bodies recognised for health physics control (Authorized Inspection Organisations).

- The first mission includes the inventory, the analysis and the evaluation of license applications. This mission consists in ensuring that ionizing radiation can be used safely and that a licence can be granted.
- The second mission involves the control, the inspections and the investigations that ensure that the activities carried out comply with the license and the conditions attached to, and, in a more general way, with the regulations in force. In addition, the department must also track down any illegal activity carried out without authorization. Synergy between these two missions mainly aims at improving: 1) the safety in general, and 2) the protection of the workers, the public and the environment against the hazards of ionizing radiation.
- The third mission includes the contribution to a regulatory framework for the disposal of radioactive waste of different categories, as well as the licensing for the facilities dedicated for surface disposal of short-lived low- and intermediate-level radioactive waste and future possible geological disposal of high-level and long-lived radioactive waste.

The department 'Security & Transport' is responsible for the physical protection of nuclear material, and for the regulation of transport, import, transit and export of radioactive material. Here also, the licensing activity as well as the surveillance of a specific activity have been integrated in the same

pillar, with the objective of optimizing the exchange of information and setting up a more effective control policy.

The department 'Health & Environment' is in charge of the activities relating to man and his environment (including the radiological monitoring network Telerad). This operational entity is directed towards the protection of the public, the workers and the environment in all fields, namely the medical and veterinary applications, the natural radiation sources, the radiological surveillance of the territory, the national nuclear emergency plan and the clean-up/restoration of contaminated sites.

At present, the personnel of the FANC is composed of about 150 persons. More than 60 % of them are university graduates in different fields of science (physics, chemistry, biology, medicine,, engineering, law, economics, social sciences and communication.

b) Foundation Bel V: Overall organisation

Bel V is a non-profit 'foundation', created by the FANC.

Bel V must perform its tasks and duties with experts that have to be recognised according to article 73 of the GRR-2001, ensuring that an expert has at least three years of experience in the nuclear field before he/she can be recognised as a class I expert. Bel V's personnel training budget amounts to about 10 % of its overall budget in man-hours.

At the end of 2006, in view of ISO-certification, a process oriented organisation has been implemented. Among these processes, the most important ones as regards safety are: to manage the projects/missions (manage safety assessment projects and inspection projects), to perform the inspections during operation, to provide and to manage expert services (perform safety assessment activities), to manage expertise and technical quality, to manage and to develop human resources. These processes are managed by directors who are accountable for the realisation of goals and the quality of the activities performed in the process they are in charge of.

Bel V's technical personnel is composed of some 70 (65 full-time equivalent on 31/07/2012) university graduates (engineers and scientists), and recruitment is in step with the foreseeable workload. The workload consists of a more or less constant portion related to inspection of installations, and a more variable load in time related to the progress of the licensee's projects and the number of safety assessments to be examined, and also to the assessment of incidents or specific safety problems in the installations in Belgium or abroad (Barsebäck, Forsmark, Fukushima Daiichi...).

The inspections and analyses carried out by Bel V are invoiced to the operator on the basis of hours actually worked. This system is similar to that applied by, for example, the USNRC which, in addition to a set fee per installation, charges to the operators the time actually spent on their problems. In the next future, the hourly tariff of Bel V experts will be fixed by Royal Decree.

Due to Bel V being a non-profit organisation, its financial resources are used for the payment of its personnel and related costs, for the participation in national or international working groups, for personnel training, for its research and development activities, for the maintenance a technical and regulatory documentation.

c) Bel V: Technical Activities

Besides the hierarchical structure in 3 departments, Bel V's technical staff, regardless of which department they hierarchically belong to, is attached to "Technical Responsibility Centres" (TRC), "horizontal" cells in charge of exercising nuclear and safety expertise and of maintaining the knowledge in the various technical specialities.

As from the end of the year 2006, Bel V's technical staff has carried out the technical activities within the operational processes as described above.

The management of all TRCs is performed within the process "Provide and manage expert services", managed by a director, in order to give it better support and have a harmonized approach.

The process "**Perform inspections during operation**" is in charge of inspections in all nuclear installations supervised by Bel V.

For the nuclear power plants, one Bel V engineer is assigned to one nuclear unit (hence 3 engineers for Doel, as the Doel 1 & 2 twin units are considered as a single unit, and 3 engineers for Tihange) and the managerial staff examines the problems common to a site as a whole, oversees the coherence of approaches between the sites and ensures experience feedback between all the Belgian units.

The activities performed in this process include also inspections in installations other than nuclear power plants, namely other class I facilities as well as class II and III facilities (universities, hospitals,...) having their own Health Physics Department.

The follow-up of all national and international projects linked to the operation of the installations is performed in the framework of the process "**Manage the projects/missions**".

At the national level, examples are the European "stress tests", the periodic safety reviews, the pre-licensing process of the MYRRHA Accelerator Driven System, the power increase and the replacement of steam generators, the increase of the length of the cycles and the higher burn-ups.

At the international level, the co-operation with the Safety Authorities of several countries outside the European Union (bilateral aid or INSC contracts of the European Commission) is continued.

In the frame of the periodic safety reviews, Bel V follows the evolution of the safety standards in the world (USA, Member States of the European Union, IAEA...) and examines with the licensees which new standards should be followed, in order to define the new safety reference levels, in agreement with the FANC.

Safety assessment is performed in the framework of the process "**Provide and manage expert services**". It covers support to inspection activities, the analysis of significant modifications, and analysis having a more general character: generic studies valid for all nuclear power plants, probabilistic safety assessment developed specifically for each unit but where the analysis methodologies must be identical, applications of these probabilistic studies in particular to the analysis of operational events, severe accident management, safety requirements for future reactors, safety analysis for the disposal of radioactive waste.

The process includes Bel V activities in the frame of its participation in the national emergency plan at the level of the evaluation cell (see article 16, paragraph II.L.2). It also participates in the emergency plan exercises related to the Belgian nuclear installations (nuclear power plants and other facilities), as well as in the exercises of foreign nuclear power plants located near the Belgian border, through bilateral or international collaborations.

Research and Development activities in which Bel V participates (international projects like research and development activities within programmes financed by the European Commission, bilateral and own developments in Bel V) are managed in the framework of the process "**Management of expertise and technical quality**".

Alongside its own experts, Bel V calls on services from outside specialists only very exceptionally (universities, research centres): on the one hand these should not have worked in the past on behalf of the operator on the subject, and, on the other hand, full definition of the scope, framework and precise objectives of the task or studies that would be subcontracted represents a non-negligible part of the overall effort and time that can be devoted to the job. Examples of Bel V's calling on outside expertise concerns the evaluation of neutron-ageing of the aluminium reactor vessel of the BR2 reactor or the recent reactor pressure vessel flaw issue of Doel 3 and Tihange 2 reactors.

The organisation chart of Bel V is given below:

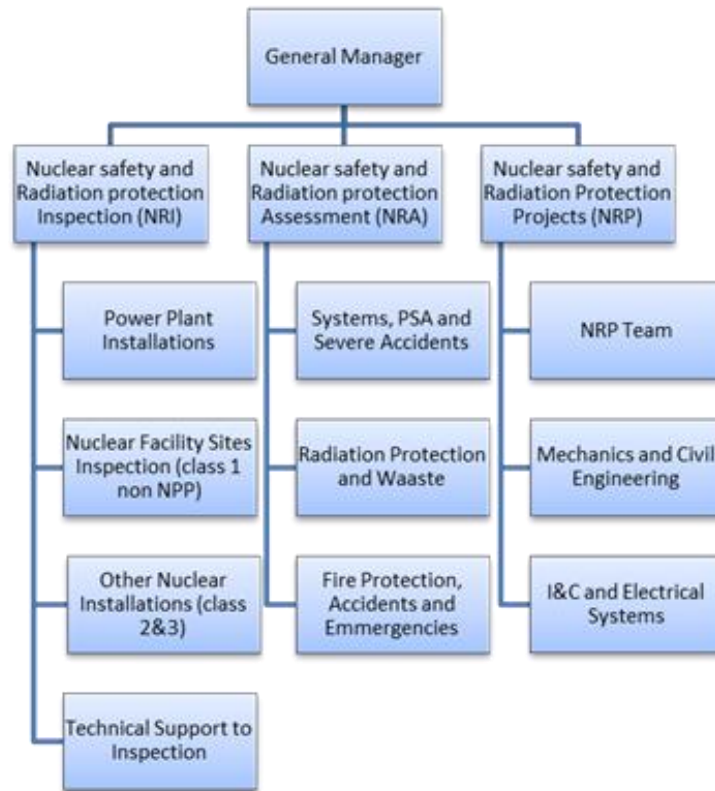


Figure 8 : Organisational Chart of Bel V

II.D.4. Position of the Regulatory Body in the Governmental Structure

The Safety Authority (FANC) is a public interest body, with a large independency and that reports to its supervising minister, the Minister of Home Affairs.

The FANC has the duty to communicate with the public. Therefore, they answer for instance any questions and requests for information received from the Government, Members of Parliament or from others.

The FANC annually presents its report of activities to the Parliament.

Bel V is a non-profit 'foundation' created by the FANC. It establishes a quarterly report and also publishes an annual activity report of activities to be submitted to its Board. This report is referred to in FANC's annual report and also presented to the Parliament.

II.D.5. Relations between the Regulatory Body and the Organisations in Charge of Nuclear Energy Promotion and Use

In Belgium the nuclear power plants are operated by a private operator. He promotes the use of nuclear energy, as does the Nuclear Forum - Forum Nucléaire, member of Foratom.

The organisations dealing with questions related to the use of nuclear energy, such as the "Centre d'Etudes Nucléaires" SCK•CEN in Mol, or the Belgian Agency for Radioactive Waste and Enriched Fissile Materials (ONDRAF/NIRAS) report to the Ministry of Economic Affairs (also to the State Secretary for Energy).

As mentioned above, the Safety Authority (the FANC) report to the Minister of Home Affairs.

The Regulatory Body play no part in nuclear energy promotion, but the FANC also has a mission to "stimulate and co-ordinate the research and development works. It establishes privileged relationships with the public organisations working in the nuclear field, with the scientific research circles and with the international organisations involved." (Art. 23 of the law of April 1994).

II.D.6. Relations between FANC and Bel V

A Management Agreement has been signed between the FANC and Bel V. The main elements of this management agreement are given hereafter.

a) Operational and strategic objectives

By delegation of the FANC, Bel V is in charge of the following regulatory activities:

(1) On site regulatory inspections and controls.

An integrated control and inspection strategy is developed jointly by the FANC and Bel V. A 3-year programme is defined and communicated to the licensees. An annual planning for inspections and controls is derived from this programme. A revision of the programme is foreseen each year, in order to take into account experience feedback from the previous years.

The annual control programme of Bel V is approved by the FANC.

Bel V is in charge of the surveillance of the good working of the Health Physics Department of the licensee.

Bel V is in charge of setting up inspections methodologies and evaluation processes for the different types of facilities it supervises.

Bel V informs the FANC on its findings. In particular, any situation that may have an impact on the public, the workers or the environment is immediately communicated to the FANC.

Each year, Bel V makes an evaluation of the safety of the installations it controls, and draw up the lessons learnt of the controls it has performed.

(2) Delivery of new installations

Bel V is in charge of the supervision of the delivery of new or modified nuclear installations. An acceptance report is sent to the FANC.

(3) Safety assessments and environmental impact assessments.

Bel V is in charge of the review of the safety analysis of the facilities it supervise.

Bel V is in charge of the verification of the safety analyses submitted by the licensee in the frame of the periodic safety reviews of its installations.

Bel V submits the results of the safety reviews to the Scientific Council of the FANC.

(4) Emergency preparedness and response

Bel V collaborates with the FANC for technical and radiological evaluations in the different cells set up in emergency planning and response: The measurement cell (CELMES) and the evaluation cell (CELEVAL).

In particular, an internal crisis centre is set up and maintained by the FANC. The FANC and Bel V are jointly responsible for the setting up of the procedures, for the staffing and for allocation of resources during emergency situations.

(5) Security of nuclear installations

Bel V is in charge of reviewing security plans on request of the FANC and of the associated on-site inspections. Bel V is also in charge of the assessment of the modifications of the security plans.

b) Transverse processes

A collaboration between FANC and Bel V is established in the following areas:

(1) Advice on regulation proposals

Bel V collaborates with the FANC to give advice on new regulation proposals, on the application and interpretation of regulations, and on regulation gaps and shortcomings.

(2) Cooperation in international activities.

Bel V and FANC activities are coordinated in a structured manner in the field of international multilateral and bilateral activities and representations, in particular in the frame of WENRA, the Convention on Nuclear Safety and the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management.

(3) Research and Development

A coordination is established between the FANC and Bel V for the research and development programmes, in order to ensure complementarity, search synergies and ensure circulation of results.

(4) Knowledge management, improvement and development of knowledge.

A collaboration will be established in the field of knowledge management.

c) Funding of Bel V

Bel V is a non-profit organisation. It is funded by:

- The FANC;
- The licensee for the on-site controls and safety assessments it performs, according a pre-defined hourly tariff. This tariff will be fixed by royal decree in the future.

This management agreement is concluded for a period of 3 years and implicitly renewed at the end of each period. It can also change/evolve in function of experience feedback, future needs or missions.

II.D.7. International relations

For the different international activities in which the Regulatory Body is involved, we refer to the section I.D.6 of the present report.

International representations and participations have been optimized between FANC and Bel V, regular information exchange meetings between FANC and Bel V take place, documentation/feedback is systematically shared and common positions are defined.

II.D.8. Conclusion

The legal framework and system described in section II.C and II.D offers a solid basis for effective and efficient implementation of regulatory responsibilities and duties.

The Belgian regulatory body has the legal powers and human and financial resources necessary to fulfil its assigned responsibilities including the powers and resources to:

- require the licensee to comply with national nuclear safety requirements and the terms of the relevant licence;
- verify this compliance through regulatory reviews, assessments and inspections; and
- carry out regulatory enforcement actions.

Independence of the regulatory body is strengthened by the legal structure of the FANC and by a clear and well defined relationship with the Government. As extensively discussed during previous review meetings of the CNS, while recognising that a regulatory body cannot be absolutely independent, it was stated and commented that both aspects of independence, de jure and de facto, are essential. It can be found in the literature¹ that those concepts rely on different important parameters like:

- clear safety objectives
- appropriate financing mechanisms
- defined accountability procedure and reporting
- transparency, adaptability to industry and society changes
- available competence
- quality assurance
- management of human resources in the regulatory body
- access to expertise

Since September 2001, when the FANC became fully operational, and in further developments of the Regulatory Body, particular attention has been devoted to implement the national structure in accordance with those values and concepts.

¹ INSAG-17 Independence in regulatory body decision making

II.E. Article 9. Responsibility of the Licence Holder

Each Contracting Party shall ensure that prime responsibility for the safety of a nuclear installation rests with the holder of the relevant licence and shall take the appropriate steps to ensure that each such licence holder meets its responsibility.

Article 2 of the Royal Decree of 20 July 2001 (GRR-2001) defines the "Licensee" as follows:

"Any natural or legal person who is responsible of a facility or a work activity that is subject to licensing or reporting according to chapter II."

Article 5.2 of the GRR-2001 also indicates that the licensee is responsible for complying with the conditions set in the licence. For the nuclear power plants the Royal Decree of Authorisation requires conformity with the Safety Analysis Report and with the document established in implementation of Article 37 of the Euratom Treaty.

This authorization sets that modifications of the descriptions included in the SAR are nevertheless acceptable if they improve the safety of the nuclear installations or have no impact on their safety.

The licensee must organise a Health Physics Department in charge of nuclear safety and radiological protection, and must also organise the safety and health at the workplace as well as in the neighbourhood. A detailed description of the duties is given in Article 23 of the GRR-2001 (Article 7-section II.C.3 of this National Report).

The operator must also conclude a civil liability insurance (Article 6.2.5 of the GRR-2001); the law of 22 July 1985, which makes the conventions of Paris and Brussels and their additional protocols applicable, and the law of 13 November 2011 set the maximum amount of the operator's liability for the damage at some Euro 1.2 billion per site and per nuclear accident.

Other obligations of the operator include information and training of the workers (including workers not belonging to its own personnel) who might be exposed to radiation, and implementing the policy to limit individual and collective doses (respectively Articles 25 and 20 of the GRR-2001).

The Belgian law also requires that the Regulatory Body permanently controls the proper implementation of the duties of the operator's Health Physics Department. Article 23.8 of the GRR-2001 specifies a number of specific tasks in that respect.

As referred to in Article 8 of the present National Report, a Bel V inspector is assigned to each nuclear power unit. The inspection visits that he makes at the unit (where he has total freedom of movement, regardless whether or not he is accompanied by unit personnel) take up about 25% of his working time; the rest of the time, the inspector is at Bel V offices where he follows-up the inspections, writes the inspection reports, collects and analyses relevant information, discusses with the technical experts and exchanges information and gets feedback from the other nuclear power units. In this way the Bel V inspector can verify daily how the operator ensures his obligations and responsibilities.

II.F. Article 10. Priority to Safety

Each Contracting Party shall take the appropriate steps to ensure that all organisations engaged in activities directly related to nuclear installations shall establish policies that give due priority to nuclear safety.

II.F.1. NPPs Licensee Safety Policy and Safety Culture

a) **Nuclear Safety policy Declaration**

In order to state precisely the nuclear safety policy during operation, the CEO of GDF SUEZ BELUX in charge of the day-to-day management of Electrabel S.A. has established and backs up the following "Policy Declaration on Nuclear Safety", which is included in the Safety Analysis Reports of the nuclear units:

"We attach the greatest importance to the protection of all members of personnel involved in operation of our nuclear power plants, of the public and the environment. Therefore, we actively support a strong nuclear safety policy in all phases of the operating processes of our power plants.

Safety = the first priority

- We ensure that safety takes precedence over production, in all circumstances.
- We ensure that safety is present everywhere in all operational processes.
- We anticipate the laws and regulations concerning nuclear safety and apply them scrupulously.
- We develop and promote a high level of safety culture.

Safety = a process of continuous improvement

- We set objectives and corresponding action plans so as to continually improve nuclear safety.
- We constantly assess the safety level of our activities, and compare them with the best practices and international standards.
- We involve all our personnel in this process of continuous improvement and ensure that they actively participate in it.

Strict controls

- We maintain a constructive dialogue with the authorities and safety institutions, as well as the other parties involved.
- We constantly measure the effectiveness with which our safety policy is applied.
- We have regular external audits and international comparisons carried out."

b) Safety Culture

The GDF-Suez Electrabel approach for implementing "Safety Culture" is schematically given in the figure below:

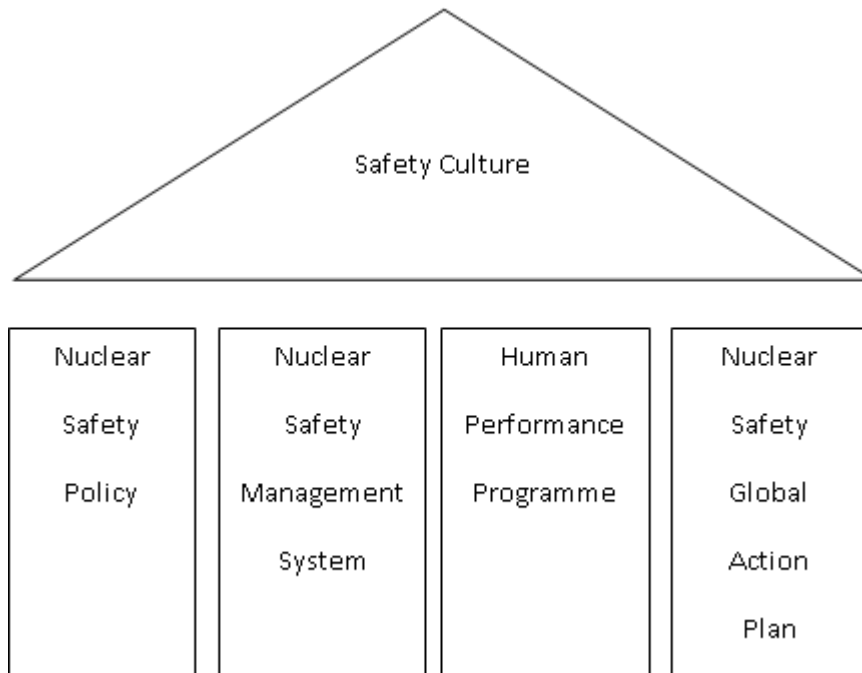


Figure 9 : GDF-Suez Electrabel Safety Culture Pillars

It is based on the following four pillars:

Pillar 1: Values and Behaviours promoted by the Nuclear Safety Policy Declaration

The first principle stated in this Nuclear Safety Policy is "Safety = the first priority".

This Nuclear Policy is posted in many places on the site and at least at the entrance of each building. The document is also integrally copied in the management expectations booklets. During the initial training in nuclear safety, all employees receive the Nuclear Safety Policy document and a specific module is devoted to explain this policy.

The way to implement the principles defined in the Nuclear Safety Policy is described in the management system. The role, responsibilities and accountabilities of each level of the management regarding nuclear safety are clearly defined by following the INSAG-4 "Safety Culture" from IAEA.

Pillar 2: Organizational and individual behaviours implemented through Nuclear Safety Management System

Below the Nuclear Safety Policy, on a second level, the Nuclear Safety Management System provides structure and direction to the organization in a way that permits and promotes the development of a strong safety culture together with the achievement of high levels of safety and excellent performance.

The organizational and individual behaviours described in the Nuclear Safety Management System are provided as guidance to staff. Process owners are in charge to integrate these behaviours into the processes they are responsible for.

The management system promotes a working environment in which staff can raise safety issues without fear of harassment, intimidation, retaliation or discrimination.

The change management covers both the management of organizational changes and the willingness of teams and individuals to adapt to organizational changes that improve safety business performance.

As Electrabel strives for continuously developing and improving its employees competence and performance, the Employees Performance Management process involves, in an individual and interactive way with the employee, the definition of objectives with regard to his/her competence

development, job performance, the application of corporate values and giving feedback on the employee his/her way of performing.

Pillar 3: Human performance policy within Electrabel

Tihange and Doel power plants have developed a common human performance policy which is based on two approaches:

- A bottom-up approach, which analyses the root causes of events (including the human factor)
- A top-down approach, which relies on human performance tools, safety culture awareness, and tasks observation.

Efficient implementation of the human performance policy in the field requires training and coaching, as well as transparency, trust, and mutual respect (no blame culture).

Pillar 4: Electrabel Global Nuclear Safety action plan

The Global Plan for nuclear safety is an output of the Nuclear Safety Management System. It lays down main objectives of Electrabel in nuclear safety for the coming years (from 2011 to 2015). As a fourth pillar, these are aimed in particular at continuously improving the performance and the safety culture.

These objectives are grouped in thirteen themes as following

- Management, organization, and administration
- Competence and Knowledge Management
- Operations
- Fire Protection
- Maintenance
- Engineering
- Facility Configuration Management
- Nuclear Fuel
- Operating experience feedback
- Radiation protection
- Emergency Plan
- Chemistry
- Site Security and Non-Proliferation

With this Global Plan, Electrabel formally expresses clear objectives to consolidate its safety approach and improve its safety culture.

Regarding safety Culture specifically, the Global Plan for Nuclear Safety 2011-2015 states the following:

"A strong safety culture is required in order to achieve zero-accident operation. This means that everyone has –and must acutely feel– personal responsibility for nuclear safety and contribute to human performance excellence. To achieve this target, we must carry out the following over the next five years:

- Deepen the personal sense of responsibility for problem solving: efficient leadership requires rapid decision-making and an individual sense of responsibility geared towards positive results with every member of staff committed to this ideal;
- Increase and ensure the presence of managers in the field to bolster compliance with instructions and expectations with the application of a policy of zero tolerance regarding nuclear safety failings;
- Improve the general behaviour in terms of human performance by better implementation and use of tools to reduce human error in order to match and even exceed the level of the best power stations, instil a questioning attitude, ensure adherence to procedures, apply a rigorous approach, employ risk analysis, use a conservative decision-making process, ensure the application of the in-depth defence principle, carry out internal and independent inspections, secure communication, and take operational feedback on-board during pre-job briefings and post-job reviews."

c) Organisation

Nuclear activities within Electrabel are managed on a four level structure:

- Corporate level,
- Business Unit level,

- Nuclear Generation level and
- Nuclear Power Plant level.

The departments at **corporate level** playing a major role that are most noteworthy with regard to nuclear safety are:

- The **Electrabel Corporate Nuclear Safety Department (ECNSD)**: this department is in charge of evaluating the effectiveness of the management of nuclear safety in the nuclear power plants. The six processes ECNSD is involved in are determining nuclear safety strategy, coordinating actions regarding nuclear safety according to the Electrabel Global Plan, reporting on nuclear safety, gathering expertise on nuclear safety, independent monitoring of nuclear safety and providing operational support for the nuclear power plants. The ECNSD department reports directly to the Health and Safety and Nuclear Safety Officer, who is by law the head of the Health Physics Department. Through the Health and Safety and Nuclear Safety Officer, ECNSD reports directly to the CEO.
- The **Human Resources Department** is located on the corporate level. The activities of Human Resources are mostly focused on the competency development and knowledge management of the personnel of Electrabel.

The creation of the position of Chief Nuclear Officer (CNO) has introduced an additional level in the organization of Electrabel: the **Nuclear Generation level**. The CNO is responsible for the safety, reliability and performance of the Nuclear Plants of Electrabel

Noteworthy the Nuclear Assets & Projects Group at corporate level includes the following departments:

- **Process and Performance Management (PPM)** department is in charge of the Quality Assurance and Operational Experience activities at corporate level.
- **Asset Management & Strategy (AM&S)** department is in charge of the strategic assets management and of some support activities. It manages large-scale safety projects common to the NPP's and handles project coordination between them.
- **Nuclear Fuel** department is in charge of all the fuel handling operations, the follow-up of the cycles as well as of the relations with Synatom, the company who is in charge of all aspects concerning procurement of new fuel and the back-end of the fuel cycle.
- **Nuclear Liabilities** department is in charge of managing radioactive wastes inventories, defining plant shutdown and dismantling strategy, periodically assessing the financial provisions to cover liabilities and preparing final shutdown and dismantling

At the **Nuclear Power Plant level**, the organisation is structured in 5 departments:

- The **Maintenance** department is in charge of ensuring the short and long term availability of the installations and equipment. It is also responsible for the management of contractors.
- The **Operations** department is in charge of the safe conduct of the generation process and of the installations.
- **Engineering Support** is in charge of the management of the modifications and projects on site and of the management of the generic issues and long-term concerns. Furthermore the Engineering Support department has the competency of Design Authority, validating the conformity of proposed changes with the overall safety design basis.
- The **Continuous improvement** department is in charge of Human Factors and operational Experience activities
- The **Care** department is in charge of surveillance in radioprotection (Health Physics Control in the sense of the GRR-2001), measurements, protection of the workers (industrial safety), fire protection, environment and safety of the installations (including the setting up and the management of the emergency planning and preparedness). It is the local representative of the centralized Health Physics Department (as required by the regulations) and has the appropriate delegation from this department to perform the formal approvals required by the regulations. It ensures the respect of the nuclear safety culture by independent technical checks and thus forms the link with the Electrabel Corporate Nuclear Safety Department (as mentioned before).

The figure below shows the organisation of ECNSD, the functional links with the Care departments on the two sites and the corresponding delegations.

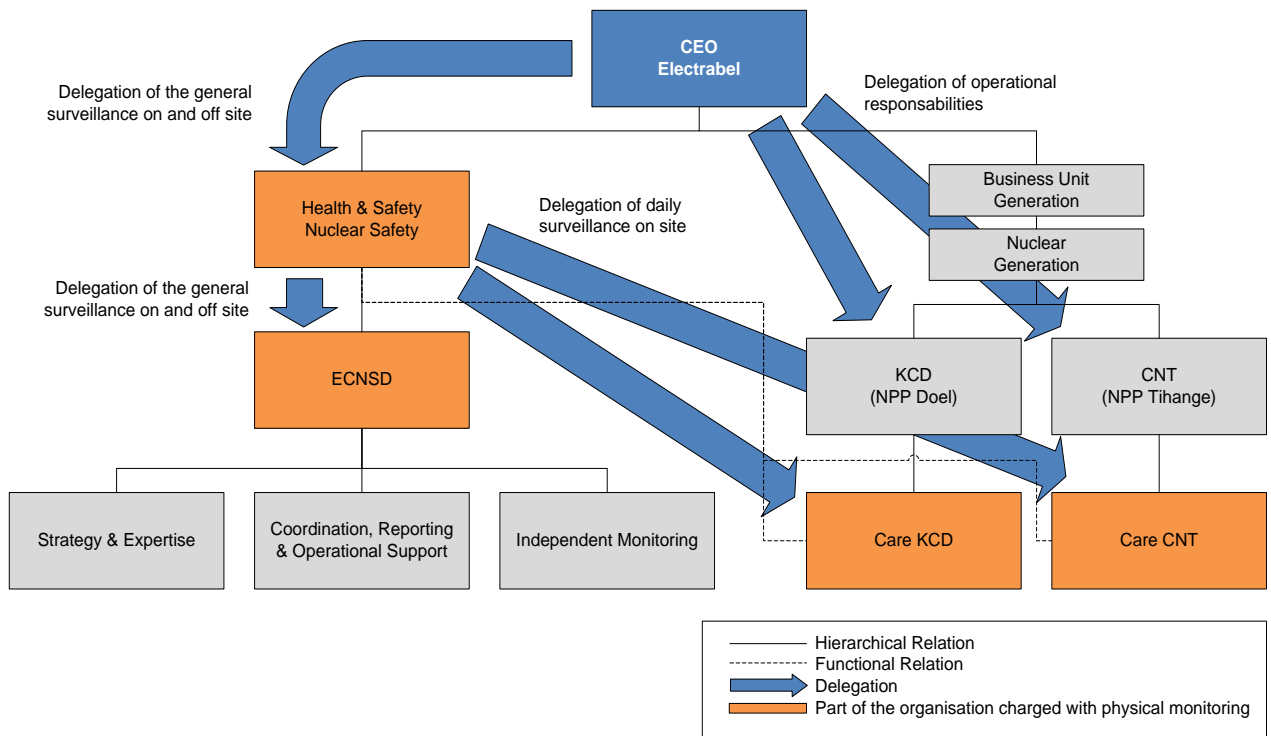


Table 4 : Organisational structure of ECNSD

d) Monitoring & Assessment of safety performance

In order to ensure optimum efficiency, the internal assessment of Safety is organised into different levels of control where each level corresponds to the different levels of the operational hierarchical line.

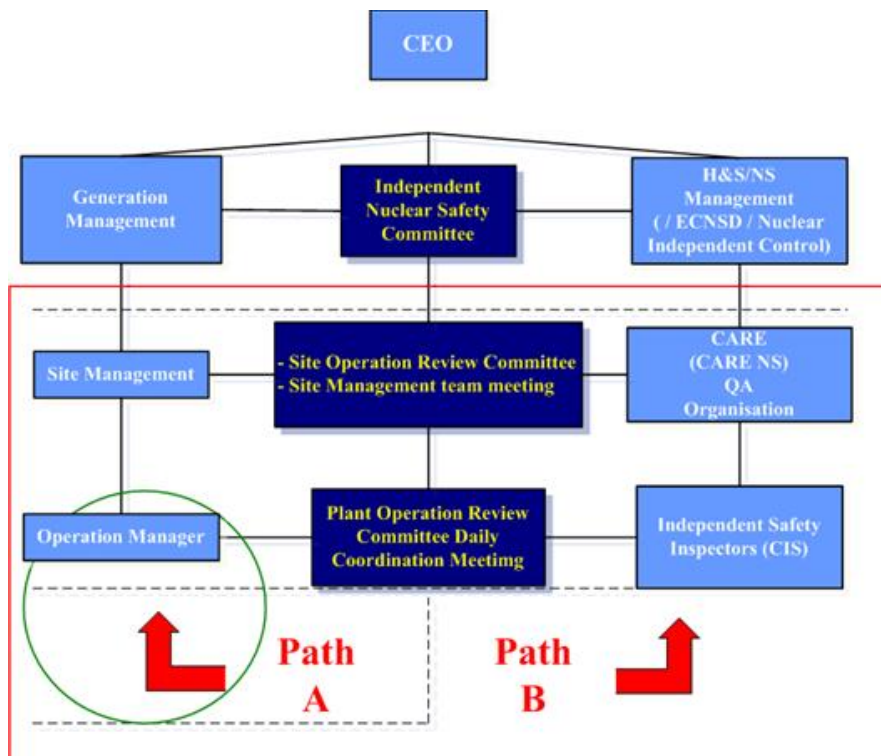


Figure 10 : Internal Safety Assessment

The operational line performs its own self-assessment.

Path A represents the operational line assuming final responsibility for nuclear safety. Path B represents the path entrusted with monitoring and supervision. In order to ensure its independent control mission, Path B is hierarchically totally independent from the operational hierarchical line.

There are three independent levels of Quality Control (QC1, QC2, QC3) and one level of Quality Assurance (QA):

- **QA:** performed by QA organisation, to check compliance with the quality requirements indicated in the nuclear safety reference system and to monitor compliance with the management systems,
- **QC1:** performed by and in the operational departments, to ascertain the technical quality of interventions (Self-control Point, Witness Point and Hold Point) and to control compliance with their processes,
- **QC2:** performed by independent safety inspectors, by using the Key Performance Indicators, the internal and external Operational Feedback, benchmarking, follow-up of corrective actions, "external" data (AIO, external audits, etc.), self-assessments, etc., together with its own controls, to measure the effectiveness of Nuclear Safety management and to present proposals to further improve Nuclear Safety,
- **QC3:** performed by the Nuclear Independent Control (attached to ECNSD), which uses the results of the abovementioned controls, together with its own assessments, to draw up an overall picture of Nuclear Safety of EBL and to propose areas for improvement.

II.F.2. Research Reactors

The general management published a safety and security charter stating the importance of safety for the operation of the installations. The charter also promotes a positive attitude towards safety culture. Additionally, attention is asked for security and physical protection aspects. In 2010, this charter is completed by the publication of management expectation on the use of procedures.

These general statements are further put in practice by a number of actions. A short training on the aspects of safety culture was given to all members of the personnel. The aim of this training is to convince the personnel that reporting of unusual or unsafe situations, including those as a consequence of own errors, is an important way to prevent accidents. For BR2, a system to report these events (technical and non-technical) already existed. This is a complete open system. Every member of the personnel can introduce a report without restriction. The reports are discussed during the daily operators meeting and an action is defined if necessary. This reporting is already a number of years in operation and is considered as very valuable. Based on this experience, a reporting system for the rest of the installation of the SCK•CEN (including the BR1 reactor) is set up. The system is centralized by the internal safety services.

Another point of attention is the learning from operational experience feedback (OEF), both from internal and from external events. Personnel is encouraged to report facts with a potential interest for other, regardless whether these are incidents or good practices. For the external OEF, special attention is paid to the IAEA incident reporting system for research reactors. Information from incidents from power reactors is used insofar the subject is applicable to BR1 or BR2.

The training of the personnel also included ways for risk analysis, for use during the preparation of a task or just before and during the execution of the task. Operating procedures, especially the procedure for executing non-standard tasks, include a risk analysis. In case of an incident, an investigation on the causes is executed. The cooperation of the operators is solicited. Everyone is expected to add his information, which will be treated blame free.

A last important action is to keep the knowledge of the installation. The SCK•CEN has an operation history of more than 50 years, which means that people involved in the design and building of the installations are no longer available. In this way it is very important to keep all documentation about the installations in good condition in such way that it is readily available. A special action was initiated about this issue.

In order to coordinate all these actions on safety, an integrated management system is under development, based on the IAEA Standard GS-R-3 (The Management System for Facilities and Activities).

II.F.3. Regulatory Body

The FANC is responsible (amongst other duties) for the supervision and control of all the activities concerning radiological protection and nuclear safety.

Radiological protection, and implicitly nuclear safety, is emphasised in the general principles of the GRR-2001. However, special emphasis has been put on safety by the FANC.

End 2003, the FANC established its "*General Inspection and Control Policy*". This document is quite explicit regarding priority to safety, and is reproduced hereafter:

"The basic principles of the General Inspection and Control Policy"

The inspections and controls serve to verify that the activities performed by the operator/company are undertaken in a safe manner. For this purpose, it is necessary that:

- the operator/company has a management and a policy aimed at safety and its improvement, pursued in a fairly continuous manner. The necessary measures have to be taken, on the one hand, to prevent accidents and, on the other, to limit the consequences of possible accidents;
- the operator/company disposes of competent and well-trained personnel;
- the operator/company pursues (and preserves) safety, reliability and quality while designing, constructing, operating, maintaining, closing down and dismantling his/its facilities/installations;
- the operator/company is able to prove at all times that he/it complies with all of the provisions of the regulation and the operating conditions stipulated in the licences;
- the operator/company disposes of a system enabling him/it to draw lessons from internal and foreign experiences.

The operational measures for the implementation of the General Inspection and Control Policy

The inspections and controls are thus a targeted assessment of the activities of the operator/company in order to bring to light the possible problems, shortcomings or violations of the operator with regard to the above-mentioned obligations. However, these inspections and controls shall in no way release the operator/company from his/its fundamental and entire obligation and responsibility to guarantee the safety of his/its facilities/installations and the protection of his/its workers, the population and the environment. The inspections and controls may include the following: analyses, studies, assessments, observations, measurements, tests taken by, or on behalf of the FANC/Bel V in order to verify if materials, components, systems and structures, as well as operational activities, processes, procedures, competences and performances of the persons involved are in conformity with the prescriptions of the regulation on ionising radiation, the operating conditions stipulated in the licences and safety in general. Within the framework of continuous improvements, the services of the FANC and Bel V which perform the inspections and controls, will obtain a quality certification.

...

Bel V elaborates control strategies for the implementation of this general policy of the FANC. The FANC will establish, in consultation with Bel V, objectives (which Bel V will have to pursue) and indicators (specifying the extent to which Bel V is achieving the intended objectives).

The FANC will periodically evaluate its general inspection and control policy."

In application of these basic principles, since January 2009, FANC and Bel V developed a common strategy for inspections and control of the nuclear installations. This strategy guarantees a still more integrated approach in the field of nuclear safety and radiation protection. A 3 years based programme is defined and communicated to the licensees. An annual planning for inspections established, based on this programme. A revision of the programme is foreseen each year, to take into account experience feedback from the preceding years. The process is explained in more details on the FANC web site (in French and Dutch): <http://www.fanc.fgov.be/fr/page/la-ici-strategie-d-inspection-et-de-controle-integree-pour-la-periode-2012-2014-pour-les-etablissements-nucleaires-de-base-enb/1438.aspx> .

As a matter of fact, on the basis of its large inspection experience as well as of its well-established know-how in collecting and interpreting operation feedback data, Bel V has, in the course of the years, developed an inspection and safety assessment strategy aiming at the assessment of how the

licensees manage safety, with specific emphasis on the implementation of the GRR-2001 and of the licenses of the various installations.

This strategy contains the implementation of a permanent monitoring of the licensee and of conformity checks of the installations, general objectives and an inspection programme with various types of inspections. This strategy is evolving with time and safety concerns (e.g. human and organisational performances), and supported by strong programmes of expert initial training and retraining, of operating experience data collection and analysis, of specific research and development activities.

This strategy is imbedded in the various processes of the ISO-9001:2008 quality system of Bel V (certification obtained in the beginning of 2010), which is based on expert assessment and judgement. The system allows a clear definition of responsibilities and a better tracing of the performances.

II.G. Article 11. Financial and Human Resources

- 1) Each Contracting Party shall take the appropriate steps to ensure that adequate financial resources are available to support the safety of each nuclear installation throughout its life.
- 2) Each Contracting Party shall take the appropriate steps to ensure that sufficient numbers of qualified staff with appropriate education, training and retraining are available for all safety related activities in or for each nuclear installation, throughout its life

II.G.1. NPPs

a) Operator's Financial and Human Resources to use the Installation throughout its Industrial Life

The Doel and Tihange power plants are operated by Electrabel, a member of the GDF-Suez group that was created after the merger in 2008 of 2 groups "Gaz de France" and "Suez". The share of the company in electricity generating capacity in Belgium amounts to 64% in 2010.

Main activities of Electrabel are the generation and commercialisation of electricity and gas in Europe. In Belgium, Electrabel is the owner of the twin units 1 and 2 (100%) and the units 3 and 4 (89.8%) of Doel, and of the unit 1 (50%) and of the units 2 and 3 (89,8 %) in Tihange. The installed power of Belgium's nuclear generating units accounts for some 40 % of all installed power in Belgium. Nuclear electricity accounts for some 55% of all electricity produced in Belgium (see table 1 of the Introduction of this Report).

About 1900 people (about one hundred at corporate level and the remaining equally distributed on the NPP sites) are devoted to nuclear power plant operation among Electrabel's total workforce in Belgium of around 7000. In September 2002, the company Elia System Operator was appointed by the Belgian Government as the Manager of the electricity distribution network. This activity is now completely separated from the activity of electricity generation. Electrabel has signed specific connection contracts with Elia. In accordance with the legislation on deregulation of the electricity sector in Europe, all distribution activities in the three regions of Belgium have been separated and turned into independent companies.

The GDF-Suez group has also an Engineering division, Tractebel Engineering, which is the Architect-Engineer of the Belgian nuclear power units (and of most of the fossil fired plants) and which houses know-how accumulated over fifty years of nuclear technology, which started with the construction of the first research reactors at the Mol Research Centre.

b) Financing of Safety Improvements during Operation

Major safety improvements to the Belgian nuclear power stations emanate from the periodic safety reviews (ten-yearly) and are financed through annual provisions (1/10th each year). Cost of specific projects and for replacement of aged or obsolete components are amortized on the remaining lifetime of the concerned power plant.

c) Financial and Human Provisions for Future Decommissioning and for Management of the Waste produced by the Installations

The existing mechanisms are described in the Belgian report for the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management. More details can be found in that report, available on the FANC and IAEA web sites.

d) Rules and Requirements for Qualification, Training and Re-training of Personnel

The Safety Analysis Report (chapter 13) deals particularly with personnel qualification, training and re-training. Qualification of the personnel is inspired from the ANS 3.1 standard, though adapted to the Belgian educational system. The Safety Analysis Report defines the level of qualification corresponding to each of the safety-related functions. It does not state the individual qualifications of each person in the organisational chart. However, proof of qualification of all the operating personnel is available to Bel V). The functions and qualifications prescribed by the US regulations are transposed in function of the educational system structure and curricula existing in Belgium.

The training programmes are defined in the Safety Analysis Report, which includes a "function-programme" correlation chart. Chapter 13 of the Safety Analysis Report lists exhaustively all posts for

which an authorization is required. This authorization is based on the positive opinion expressed by an Assessment Committee, which examines the candidate's knowledge. This qualification is reviewed every two years or, if an authorized person has ceased during four months or more performing the function for which he/she was qualified. It is renewed on the condition of, among other, a favourable advice of the Assessment Committee on the basis of the individual's training and activity file.

Bel V is member of the Assessment Committee, with veto right.

A knowledge re-training programme for all authorized personnel is defined in function of the occupied position. The contents of this programme which is discussed with Bel V, is essentially operation-focused and includes, among other, a refresher course regarding the theoretical and practical knowledge (two weeks per year), training on the full-scope simulator (two weeks every two years) and, in teams, a review of the descriptions of the different systems (two weeks per year).

The SRNI-2011 requires that the Licensee identifies in a systematic and documented way, the needs with regard to the qualification and training of personnel executing safety-related activities

The GRR-2001 requires an annual retraining of the whole personnel on the basic rules of radiological protection, including the good practices for an efficient protection and a reminder of the emergency procedures at the work site.

e) Training at Electrabel

(1) Electrabel training policy

The Electrabel policy statement on competency development and personnel training recognizes that the training of personnel and the continuous development of their skills are essential for the on-going safety and optimal performance of both the on-site plant staff and the installation.

Through this policy, the Doel and Tihange NPP management ensures that every employee receives appropriate training and only qualified personnel are assigned to tasks involving risks.

A Job Atlas Handbook has been developed at the Electrabel Corporate level. The Job Atlas Handbook lists all of the functions within Electrabel Corporate, as well as the corresponding competency and skills required. A detailed description has been defined for each function and a link has been made with the competences necessary to carry out each of these functions.

Every new employee follows an initial training programme that is aligned with their job description.

Every staff of Electrabel has an individual development plan. The content and implementation of this plan follows a four-step approach:

1. Analysis of the gaps between the competences required in the Job Atlas Handbook and the level as assessed by the individual and their manager
2. Creation of individual development plans
3. Implementation of development actions
4. Coaching and monitoring, evaluation and feedback

Managers regularly check that the aims of the training courses are being met and suggest improvements. To do so, they participate in training, perform verifications and/or gather feedback and evaluation results.

Article 6.2 of SRNI-2011 (WENRA Reference Level D.2.1) states: "Only qualified persons that have the necessary knowledge, skills, and safety attitudes shall be allowed to carry out tasks important to safety. The licensee shall ensure that all personnel performing safety-related duties including contractors have been adequately trained and qualified". All employees in question, including contractors, have obtained a competence pass ('Bevoegdheidsverklaring' in Doel, 'Passeport Métier' in Tihange), which shows that they have received adequate training and are fully qualified. The acquisition of competences during a training program is formally checked.

Training Facilities:

Each site has a Training Centre (on site or off-site) with a number of training facilities. It includes:

- Training rooms equipped with blackboards, PCs, etc.
- A miniature size version of a reactor unit
- A field simulator for work practices and human performance tools (the Human Performance Simulator)
- A room for hands-on training, for instance on the operation of pneumatic valves and PID controllers

- A room for the initial training of operators featuring a large number of demonstration tools
- Simulators (full-scope or multifunctional): Both Doel and Tihange have full-scope simulators.
 - In Tihange, the full-scope simulator is a precise replica of Tihange Unit 2. Extensions such as additional hardware panels and screens have been added to the equipment in order to provide the best possible training of Unit 1 and Unit 3 operators. A second simulator, with a non-replica man-machine interface, is used to illustrate specific aspects related to regulations, primarily through the projection of images. The three units being simulated on this "Multifunction simulator", it suits as a complement for the training of units 1 and 3.
 - Doel has two full-scope simulators: these are precise replicas of Doel Unit 1 and unit 4. The full-scope simulator of Unit 4 can be used in Unit 3 mode.

(2) Training Requirements

The training cycle is subdivided into two parts:

1. Initial safety training
2. Refresher safety training

Initial safety training includes course on nuclear safety, health and safety and environmental issues and must be completed by every NPP employee before they start their job. The initial training programme is tailored to the nature of function that will be occupied by the employee. Three levels have been defined accordingly.

Refresher safety training is given on an annual basis and is mandatory. It keeps employees informed about changes and operating experience in the areas of nuclear safety, industrial safety, radiological protection, environmental safety, human performance and management expectations. For technical functions, an additional refresher course has been developed but runs over 5 years.

(3) Training programs

Training programs have been developed for Operations personnel, Maintenance personnel, technical and support personnel and management and supervisory personnel.

More details are given below on the training programs for Operations and Maintenance personnel:

Operations personnel:

Members of staff who are directly responsible for the operation of the reactor units must receive an operator's authorisation. This certification must be obtained before the person is nominated for a position.

The training programme for authorised operators (Shift Supervisors and Control Room Operators) is in line with legal requirements. It comprises a basic training package, training in emergency procedures, and complementary training courses. The training programme includes:

- Control room training under the supervision of a Shift Manager.
- Hands-on training through integration in a team of Shift Supervisors and/or Control Room Operators
- Simulator training given by the Operations Support Service
- Training on specific installations, covering aspects such as fire fighting and first aid.

The periodic retraining of authorised operators also meets legal requirements. It is established by the Operations Service and comprises the following elements:

- One week refresher course, per year, in classroom and in other installations suited for exercises, in line with the function.
- Two week internal team training, per year, under the supervision of the Shift Supervisor
- Two weeks of full-scale simulator training, per year, given by the Operations Support Service.

As with certified operators, the training program for Field Operators is in line with legal requirements. It also comprises a basic training package, training in emergency matters, and complementary training courses. The training program includes:

- Classroom training under the supervision of a Shift Supervisor. This training covers thermodynamics, electrical and electrotechnical principles, systems and components, circuits, instrumentation, and safety principles
- Hands-on training through integration in a team of Field Operators
- Training on specific installations, covering aspects such as fire fighting

The annual retraining programme of Field Operators is established by the Operations Service and is based on a two day refresher course in a control room and in other installations suited for exercises, in line with the function.

Maintenance personnel:

After the initial generic training course, future technicians follow a specific training programme. This programme specifically addresses mechanical, electrical and I&C technicians. It lasts approximately one year. Other team-specific training courses are provided in addition to this programme.

The switch from a technician to a first technician and further to team leading function requires completion of specific training courses.

(4) GDF-Suez Nuclear Training Programme

In 2005 GDF-Suez decided to develop its nuclear activities and created a dedicated Nuclear Activities Division. This Division is now called GDF SUEZ Nuclear Development (GSND). One of its missions is to:

- Anticipate needs in junior engineers (max. 2 years experience) for replacing retiring managers and for staffing new nuclear projects
- Build up a Nuclear Training Programme (NTP):
 - **NTP Junior programme:** for **junior engineers** by giving them a general view on all the aspects of the nuclear activities and to help them build a strong network through the GDF-Suez Group.
This programme (400 hours) consists in different types of trainings in order to improve 3 types of competencies (métier – behavioural – functional)
 - **NTP Majors programme:** a similar training programme of three weeks was launched in April 2010 for **senior engineers** coming from several entities of the Group, but having no specific nuclear knowledge. This will enable them to subsequently reinforce the nuclear activities of the Group and their comprehension of our activity.
 - **NTP Support programme:** a training programme of two days for managers in support departments like Legal, Finance, HR, Procurement to explain the specificities of the nuclear energy sector. During this training, trainees also better understand their contribution to nuclear safety.
 - **NTP Generation programme:** This program was organized for the first time in 2011 as NTP Track bis. Since 2012, it is called NTP Generation. It is specifically dedicated to more experienced engineers working on a nuclear power plant who have not yet had the opportunity to follow the NTP Juniors. The program with duration of 210 training hours deals with nuclear theory and is concluded by a formal technical test.
 - **NTP technicians:** in 2012, the Group has decided also to develop a training programme for technicians. This program is under construction.

(5) Contractor Training and Qualifications

Contractors are responsible for the training of their own personnel. Nevertheless, Electrabel shall ensure that all contractors performing safety-related duties have been adequately trained and qualified". All contractors in question have obtained a competence pass ('Bevoegdheidsverklaring' in Doel, 'Passeport Métier' in Tihange), which shows that they have received adequate training and are fully qualified. The acquisition of competences during a training program is formally checked. Moreover training in radiological protection is legally required and is made specific to the site where they will work. They must pass an examination at the site before they are allowed to the work place. An intensive training programme for all personnel of contractors has been put in place, focussing on nuclear safety and work in a nuclear environment. The successful completion of this training is mandatory before being allowed to work on the site of the nuclear power plants.

A general training programme is set up for all contractors. This general training programme focuses on safety culture (both nuclear and industrial safety), is carried out partly on a theoretical basis and partly on a hands-on approach using the Human Performance Simulator (see also II.H.1.e). It covers the 4 tools for the effective application of the human performance principles, as the adherence to procedures (stressing the need for a strict respect of prescribed steps), the interrogative attitude (the

principle to correctly apply the instructions using the STAR methodology: Stop – Think – Act – Review), the use of secured communication and the use of the pre-job briefing methodology.

II.G.2. Research Reactors

a) Financial resources

The SCK•CEN, the Belgian Nuclear Research Centre is a "Foundation of Public Utility" (FPU) with a legal status according to private law, set up according to the law on non-profit organisations, under the supervision of the Belgian Federal Minister in charge of Energy. From the first of January 2005 the SCK•CEN, like any other non-profit organization has to apply the principles and rules prescribed by Belgian accounting rules. The turnover and the operating profit of the previous years are defined in accordance to this law. The adequacy of the SCK•CEN's financial system and internal controls is assessed by an external auditor. According to the safety and security charter, the management hereby is committed to provide all necessary financial means to enhance safety and to ensure all required security measures.

The future cost for dismantling is covered by funds. With respect to these technical liabilities, the following rules for funding apply. All dismantling costs for installations built and in operation before 1989 are covered by a special 'Technical Liabilities Fund', which is administered outside the SCK•CEN. All new technical liabilities after January 1989 are financed by the SCK•CEN by means of setting up the necessary provisions. The total liabilities are periodically reassessed and total amounts have to be available at the moment of dismantling and decontamination. The necessary financial means are funded by means of annual government grant and by revenues from contract research and services to third parties.

b) Human resources

The minimum requirements for operating personnel are detailed in the safety analysis report both for BR1 and BR2. These requirements are the necessary education and training of the personnel. The minimum number of personnel necessary for operating the reactor is also specified. For BR2 additional requirements for training are defined. Each reactor operator has to receive two weeks training every year. The initial authorisation as a reactor operator is given on advice of a committee, in which the Health Physics Department and of the FANC (Bel V), are represented with veto power. Reauthorisation is necessary every three year or after a longer period of non-activity as an operator. The requirements for BR1 personnel are less formalized. The appointment of the BR1 reactor manager has to be confirmed by the health physics and safety department. The training of the operators is defined by the BR1 reactor manager case by case. This is acceptable due to the limited number of operators for BR1.

II.G.3. The Belgian education programme in nuclear engineering

As a joint effort to maintain and further develop a high quality programme in nuclear engineering in Belgium, the Belgian Nuclear Higher Education Network (BNEN) has been created in 2001 by six Belgian universities and the SCK•CEN.

In the framework of the new architecture of higher education in Europe, the BNEN created a 60 ECTS "Master of Science in Nuclear Engineering" programme. To be admitted to this programme, students must already hold a university degree in engineering or equivalent education

The BNEN programme is given in the table below:

Course	ECTS²
Nuclear energy: introduction	3
Introduction to nuclear physics	3
Nuclear reactor theory en experiments	8
Nuclear thermal-hydraulics	6
Operation and control	3
Reliability and safety	3
Nuclear fuel cycle and applied radiochemistry	3
Nuclear materials I	3
Nuclear materials II	3
Radiation protection and nuclear measurements	6
Advanced courses	4
Project and internship	15
Total	60

Table 5 : BNEN Curriculum

More information can be found on the BNEN Internet site: <http://bnen.sckcen.be>

The courses are given at the SCK•CEN in Mol. This gives the students the opportunity to see the installations. A number of practical exercises are performed with the BR1 reactor. The SCK•CEN is also responsible for the secretariat of BNEN.

The SCK•CEN offers two more specialized courses for nuclear operators. One is a course in radiological protection and health physics instrumentation intended for operating personnel. This course is regularly followed by personnel of the Belgian nuclear power plants. The second course is an advanced course on nuclear emergency planning. This course is organized annually. The current edition of this course is set up in collaboration with the main European actors and in the framework of developing a supranational training programme as formulated by the European platform on emergency and post-accident preparedness and response initiated by the partners in the FP6 project EURANOS (European approach to nuclear and radiological emergency management and rehabilitation strategies, (www.eu-neris.net)). One of the objectives of this platform is to maintain and enhance knowledge and competence through emergency exercises, training and education, thus fostering best practice in emergency response.

Parallel efforts were also made to create a European network of academic institutions active in nuclear engineering education, to establish links with the International Atomic Energy Agency (IAEA), with the Nuclear Energy Agency of the OECD (NEA), and other international bodies like the World Nuclear University (WNU).

Today, the European network has been established as an international association of about twenty universities co-operating with the European stakeholders (industry, regulators, research centres), and is strongly supported by the European Commission. Its name is ENEN (European Nuclear Education Network). It is legally based at the premises of the "Institut National Supérieur des Sciences et Techniques Nucléaires" (INSTN) at Saclay (France), and BNEN is the Belgian pole of this network. Students registering to any of the participating institutions are offered the opportunity to coherently take a part of their basic nuclear education at different places in Europe while cumulating credit units. Practical laboratory sessions and advanced subjects taught in a modular way are also offered to enrich the programmes. Thanks to ENEN, several courses organised by the BNEN consortium are taken by a significant number of foreign students.

² ECTS stands for "European Credit Transfer and Accumulation System", 1 unit corresponds to approximately 10 learning hours

II.H. Article 12. Human Factors

Each Contracting Party shall take the appropriate steps to ensure that the capabilities and limitations of human performance are taken into account throughout the life of a nuclear installation.

Accounting for human factors at the design stage is discussed in Article 18 of the present National Report. The text below is centred on human factors during the operational period of the power plants.

II.H.1. NPPs Licensee (Electrabel) Human Performance Programme

As already mentioned in article 10, the human performance policy is based on two approaches:

A bottom-up approach

- Everyone is encouraged to report suggestions and anomalies or human errors in a software application (SmartGen). These reports are used to improve our performances.
- Root cause analysis of errors and malfunctions cover both technical aspects and human factors in order to reinforce defence barriers. Such an analysis therefore:
 - Highlights and explains all deviations linked to an event
 - Identifies the real and potential consequences of these deviations
 - Defines the corrective actions to be implemented to avoid recurrence of the event

A top-down approach

- The top-down human performance approach is based on leadership, values, change management and organisational behaviour.

The focus is to ensure the integration of good safety behaviour and use of human error reduction tools (HU tools):

- Management expectations: The HU tools are embedded in the Management Expectations booklets, specific procedures and execution aids (e.g. pre-job documents, work permit, observation forms, etc.). Films were made to clarify specific expectations (e.g. for alarm management in the control room).
- Tasks observation : Managers and supervisors frequently conduct task observation in the field in order to:
 - Reinforce management expectations, including human performance, by valuing the appropriate behaviour and correcting deviations.
 - Identify and correct deviations.
 - Reinforce contacts with the field
- Communication: Specific HU communication is achieved by using electronic Public Address display, newsflashes, films, magnetic posters and during training sessions.
- Training: Workshops and training for leaders and teams have been delivered to enhance leadership and coaching skills. After the initial Human Performance training, the HU training was embedded into initial training, control room training and field simulator training. HU also became part of the improved self-assessment approach, making the link with operating experience thus closing the learning loop (with special attention for using observation results).

a) *Human performance action plan*

Tihange NPP has established a human performance (HU) improvement plan for the period covering 2010-2012. This plan is built the following elements:

- HU project steering committee: this new committee meet every two months and directs all actions related to the HU project (set targets and monitor progress) and ensure consistency of actions within the different departments (e.g. communication, training courses).
- Training of personnel and contractors : All personnel has participated to the one day training to understand why human error is natural and how to prevent it (50% theory) and then apply acquired knowledge on the human performance simulator or on the full scale simulator (50% practice). A meeting with contractors' managers (boss to boss meeting) has been organized to explain the HU action plan. Team leaders did follow a specific HU training with exercise on the human performance simulator. Training for contractor's workers was incorporated into

the nuclear safety refresher training of two day with practice on the human performance simulator.

- Coaching Managers in the field: Managers (executives and supervisors) did receive an individual coaching to perform task observations (external coach). A new booklet outlining the expectations to perform a good task observation has been edited and used during the training. The task observation form has been simplified.
- Communication: A poster campaign on the use of HU tools was launched in 2011. Communication has been made around the new booklet outlining how to perform a good task observation. Specific HU communication is achieved by using electronic Public Address display, newflashes, films, magnetic posters and during training sessions.

The plant manager requests from each department a specific yearly human performance (HU) improvement plan.

A pilot project of champion network has been created in the department Care (Environment, Radiation Protection, Industrial Safety, Nuclear Safety, Fire Protection, and Emergency Preparedness). They meet two to three times a year. They did receive a specific two days training course. Each HU champion supports the use of HU tools in his or her team. In function of the results this network will be extended to all departments.

While the HU tools are common at site level, the way to apply them in practice has been described specifically for the main jobs (operator, chemist, electrician...).

At Doel NPP the HU improvement plan is built around the following elements:

- Training: Emphasise the HU tools in the job certification programme. Coherent use of training and human performance simulator to learn new behaviours. HU tools are integrated within the on the job training. HU training for Fire Safety personnel.
- Coaching: Certification of new HU coaches in all departments and recertification of existing coaches. Paired observation during outage and normal operation. Support training for contractors and on human performance simulator.
- Consolidation: Include HU in the objectives of the workers, self-assessment with a maturity scale representing the level of implementation of HU tools.

b) *Use of human error reduction tools (HU tools)*

The focus is to ensure the integration of good safety behaviour and use of human error reduction tools (HU tools):

- Situation awareness: includes workplace screenings, questioning attitude, anticipation and time-outs (pause before starting an activity if anything is uncertain)
- Self-control: revolves around the STAR concept of 'Stop-Think-Act-Review'.
- Pre-job briefings: interactive dialogues that cover the task to be carried out – taking into account experience, risks and error precursors, as well as the worst-case scenarios. In some cases Pre-job briefings are referred as "Tool box meetings".
- Post-job debriefings: reporting that a task is completed, notifying any abnormality, reviewing the paperwork fully and highlighting lessons learned (input for operating experience and optimization of procedures).
- External verifications on practices: peer checks, concurrent and independent verifications to safeguard quality and safety
- Effective communication: taking into account basic principles of good communication (such as informing all parties involved), favouring direct dialogues, securing understanding by three-way communication, phonetic alphabet.
- Careful decision-making: includes anticipating, evaluating options, checking assumptions, conservative decision taking and thinking as a team.
- Intelligent use of procedures: making sure that procedures are correctly understood and applied in practice. In case of doubt, one stops and changes are only made after appropriate consultation and red-marking.

c) *Operating experience feedback*

Operating experience feedback is communicated as extensively as possible and integrated as soon as possible into the relevant training courses. Yellow stickies exercises are used periodically within the teams to define from the OE reporting database the actions for improvement.

d) Task observations

In addition, task observations are held in order to:

- Reinforce management expectations, including human performance, by valuing the appropriate behaviour and correcting deviations.
- Identify and correct deviations.
- Reinforce contacts with the field.

e) Human Performance Simulator

Tihange and Doel NPP are equipped with their own "human performance simulator". This training facility is considered among worldwide nuclear operators as an excellent training tool to model safety behaviours (good practice OSART). This training model comprises essentially all important parts that are typical for an intervention in a nuclear installation like:

- A dressing room: to prepare entrance and exit of a nuclear zone with appropriate suits, including clothes, dosimeter, and contamination checking before and after intervention.
- A briefing space: where teams can prepare preliminary works or give some orders before an intervention exercise.
- A tool store: to store necessary tools, or spare pieces
- A radioprotection room: located next to the entrance of the nuclear zone, where staff can find a radioprotection supervisor, and contamination monitors.
- An electrical room: local with electrical board and batteries.
- A control room: with control panel from which staff can operate equipment.
- A mechanical room: where mechanical equipment such as pumps, valves, tanks, etc... is present.

Trainees enhance their safety attitudes and behaviour by responding to simulated problems and changing conditions being encountered during an intervention. Different scenarios of intervention have been developed for training purposes. Trainees are recorded on video and followed by instructors to coach them and improve their safety behaviours.



Figure 11: Human Performance Simulator

II.H.2. Research Reactors

In 2007 a number of events occurred at the SCK•CEN, mostly at BR2, which indicated weaknesses in safety culture. The SCK•CEN reported these precursor events to the authorities and ordered an internal and external audit on safety culture. Based on both audits, an action plan for improvement of safety culture was launched. The main themes of the action plan concentrated on safety training, knowledge management and organizational aspects. The content of the action plan was discussed with the authorities and a regular follow-up was foreseen. The action plan was completed in 2012.

a) Organizational aspects

Training programmes and knowledge management are centralized in one service, the expert group communication, education and knowledge management. Training programmes with safety aspects are defined in cooperation with the health physics and safety expert group.

b) Training

According to the action plan on safety culture, training was given on safety, with special attention on reporting of incidents and unusual events. Most of the training is given in-house, but external training is possible. For BR2 operators, two weeks training per year is foreseen. Training on a simulator, as is the practice in power plants is not possible for BR1 or BR2. However, even BR2 has at least 5 to 6 reactor starts per year. Meanwhile, there are regularly measurement programmes for which the reactor is made critical. In this way operators are for a great deal trained on the job. During the last years, practical training for the BR2 operators was given at foreign research reactors (AZUR in Cadarache, France and the TRIGA reactor of the technical university of Vienna, Austria). In 2009 the operators received also a number of training days at the nuclear power plant of Doel. Training requirements for personnel of BR1 is less formalized. The number of operators for BR1 is very limited and the reactor is not operated outside normal working hours or during holiday periods

c) Knowledge management

For an organisation with an operating experience of more than 50 years, knowledge management is an important issue. People present at the start of the installations are no longer available. Being a research environment, a number of modifications are made and new experiments are set up. An action is taken to collect all design documentation of the installation and make it readily available. For person with a key function a replacement person must be available, with an equivalent knowledge or with capacity to get this knowledge quickly.

II.H.3. Safety Culture Observations by the Regulatory Body

The Federal Agency for Nuclear Control and Bel V have jointly developed and implemented a Safety Culture observations process. Observations are made by an inspector or a safety analyst during any contact with a licensee³. These observations are filled in an observation sheet aimed at describing fact and context issues. These observations are linked to Safety culture attributes based on IAEA standards⁴.

On a monthly basis the "Safety Culture coordinator" within Bel V analyses observations (with a quality of description and classification perspective) and gives a feed-back to the observation maker. In case of an important SC discrepancy, a direct reporting to the licensee could be considered.

On a quarterly basis, the "Safety Culture coordinator" provides a synthetic report (monthly meeting FANC-Bel V). The aim of this report is to identify early signs of problem. Then, it could be decided to analyse a plant's performance more deeply in order to understand the underlying causes of a problem or to focus inspections on specific dimensions.

On an annual basis, the "Safety Culture coordinator" provides a detailed report on the observations (with a safety perspective). The aim is to identify persistent signs of problem or good practices. These statements feed the next annual inspection programme. A synthesis is presented to the licensee. The discussion objective is to be sure that the licensee understands the regulator's concerns.

In terms of Regulatory Body evaluation, Safety Culture observations are then central pieces of a broader oversight process trying to identify and analyse Safety Culture dimensions.

³ Inspections (routine, topical and reactive), meetings with licensees, training activities, formal and informal discussions with plant staff at various levels, document review, review of event reports (including low level) and corrective actions implemented, observation of activities and conditions in the field...

⁴ IAEA/CNCAN (2010). *Guidelines for Regulatory Oversight of Safety Culture in Licensees' Organisations*. IAEA/BNRA (2011). *Guidelines for Regulatory Oversight of Safety Culture in Licensees' Organisations*.

II.I. Article 13. Quality Assurance

Each Contracting Party shall take the appropriate steps to ensure that quality assurance programmes are established and implemented with a view to providing confidence that specified requirements for all activities important to nuclear safety are satisfied throughout the life of a nuclear installation.

II.I.1. NPPs

As the USA safety rules were applied for the 4 most recent Belgian units as early as at their design stage, 10 CFR50 Appendix B requirements were adopted for these units, as well as the ASME code quality-assurance stipulations for pressure vessels. Also taken into account were the 50-C-QA codes and the resulting safety guidelines (including 50-SG-QA5) developed in the scope of the IAEA's NUSS programme.

At the time of putting into service the Doel 1 & 2 and Tihange 1 units, i.e. 1974-1975, that level of quality-assurance formalism was not yet required. However, during the 1st periodic safety review of these units, the request was formulated to apply to them the same quality-assurance rules as were applied to the more recent units: accordingly, any new installations, modifications, repairs and replacement at the earlier units were from 1985 on made consistent with the formal QA requirements.

The responsibility for applying the quality assurance programme is assumed by the operator who subcontracts the related tasks to his Architect-Engineer during the design and construction phases of the power stations, up to and including their start-up tests.

While following the evolution of the international practices, Electrabel evolved from its quality assurance system during operation to a quality management system, in September 2006. This management system includes the previous applicable quality assurance system. The elaboration of the quality management system was based primarily on a general safety requirement published by the AIEA (GS-R-3: "The management System for Facilities and Activities", 2006).

The QA programme is described in chapter 17 of the Safety Analysis Report which deals with the design and construction phases, followed by the operation period. As there is no unit under construction at present in Belgium, emphasis is put on how the quality management system is applied during operation.

a) Equipment and Activities concerned

The quality management system applies to any safety-related equipment, components and structure as well as to any activity that may affect their Quality. It applies also to the safety-related activities, e.g. human performance, organisational performance, safety culture, radiological protection, radioactive waste management, fire detection and protection, environmental monitoring, nuclear fuel management, emergency intervention and site security.

These equipment, components, structures and activities are known as Quality Monitored items. Quality Monitored items are identified in the Safety Analysis Report of each unit.

b) Quality Management System

(1) Objective and origins

The principal goal of Electrabel's quality management system is to ensure and to improve safety at Electrabel's Doel and Tihange power stations through a common approach and via plant-specific approaches. The system accomplishes this by establishing policies and related objectives.

The Deming diagram, which specifies the following recursive four-step cycle, is the basis for this management system: plan, do, check, act.

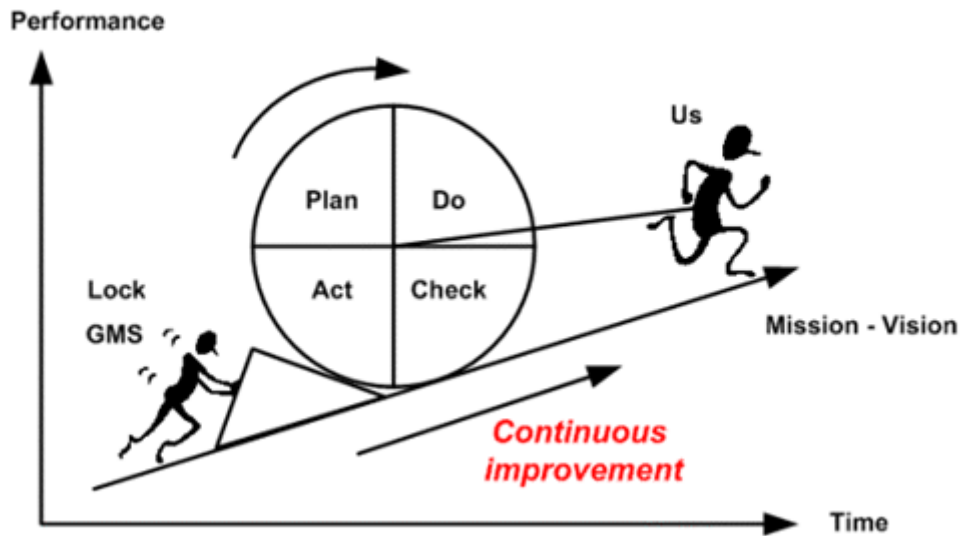


Figure 12 : Deming diagram for continuous improvement

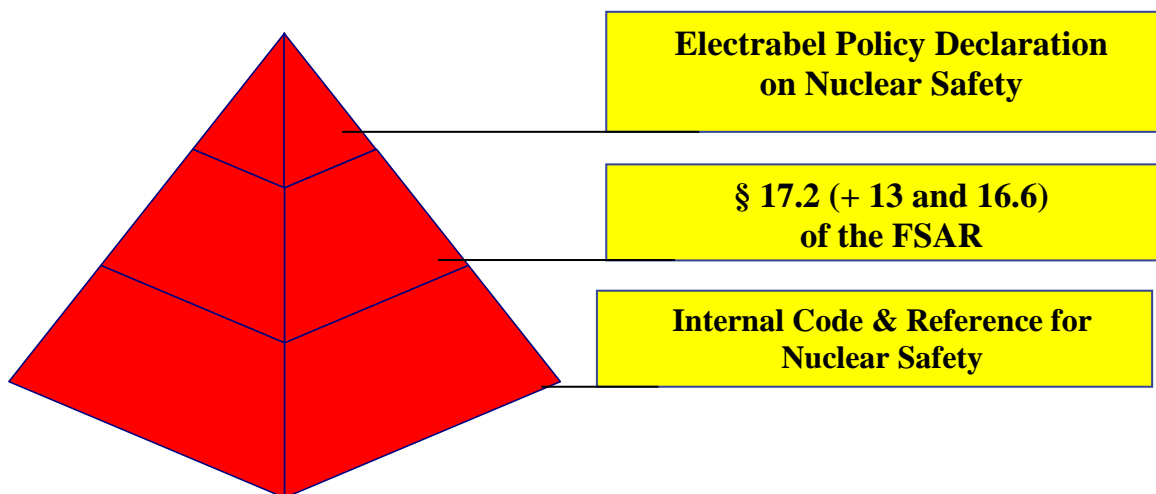
The management system also integrates the provisions of the following regulatory requirements and guidance:

- Licenses to operate a nuclear power plant, inclusive the codes and standards they refer to
- Belgian Nuclear safety regulations
- Other international standards and codes adapted and implemented for Electrabel's Generation Business Unit

(2) Key documents

Electrabel's management system is described in a number of documents that move downwards from broad principles towards technical specifications and daily practices:

- Chapter 17.2 of the FSAR
- Electrabel's Internal Nuclear Safety Code
- Electrabel's Reference for Nuclear Safety
- Execution documents



(3) Focus and application

The management system supports the general objectives of safety management recognized at the international level and described in the IAEA report INSAG 13: "Management of Operational Safety in Nuclear Power Plants", 1999. The two objectives are as follows:

- Focus on the performance of the organisation to ensure and continuously improve safety, through planning, supervision and monitoring of safety processes in all situations (normal, incident and emergency)
- Stimulate and support a strong safety culture by developing and reinforcing good safety attitudes, values and behaviour in individuals, teams and organisations, in order to allow them to carry out their activities safely

The management system is applicable to every Electrabel entity that exercises any activity related to safety, even if the entity is not within the management hierarchy of the Doel and Tihange sites. Moreover, the structure of separate quality management systems at each site has been replaced by a single unified system covering both sites.

The management system is established, implemented, assessed and continually improved. It has been aligned with the goals of Electrabel and contributes to their achievement. The main aim of the management system shall be to achieve and enhance safety by:

- Bringing together in a coherent manner all the requirements for managing the organization;
- Describing the planned and systematic actions necessary to provide adequate confidence that all these requirements are satisfied;
- Ensuring that health, environmental, security, quality and economic requirements are not considered separately from safety requirements, to help preclude their possible negative impact on safety.

Safety is paramount within the management system, overriding all other demands

c) *Electrabel's Internal Code and Reference for Nuclear Safety*

The Internal Code defines all directives and general principles related to the implementation of the nuclear safety policy within Electrabel. This document is developed and maintained by the Electrabel Corporate Nuclear Safety Department (ECNSD) verifies and is approved by CEO of GDF SUEZ BELUX in charge of the day-to-day management of Electrabel S.A.

The goals of the Internal Code are to:

- Define rules to ensure the management system of Electrabel meets its objectives,
- Define responsibilities regarding nuclear safety,
- Ensure the systematic and formal management of all aspects related to nuclear safety.

In addition, the Reference for Nuclear Safety (Référentiel de Sûreté Nucléaire) describes the quality assurance requirements for the processes of the nuclear safety management system. It complements the Internal Code. This document is developed and maintained by the Electrabel Corporate Nuclear Safety Department (ECNSD) and is approved by the Head of the Business Entity Generation.

Each Electrabel entity must translate the directives and general principles of the Internal Code into local procedures and instructions taking into account the QA minimal requirements levels defined in the Safety Reference.

d) *Training regarding Quality Assurance Objectives*

A general training is given regarding the quality assurance objectives and the means for achieving these to all personnel who perform quality-related activities in the various services. This training is maintained and updated when necessary.

e) *Periodic Evaluation*

The Plant Operating Review Committees (PORC), the Site Operating Review Committees (SORC) and the Independent Nuclear Safety Committee (INSC) perform a periodical assessment of the nuclear safety effectiveness; the way it is implemented, the possible improvements to be brought to the programme ... The General Management approves the written action plan.

As regards the regulatory control activities, AVN (now Bel V) examined in the frame of the licensing process of each unit the quality assurance system to be implemented during the design, construction and operational phases (chapter 17 of the Safety Analysis Report, Electrabel Internal Code, ...) and

verified the practical implementation of the various regulations (10 CFR 50 Appendix B, ASME code,...) throughout these phases.

As regards pressure vessels for which the ASME code or the conventional Belgian regulations (RGPT) are applicable, the intervention of an Authorised Inspection Agency (AIA) is required as an independent inspection organisation, and Bel V has taken into account the results of those inspections.

During power plant operation, Bel V performs systematic inspections, including some dedicated to quality assurance procedures assessment during operation. The quality assurance aspects are also reviewed during examination of modifications to the installations, incident reports, etc.

II.I.2. Research Reactors

The SCK•CEN has a formal quality assurance system which includes a number of services such as the production of radioisotopes and the irradiation of silicon for which the system is certified. However the formal QA plan is introduced up to level of the operation of the reactors. From the point of view of QA, all operational procedures are considered as work instructions. This has the advantage that procedures can be updated more quickly.

II.I.3. Activities of the Regulatory Body

In 2010, FANC and Bel V asked the licensees of nuclear facilities (including the NPPs and RRs) to perform a gap analysis between their management system and the requirements of the safety guide GS-R-3. Since the SRNI-2011 became into force on the 1st March 2013, article 5 of SRNI-2011 imposes to the licensees of nuclear facilities to set up an integrated management system. This article is based on the WENRA reference level "issue C – Management System", which is itself derived from the IAEA Safety guide GS-R-3.

The results were received and analysed by FANC and Bel V. End 2012, FANC and Bel V sent the results of their analysis to the licensees and asked them to take the necessary corrective actions in order to be fully in compliance with the GS-R-3 by the end of 2013.

An inspection campaign is programmed in 2014 in order to verify the implementation of the corrective actions and the compliance with GS-R-3.

II.J. Article 14. Assessment and Verification of Safety

Each Contracting Party shall take the appropriate steps to ensure that:

- 1) comprehensive and systematic safety assessments are carried out before the construction and commissioning of a nuclear installation and throughout its life. Such assessments shall be well documented, subsequently updated in the light of operating experience and significant new safety information, and reviewed under the authority of the regulatory body;
- 2) verification by analysis, surveillance, testing and inspection is carried out to ensure that the physical state and the operation of a nuclear installation continue to be in accordance with its design, applicable national safety requirements, and operational limits and conditions.

II.J.1. NPPs

a) *Licensing Process*

The process initially applied for licensing of the Belgian nuclear power plants was described in previous reports for the Convention. Since the process would no longer be the same today and since many organisations and committees that played a role in this process do no longer exist (being replaced by other organisations and committees), it was judged no longer appropriate to describe this historic information in this report. However, if needed, the reader can find the information in the 2007 report for the Convention (in particular in paragraphs II.B, II.D en II.J.1).

In section II.B.1 of this report, more information can be found concerning an important outcome of the original licensing of the NPPs, being the high level of protection against external accidents (airplane crash, explosion, large fire, toxic gases).

Furthermore, it is worthwhile to note that the Safety Analysis Report (SAR) of all plants are drawn up according to the standard format and content as applied in US, i.e. in accordance to Regulatory Guide 1.70 (revision 2 or 3). This was the case from the very beginning for the four more recent units (Doel 3 and 4, Tihange 2 and 3), while for the older units (Doel 1 & 2 and Tihange 1) the SAR was rewritten in this format afterwards, although minor deviations from the standard table of content of RG 1.70 may exist.

More recently, the table of content of the SAR was extended:

- To include a new section (in Chapter 3) on the Probabilistic Safety Assessment performed for that plant (a consequence of the periodic safety reviews).
- To include a new section (in Chapter 3) on the Ageing Management Programme (a consequence of the WENRA Action plan, in particular WENRA Reference Level N.2.8).

Article 13 of the SRNI-2011 stipulates that the SAR shall be kept updated throughout the life of the installation so that the SAR exactly reflects its present state.

b) *Periodic Safety Reviews*

Article 14 of the SRNI-2011 requires a ten-yearly periodic safety review for each nuclear unit. The general objectives of these periodic safety reviews are as follows:

- to demonstrate that the unit has at least the same level of safety as it had when the licence was granted to operate it at full power, or since its latest periodic safety review;
- to inspect the condition of the unit, devoting more particular attention to ageing and wear and to other factors which may affect its safe operation during the next ten years;
- to justify the unit's current level of safety, taking into account the most recent safety regulations and practices and, if necessary, to propose appropriate improvements.

The first of these periodic safety reviews took place in 1985 for the Doel 1 & 2 and Tihange 1 units. At the time of design of these units, i.e. in the early 1970s, the safety rules were less numerous and less detailed than they were for the later Belgian units that were started between 1980 and 1985. For instance, physical separation was less strictly applied, seismic and post-accidental qualification were less developed, the notion of high-energy line break did not apply to all systems, external accidents were not systematically considered.

The different subjects examined during these periodic safety reviews are detailed in Appendix 5.

These 1st periodic safety reviews were conducted very comprehensively and were an in-depth review of the safety of the nuclear power plants. This made it possible to identify coherent solutions and, at times, to simultaneously solve several problems (an example is the emergency building, i.e., the bunker, of Doel 1 & 2). It also demonstrated that it is even possible to improve strongly design- and lay-out dependent systems of the nuclear power plant: taking into account a higher-intensity earthquake, protection against external accidents, a new reactor protection system...

For instance, at Tihange 1, considering a design earthquake of 0.17 g acceleration (value of the Safe Shutdown Earthquake defined in the safety analysis of Tihange 2 and 3) instead of the original value of 0.1 g used in the design of unit 1, resulted in recalculating with much more elaborate methods the seismic behaviour of all the buildings, and strengthening a number of structures. Also, the resistance to earthquake of many equipment and components had to be reviewed, based on feedback from experience with equipment which had undergone a real earthquake. Similarly, external accidents due to human activity were considered. Other fields included protection against high-energy line breaks, protection against primary system overpressure, improvement of fire protection, improvements of the reliability of systems, more effective training of operators (training centres with several simulators), improvements to the man-machine interface, systematic utilisation of both national and international feedback of operating experience.

Similar steps were followed for Doel 1 & 2. In the design and during the construction of Doel 1 & 2, earthquakes had not been considered as a factor influencing the design requirements, due to the weak seismic activity of the region. For Doel 3 and 4, applying the USNRC rules has imposed a minimum of 0.1 g for the Safe Shutdown Earthquake (SSE). For Doel 1 & 2, the same methodology for defining the SSE has been followed, except the requirement of a minimum value of 0.1 g. The resulting SSE retained for the design has an acceleration of 0.056 g.

As for Tihange 1, this led to a check of the resistance of buildings and equipment. Moreover, to cope with accidents of external origin, a bunkered and seismically resistant building has been erected, containing so-called emergency safeguard systems, which allow maintaining primary water inventory, ensuring reactor sub-criticality and residual heat removal and coping with accidents like a fire in the electrical auxiliaries building (including the loss of the main control room), the total loss of electric power (external grid and the safety Diesels), the SSE, a high-energy line break.

In this way the safety level of these units was raised towards a level closer to that of the most modern units. All the analyses were conducted according to deterministic safety rules and complemented with reliability analysis of the various systems.

The 1st periodic safety review of the most recent units (Doel 3 and 4, Tihange 2 and 3) and the 2nd periodic safety review of Doel 1 & 2 and Tihange 1 did not require reviewing the design bases, since post-TMI actions had already been taken into account and there had been no major evolution in the regulations during that period.

During these safety reviews, national and international feedback were examined; the results of probabilistic safety studies made for power operation or for shut down states were taken into account, the severe accident consequences were analysed in order to infer prevention and mitigation measures, structural and equipment ageing were evaluated, as well as qualification problems, and the field of accidents that are considered as design-basis accidents was broadened. The PSAs and the analyses of severe accidents resulted in the installation of (autocatalytic) hydrogen recombiners inside the reactor containment for all units.

The second periodic safety reviews of the most recent units (Doel 3 and 4, Tihange 2 and 3), and the third periodic safety review of the oldest ones (Doel 1 & 2, and Tihange 1) include two sets of topics: the first one is made of topics common to all units ("fleet approach"), the second one addresses aspects specific to one unit.

All these periodic safety reviews include two parts: one part "studies", another part "implementation" of the results of the studies.

A large number of modifications have been made on the first Belgian units. The most important modifications resulting from these periodic safety reviews are indicated in Appendix 1 of this Report, in the description of each unit.

c) *During operation of the installations*

Experience feedback leads the operator to envisage modifications of the installations or launch major projects such as replacement of the steam generators or power increase. These activities are carried out in addition to those related to the periodic safety reviews.

The proposals for modifications to the installations are examined by the Health Physics Department of the operator, who discusses them with the Bel V inspector. Each proposal is classified into one of the three following categories:

- Major modifications that change the basic characteristics of the unit. These modifications are subject to the application for a licence under the provisions of Article 6 of the GRR-2001. A major modification requires a new license application, and follows a licensing scheme similar to that described section II.C.7: The safety analysis performed by Bel V is presented to the FANC. The results of this analysis are presented to the FANC's Scientific Council, who will produce its conclusions on the acceptability of the modification and will propose, if deemed necessary, additional operational conditions. A new Royal Decree of Authorisation is prepared by the FANC and finally signed by the Minister of Home Affairs and the King. The implementation of that modification will be authorised by the Health Physics Department. Bel V verifies the conformity with the Royal Decree of Authorisation.
- Less important modifications that have a potential impact on safety. In a first phase, the requesting department of the licensee, indicating the justification for the intervention, presents a proposal for modification. In a second phase, the proposal is examined on its technical merits, and later on also by a multidisciplinary team including a.o. the Health Physics Department. After approval by the departments involved, the proposal is submitted to the management of the licensee, who can decide to continue final studies for the proposed modification. In the next phase, studies are completed and approval of both the Health Physics Department and of Bel V is sought to prepare the implementation of the modifications. The proposal is thus also examined by the inspector of Bel V, and by Bel V's technical responsibility centres, which may result in amendments being requested to the modification file. Further activities then imply the implementation, and testing of the modifications. Commissioning of the completed modification is subject to a positive delivery report, issued after validation of the modification and re-qualification of the portion of the installation that was modified, plus updating the operational documents. The Health Physics Department formally approves of the modification when all the files, procedures and the Safety Analysis Report have been adequately updated and Bel V can then issue a final delivery report. Such modification can either be hardware modification or organisational modification.
- Modifications without impact on safety, that usually do not imply modification of the Safety Analysis Report and which comply with all the safety rules of the installation. These modifications have to be approved only by the Health Physics Department of the unit, without formal involvement of Bel V, except for the possible pages of the Safety Analysis Report to be updated.

d) *Certain studies relating to the modifications*

Certain studies relating to modifications or initiated in the scope of the periodic safety reviews were so substantial that they had to be tackled as projects having their own specific structure:

- Severe accident analyses: ultimate strength of the containment in case of internal overpressure, installation of autocatalytic recombiners to prevent containment hydrogen build-up (installed in all the Belgian units), reactivity accidents during operation and during shut down states.
- Power increase and burn-up cycle extension studies.
- Use of mixed core (presence in the core of fuel assemblies from different suppliers) requiring detailed studies regarding mechanical, neutronic and thermal-hydraulic compatibility.
- Replacement of the steam generators, whether or not linked to a power increase.
- Replacement of technologically obsolescent systems (instrumentation and control systems) addressing software qualification issues.
- Set up of an integrated ageing management system, in order to assure that safety related structures, systems and components remain qualified within their defined service life.

- Continuous development of probabilistic safety analyses (PSAs) of L1 and L2 for the Doel and Tihange nuclear power plants (NPPs) performed by Tractebel Engineering (TE), on behalf of the utility Electrabel.
- Extension of the PSA-models to include internal hazards (e.g. flooding and fire)
- Operational use of the PSA-models to complement the evaluation of modifications to the NPPs.
- More details on the topics mentioned can be found in previous national reports

e) Verification Programmes

The technical specifications (chapter 16 of the Safety Analysis Report) were examined at the time of the licensing process; their amendment during operation falls under the prescriptions for modifications that are subject only to approval by the operator's Health Physics Department and by Bel V. These technical specifications are reviewed in the frame of the period safety reviews. They have been completely rewritten at least once during the life of each nuclear power plant.

These specifications indicate for each status of the unit the operational limits and conditions, specifying also the actions to be taken if limits are exceeded. They also list the inspections and tests to be performed and their periodicity.

Specific programmes are established, in particular for:

- examinations and tests required by the ASME Code.
- inspection and repair of the steam generator tubes.
- fire protection.
- tests of ventilation filters.
- inspection of the primary pump fly-wheels.
- examination of irradiation samples of the pressure vessel.

Each safety-related equipment has a qualification file that contains all the qualification test requirements and results. In this file are also recorded the results of ageing tests or experience feedback of similar equipment, so defining the qualified life of the equipment. The qualified life determines the frequency of replacement of that equipment, which can be re-assessed in function of the real operation conditions and location of that equipment.

The reactor coolant pressure boundary is treated in a specific way. It was originally designed to ensure a minimum useful life taking into account a limited number of transients during normal, incidental and accidental operation. As for the reactor vessel, it is monitored according to the transition temperature evolution (NDT) based on an irradiated samples withdrawal programme. The occurrence rate of the design transients is strictly recorded under the close supervision of Bel V.

With regard to all passive components important to safety on one hand, and the components important for the availability of the plant on the other hand, it is foreseen to make the component inventory and to follow in a systematic way all phenomena which have an impact on the lifetime of these components.

An In-Service Inspection programme is permanently implemented by personnel specifically qualified for these inspections, which are carried out during power operation of the unit or in shut down states.

All these tests and inspections are performed under fully detailed documented procedures.

II.J.2. Research Reactors

a) Main Results of Continuous and Periodical Safety Monitoring

During the operational lifetime of the installation modifications may be deemed necessary.

The modifications are treated with the same process as above described for the NPPs.

Experimental devices are not considered as modification of the reactor. A dedicated step wise approval system is developed. The experiment is at first discussed in an internal advisory committee. Based on the advice, the experiment has to be approved by the Health Physics Department and Bel V has to confirm this decision.

The installations of the SCK•CEN are also subject to periodic safety reviews.

According to the licence for operation of the SCK•CEN installations, the reactors BR1 and BR2 have to undergo a 5 yearly safety review. The result of this review has to be reported to the authorities. In 2009 the periodicity of the safety reviews was changed by royal decree to 10 years, as is the practice for nuclear power plants.

b) BR1

The last safety review of BR1 included four topics:

- A programme for the modernization of the fixed radiation monitoring systems has been defined.
- A seismic qualification has been performed. The reactor can withstand an earthquake that is expected with a frequency of one every 10.000 years. The main issue was to prove that the loose staked graphite pile would remain intact and would not show displacements that could prevent the fall of a control rod. This point could be proven.
- A few years ago an increased iodine release, still within operating limits, was observed. A number of fuel channels were unloaded and some failed fuel elements were found. An investigation programme was started in order to find the root cause of these failures. These can be attributed to the long-time slow interaction between the metallic uranium and the aluminium cladding.
- The study of the consequences of a full electrical black out. Although the reactor needs no active cooling after scram, one loses the readings of the instrumentation and it is difficult to have a good knowledge about the situation. Therefore the number of instruments connected to the battery backup system will be increased.

c) BR2

BR2 underwent from 1995 to 1997 a thorough refurbishment. The second beryllium matrix was nearing its end of life at that time and it was decided to replace it. A matrix was available from a zero power mock-up of BR2, called BR02, which was no longer in use. This BR02 matrix was fully qualified for use in BR2 and could be used for BR2 without any problem. According to the licence the matrix has to be inspected on regular intervals to follow cracking. Due to neutron irradiation gases (helium and tritium) are formed in the beryllium. This causes swelling and the initial space between the beryllium blocks will be consumed and blocks will make contact between each other. The cracks are caused by deformation and mechanical stresses. The licence specifies that the beryllium matrix must be replaced if the inspection indicates that there is a risk of losing material. At the latest, the replacement must be done if the fluence reaches 6.4×10^{22} fast neutrons per cm^2 for the most irradiated channel.

In case of replacement of the matrix, an inspection of the vessel is also required by the licence. In fact, this is the only occasion when the vessel wall is accessible. For the inspection of 1996, a fracture mechanical calculation of the vessel was made. However, the vessel is made of aluminium 5052-0 alloy. Knowledge about this material in irradiated condition is limited. Therefore it was decided to cut a number of samples out of the shroud, which is made of the same material and has received nearly the same irradiation dose. Out of these samples, tensile and fracture toughness test pieces were made. Some samples were immediately tested. The others were loaded in irradiation baskets in the reactor and a number of them will be tested on predefined time intervals. In this way a material follow-up programme for the vessel is established. The conclusion of the latest tests performed during the last periodic safety review, was that the material of the vessel has a sufficient mechanical resistance to at least 2026. Before that time a set of new samples need to be unloaded and tested.

During the lifetime of BR2 various systems were replaced. The last important modernization was the replacement of the control rod drive mechanisms with the position indicators included and the replacement of the cadmium neutron absorbers by hafnium.

Currently studies have been initiated for a next modernization and to allow operation of BR2 beyond 2016. For this, a third replacement of the beryllium matrix is foreseen in 2014.

II.K. Article 15. Radiation Protection

Each Contracting Party shall take the appropriate steps to ensure that in all operational states the radiation exposure to the workers and the public caused by a nuclear installation shall be kept as low as reasonably achievable and that no individual shall be exposed to radiation doses which exceed prescribed national dose limits.

II.K.1. Regulations

Chapter III of the GRR-2001 deals with radiological protection.

Article 20 of this Royal Decree sets among others the fundamental principles: justification if the practice, optimisation of protection and individual dose limits. Other Articles of that chapter are described in Article 7, section II.C.3 of the present National Report.

Article 23 of this Royal Decree describes the key role of the Health Physics Department (HPD). This department is, in a general way and amongst other duties, responsible for the organisation and the supervision of the necessary means for operational radiological protection, including keeping records of radioactive releases.

II.K.2. Design

Chapter III "General Protection" of the GRR-1963 introduced from the very beginning in Belgian law the radiological protection principles.

Belgian nuclear power plants design was done according to that legislation and, furthermore, consistent with the US regulations and in particular 10 CFR50 Appendix I and the related Regulatory Guide 1.21. In fact, as demonstrated in the Safety Analysis Reports of Belgium's units, the objectives of the US regulations were amply met, considering that the doses to the population computed according to the US rules are smaller by a factor of at least 3 than the criteria prescribed by these rules.

The releases limits, in annual average or in instantaneous value, were presented in the Report to the European Commission (application of article 37 of the Euratom Treaty) and are discussed in the Safety Analysis Report (chapter 11). Let us bear in mind that at the Belgian units the liquid effluents are released via one single pipe that groups the primary and secondary effluents and which is redundantly and automatically isolated in case an instantaneous limit is exceeded.

II.K.3. NPP Operation

a) ALARA Policy

Operational radiological protection programmes are inspired from chapter III of the GRR-2001 and from IAEA NS-G-2.7 (2002). Those programmes cover among others:

- Protective clothing and equipment,
- Training,
- Monitoring of individuals and workplace,
- Emergency plan,
- Health surveillance,
- Optimisation of protection,
- Etc.

The evolution has been taken into account, e.g. the introduction of the recommendations of the ICRP documents and the implementation of the Directive 96/29/EURATOM into the Belgian regulations.

To anticipate the implementation of these regulations the licensee has, on a voluntary basis, limited the individual worker dose at about the half of the dose limit which is 20 mSv for 12 consecutive months, in accordance with the GRR-2001.

Protection of the public is assured through limitation of the radioactive liquid and atmospheric releases. Those limits are presented in the Report for the European Commission (application of article 37 of the Euratom Treaty) and are discussed in the Safety Analysis Report (chapter 11), ensuring to limit the maximum dose to the individuals of the critical group well below 1 mSv per year.

b) Implementation of radiation protection programmes

(1) Dosimetric results

Various measures have been taken over the years to reduce the annual collective dose: the average value for the 7 Belgian units has been reduced by a factor of more than 4 during the 1990-2012 period.

The figure below represents the evolution of the outage collective doses of the Doel and Tihange sites since 1974.

The rise between 1974 and 1985 corresponds to the progressive start-up of the new units. The Tihange peak in 1986 is due to the extensive works linked to the first periodic safety review.

As the Tihange units operate along cycles up to 18 months, the number of refuelling outages varies from one year to the other, what introduces variations on the annual collective doses. Another factor of variation is the cumulated dose due to the replacement of steam generators. The introduction of an outage cycle of 18 months for Doel 4 in 2009 did not induce any significant variation in annual doses for the Doel NPP.

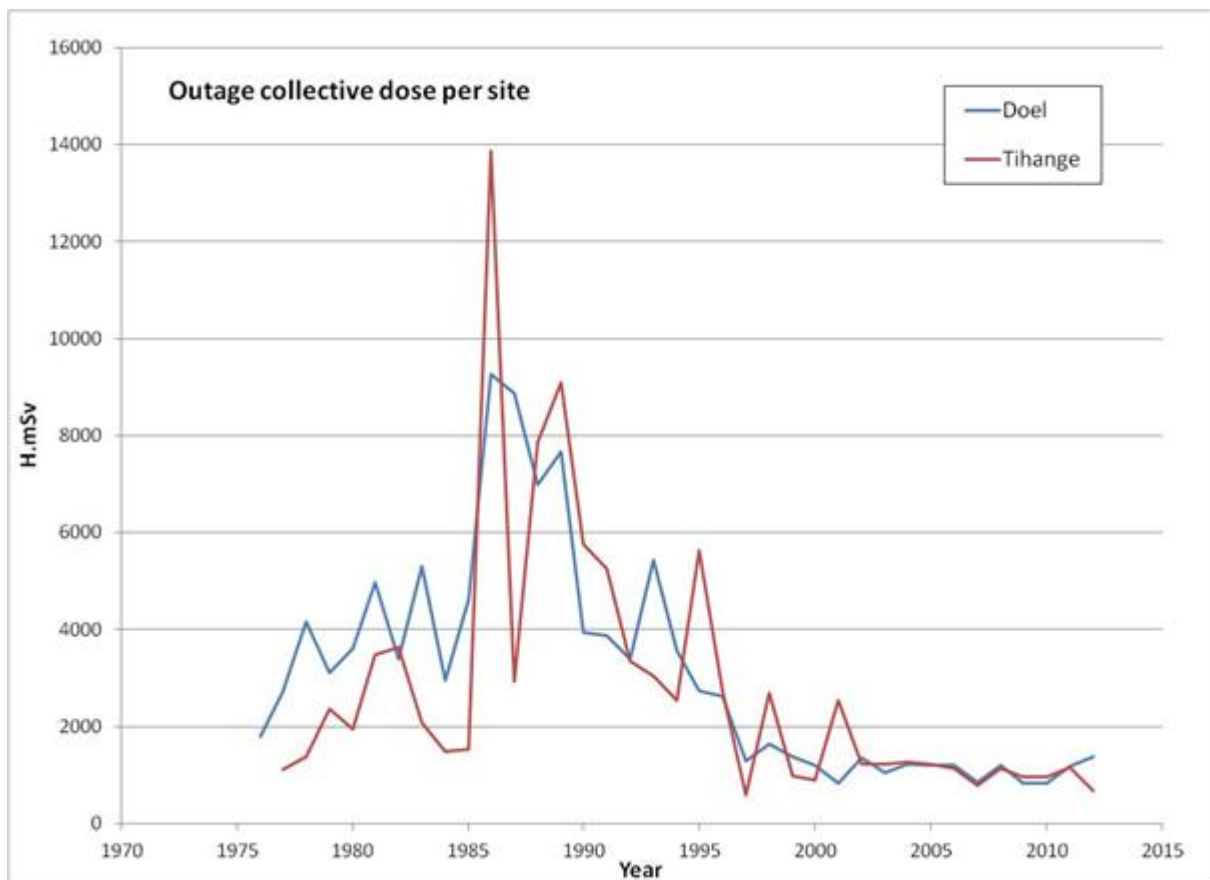


Figure 13 : Collective dose per outage

With those dose figures, Doel NPP ranks amongst the WANO best quartile for the Key Performance Indicator (KPI) Collective Dose Exposure (CRE) since a long time ago. Additional effort provided by Tihange NPP allowed to join this group late 2008.

Individual exposure amounts to an average of ~ 0.5 mSv per year. The dose constraint of 10 mSv was not exceeded anymore since 2006.

Good radiation protection performances are achieved through the optimisation of several parameters, whose main ones are briefly discussed below:

- The source term (dose rate and contamination),
- The time of exposure,
- The monitoring of working places and individuals,
- The distance from the source term,
- The protective means (shielding and protective clothes).

(2) Reduction of the source term

The primary system chemical conditioning procedure applied in preparation of the core refuelling outages proved to be very effective to reduce the dose rates induced by the contaminated systems: a continuous decrease in mean dose rates has been recorded for the primary loops. This procedure was developed thanks to operational experience feedback from pressurised water reactors.

During the period 2007 – 2009, Electrabel investigated the possibility to decrease the source term of plants characterized by higher figures than the average. Therefore Doel NPP planned to initiate Zinc injection into the primary fluid of Doel 3 from 2010. Zinc injection is fully implemented since April 2011 but one has to wait until ~ 2014 before observing an initial decreasing trend of the source term. The same project is currently considered for the unit Tihange 2.

In the period 2000 - 2007, statistics of fuel failures seemed to indicate a slight increasing trend. Therefore Electrabel put additional effort aimed at preserving the integrity of the 1st and 2nd barrier:

- Pay a special attention to the fuel assemblies quality,
- Develop an intensive Foreign Material Exclusion (FME) programme ,
- And develop an intensive programme of leakages tracking.

This effort proved to be efficient from 2009.

Finally, since 2007, special effort is put on the improvement of the radiological cleanliness of the workplaces, connected to the associated monitoring (see below). The whole Electrabel fleet can now display the following contamination performances:

- More than 97% of the RCA rooms are radiologically clean (i.e. surface contamination < 0,4 Bq/cm²) ;
- Residual individual contamination rate at the exit of radiation controlled area (RCA) ranges between 1 and 1,5 %.

(3) Monitoring of the working places and individuals

Systematic measurement is done daily of the surface contamination of the floors in representative locations during the outage. Immediate decontamination action is taken should a problem be detected. Effectiveness of the housekeeping activities inside the controlled area is pursued. Additional portable means for measuring the volumic activity (aerosols, iodine, and gases) are placed at the pool floor of the reactor building and at the access locks to the steam generators.

Since 2007, Electrabel improves the monitoring of the radiological cleanliness, covering the monitoring of the radiological cleanliness of the (un)clean working areas, monitoring of the contaminated individuals at the exit of radiation controlled area (RCA) and the tracking and elimination of the cause of contamination.

Signalling of the hot points and the ambient dose rates informs the workers about the ambient radiological conditions in which they will carry out the work: access is denied to certain locations, without specific permission of the Radiological Protection Department. Specific ALARA signals indicate very low dose-rate areas ("green" area) which the workers may use as an identified falling-back station.

Personal dosimetry of the workers is achieved through the simultaneous wearing of a passive and an active (electronic) dosimeters. The latter one is set up in order to alert the worker in case excessive dose and dose rate, depending on the type of work. Throughout the outage period, the actual-versus-estimated dosimetry trends are monitored daily, and any significant deviation is analysed and may result in corrective actions.

On 1st Jan 2012, the Tihange NPP replaced the passive film dosimeters (which are becoming obsolete) by the more precise, state-of-the-art Optically Stimulated Luminescent (OSL) dosimeters.

(4) Protective means

Shielding is systematically installed at various locations during core refuelling outages: primary pump cell floor, between steam generator and primary pump, around pressure vessel-head on its stand, vessel-well decompression piping, corridor at the hot penetrations, places of passage and waiting (access locks to the steam generators...), hand-holes of the steam generators...

Specific shields are also installed when deemed necessary with regard to the size of the work: pressuriser dome, valves, detected hot points...

Protective clothing is foreseen for both regular entrance in radiologically controlled areas and for work requiring breath protection clothing.

(5) Reducing time of exposure

Reducing the time of exposure is achieved through appropriate:

- training in radioprotection and in nuclear safety, making the workers aware of the radiation protection principles,
- pre-job briefing,
- training on make-up facilities,
- experience feedback,
- etc.

(6) Distance from the source

Keeping distance from the radiation source considered in the work preparation and supported by the monitoring system and the related databases (e.g. see above about the "green area").

c) Radioactive Releases

Discharges are defined as authorised and controlled releases into the environment, within limits set by the Authority. In addition there are operational release limits (limiting the release on time based assumptions), related with a scheme to notify the operators, the Health Physics Department, Bel V and the FANC.

Following Article 81.2 of the GRR-2001, the existing authorised release limits (gaseous and liquid releases) have been re-evaluated since 2002. The evaluation has been formally agreed by the Scientific Council of the FANC in December 2006.

The radiological impact of the authorized release limits to the most exposed individual of the public are given in the following table:

	Gaseous releases	Liquid releases	Total⁵ maximum
Tihange Site (3 units)	190µSv	80µSv	210µSv
Doel Site (4 units)	180µSv	230µSv	370µSv

Table 6 : Impact of Release Limits

From 1st January 2011, the radioactive releases have to be reported to the Belgian Safety Authorities following a new method, inspired from the 2004/2/Euratom Recommendation and ISO 11929 standard. The impact of new approach is significant, as the methodology implies a conservative declaration of isotopes below the detection level of the measurement devices, which automatically increases the release figures:

- **Iodine releases:** more than 10 % increase,
- **Aerosols releases:** more than 100 MBq/year in total for both sites, due to the fact that about 20 isotopes are below detection level and must be declared as a fixed amount.
- **Liquid releases:** about 2 times the previously declared values for both sites, due to the reason mentioned for aerosols.
- **Tritium releases:** no significant change.

The releases that took place effectively are only a few per cent of the limit values, except for tritium where the limit values had been chosen based on the operational experience of similar plants.

⁵ the Total maximum is not the sum of the dose due to the gaseous release and the dose due to the liquid release because the most exposed individual by each type of release is not in the same age category

Tihange Nuclear Power Plant					
	Gaseous releases			Liquid releases	
	Noble Gas GBq	Iodine MBq	Aerosols MBq	$\beta\gamma$ GBq	Tritium GBq
Annual limit	2 220 000	14 800	111 00	888	148 000
2008-10 average	15 433	23	3,4	13	47 367
% of the limit	0,70	0.15	0.003	1,46	32.0
2011 values	5 993	12	335	12,6	39 490
2012 values	8 154	33	266	13,6	52 627
2012 % of the limit	0,37	0,22	0,24	1,53	35,6

Doel Nuclear Power Plant					
	Gaseous releases			Liquid releases	
	Noble Gas GBq	Iodine MBq	Aerosols MBq	$\beta\gamma$ GBq	Tritium GBq
Annual limit	2 960 000	14 800	148 000	1 480	103 600
2008-10 average	25	62	6,1	3,5	48 870
% of the limit	0.001	0.42	0.004	0.24	47.17
2011 values	36 476	106	132	10,1	55 182
2012 values	35 806	36	84,3	5,8	47 566
2012 % of the limit	1,21	0,25	0,06	0,39	45,9

Table 7 : Release to the environment of the NPP-sites

Radiation monitoring of the environment and assessment of public health impact is assured by a programme set up and managed by the FANC, as stipulated in Article 71 of the GRR-2001. However a surveillance program performed by the utility, in the vicinity of the plants, is currently in development.

II.K.4. Research reactors

The management of the SCK•CEN introduced 10 mSv per year as a dose constraint for the personnel. Beside this constraint the SCK•CEN has an active ALARA policy. Each task with a potential exposure is analysed before starting and dose optimisation is performed. Afterwards, the predicted doses are compared with the real measured dose, in order to learn from the experience such that predictions for future tasks can be improved. Due to this ALARA policy, the radiation dose for the personnel has been reduced. During the last years, the total collective dose per year is about 130 man.mSv, for about 600 persons. More important, the maximum individual dose during the last years always has been lower than 10 mSv per year. A collective dose of about 70 man.mSv can be attributed to the operation of BR2. This figure remains fairly constant during the last years. Variations during the last years are due to the non-destructive inspection of the high pressure fuel test loop. The collective dose for BR1 operation is between 0.8 and 3 man.mSv per year, decreasing of the years. The main contribution to the dose is the handling of experiments, such as neutron activation analysis and reactor dosimetry.

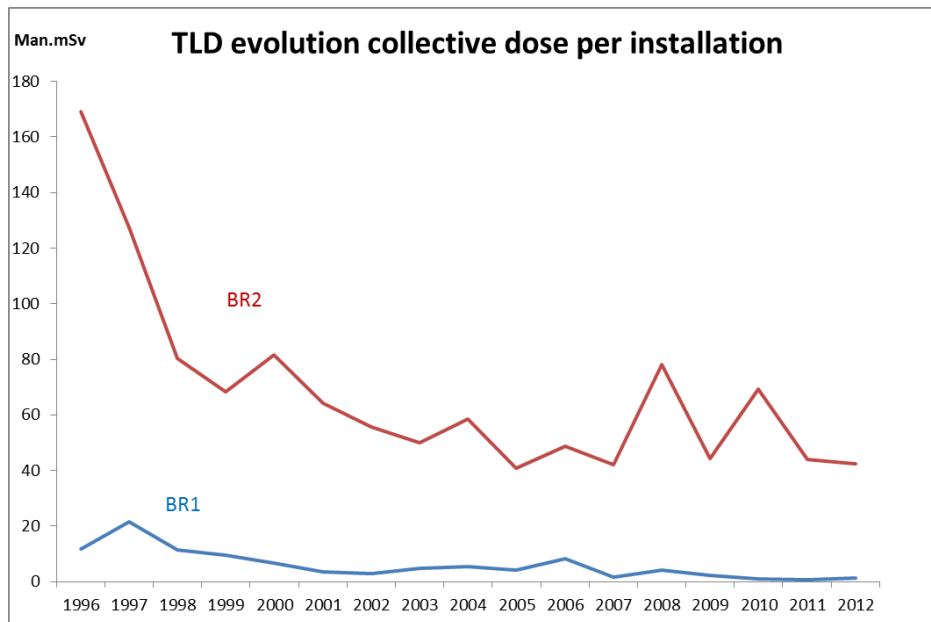


Figure 14 : Total Dose evolution per installation

a) Gaseous releases

The limits for radioactive gaseous releases were reviewed in 2002, following the implementation of the GRR-2001. The proposal was accepted by the FANC and the limits are integrated in the SCK•CEN Safety Analysis Report. The limits for the releases are defined such that the most exposed person in the environment could receive an effective dose of 100 μ Sv per year due to the operation of the SCK•CEN installations. 10 μ Sv per year is assigned to the operation of BR1 and 20 μ Sv per year to the operation of BR2.

The following gaseous releases are considered:

- For BR1: $\beta\gamma$ activity of aerosols and I-131.
- For BR2: α activity of aerosols, $\beta\gamma$ activity of aerosols, I-131, tritium and noble gases.

The releases of the last years are indicated in the following figures. The following comments could be made on the releases:

- From mid-2004 an increased release of I-131 was measured at the stack of BR1. This could possibly be an indicator for failed fuel cladding. Fuel channels with the highest thermal load were unloaded and the fuel was inspected. A number of failed fuel elements were discovered. All failed elements were replaced by new ones and since then releases of I-131 have fallen back to normal background levels.
- From end 2002 to 2004, a sharp increase in $\beta\gamma$ activity of aerosols from BR2 was measured, although no legal limits have been exceeded. The released isotope was mercury 203, which came from a quartz irradiation ampoule in the hot cell. The ampoule contained fresh irradiated mercury.
- The release level of noble gases in BR2 is normally below detection level. However, there have been a number of air cooled experiments. These caused the release of argon-41 as an activation product.
- The release of gaseous tritium is due to an old experimental device where helium-3 was used as a variable neutron screen. Irradiation with neutrons of helium-3 results in tritium. The installation is still present at the moment, but screens are no longer used with helium-3. However, they give still rise to a release of tritium.
- The years with higher level of iodine release of BR2 were due to periods with a higher failure rate of fuel plates. During the last years the number of fuel plate failures has become very low.

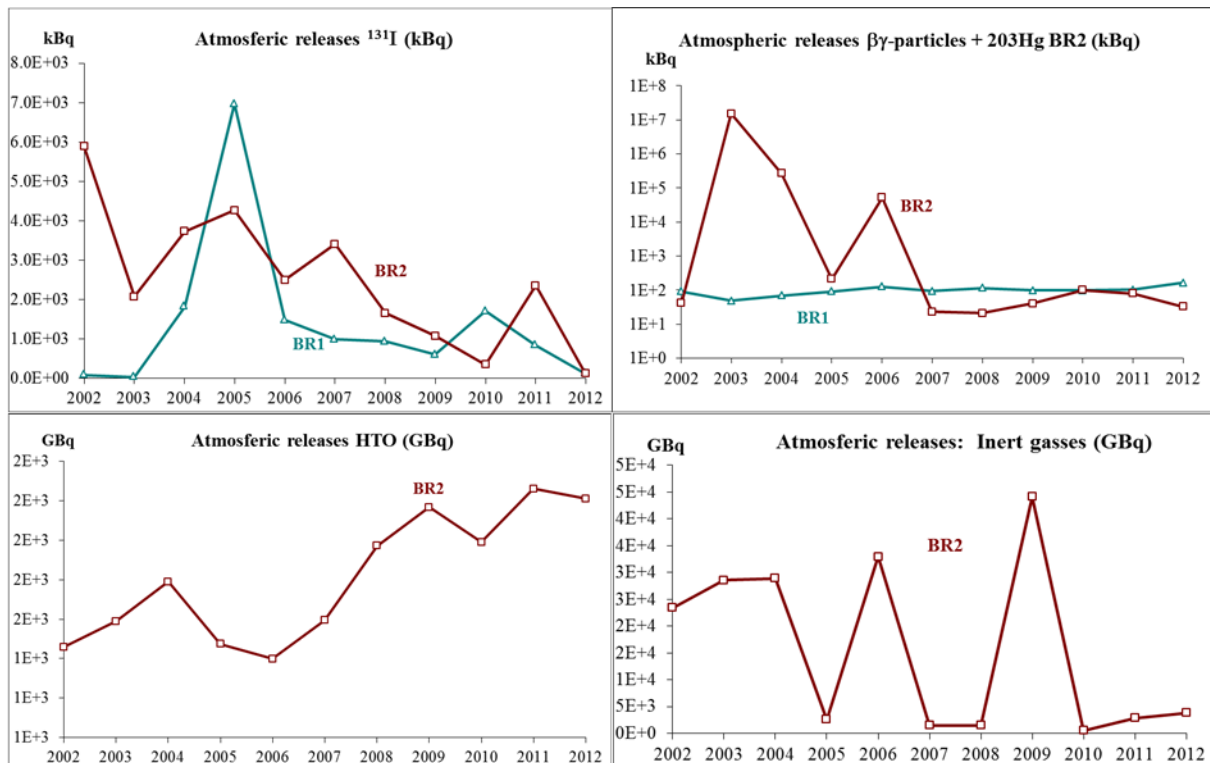


Figure 15 : Atmospheric Releases for SCK•CEN

b) Liquid releases

The SCK•CEN has no direct releases of liquid radioactive waste. All potentially contaminated water is sent to the waste treatment installation of Belgoprocess, where the water is treated before release to environment.

c) Environmental control

In addition to the direct stack measurements, 6 air measurement points are available around the site of the SCK•CEN. The α - and β - activity of air samples is continuously measured. Air samples of one of these measurement points is analysed monthly by spectrometry, in order to have an absolute measurement of the air contamination.

Possible water contamination is checked in four different situations: surface water (running water and water from lakes), ground water and drinking water. In routine, the total α - and β - activity and the concentration of tritiated water is measured. On request other measurements are possible.

Regular samples of milk and grass of a neighbouring farm are taken and measured by spectrometry for potential radioactive contamination

II.K.5. International Exchanges

The regulatory body and the Belgian operators participate actively since 1991 in the ISOE (Information System on Occupational Exposure) programme of OECD's Nuclear Energy Agency.

The Belgian NPPs operator is also participant in the working groups of the VGB (Germany).

II.L. Article 16. Emergency Preparedness

- 1) Each Contracting Party shall take the appropriate steps to ensure that there are on-site and off-site emergency plans that are routinely tested for nuclear installations and cover the activities to be carried out in the event of an emergency. For any new nuclear installation, such plans shall be prepared and tested before it commences operation above a low power level agreed by the regulatory body.
- 2) Each Contracting Party shall take the appropriate steps to ensure that, insofar as they are likely to be affected by a radiological emergency, its own population and the competent authorities of the States in the vicinity of a nuclear installation are provided with appropriate information for emergency planning and response.
- 3) Contracting Parties which do not have a nuclear installation on their territory, insofar as they are likely to be affected in the event of a radiological emergency at a nuclear installation in the vicinity, shall take the appropriate steps for the preparation and testing of emergency plans for their territory that cover the activities to be carried out in the event of such an emergency.

II.L.1. Regulatory Framework

The GRR-1963 in its Article 72 has from the beginning required an emergency plan for the regulated installations potentially presenting a serious radiological risk. This document was updated and replaced by the GRR-2001. The Royal Decree of 17 October 2003 defines a nuclear and radiological emergency plan for the Belgian territory.

This text has already been described in Article 7, § II.C.5 of the present National Report.

II.L.2. Implementation of Emergency Organisation in the Event of an Emergency

a) *Classification of Emergency*

The Royal Decree of 17 October 2003 defines three levels for the notification of emergencies, which are in ascending order of seriousness N_1 to N_3 , which the operator must use when warning the "Centre Gouvernemental de Coordination et de Crise - CGCCR" (i.e. the Governmental Centre for Co-ordination and Emergencies) which assembles under the authority of the Minister of Home Affairs. In addition, a fourth notification level ('reflex' level or N_R) has been considered to cope with events with fast kinetics. In case that an emergency situation is quickly developing (fast kinetics) and might lead within 4 hours to a radiation exposure of the population above an intervention reference level, immediate protective actions for the off-site population – without any assessment – are taken by the local authorities (Governor of the Province), waiting for the full activation of the emergency cells. The "automatic" protective actions taken under this "reflex"-phase are limited to **warning, sheltering and keep listening** within a predefined **reflex zone**. Once the crisis cells and committees are installed and operational, the Emergency Director of the authorities will decide to cancel the reflex phase and to replace it by the proper alarm level. In such case the governor of the province hosting the nuclear site is immediately notified in parallel to the warning message to the CGCCR. For each of these 4 notification levels (N_1 to $N_3 + N_R$) the notification criteria are defined in the Royal Decree of 17 October 2003. In addition, for each nuclear installation concerned, a set of particular types of events is established for each of the notification levels. In the specific case of the 'reflex' notification level, the activation criteria are based on predefined scenarios.

For example, the criterion associated with the N_1 level is defined as follows: "Event which implies a potential or real degradation of the safety level of the installation and which could further degenerate with important radiological consequences for the environment of the site. Radioactive releases, if any, are still limited and there is no immediate off-site threat (no action requested to protect the population, the food chain or drinking water). Actions to protect workers and visitors on site might be necessary."

Each of these 4 notification levels (N_1 to $N_3 + N_R$) activates the federal emergency plan. In addition to these four levels, a " N_0 " level is defined for notifying the Authorities in case of an operational anomaly. This last level does not activate the emergency plan.

All emergencies (N_1 to $N_3 + N_R$) have to be notified to the CGCCR. This permanently manned centre alerts the cells involved in the crisis management at the federal level (Emergency and Co-ordinating

Committee, evaluation cell, measurement cell, information cell, socio-economical cell) and houses these cells during the crisis situation as well.

The "Emergency Director" of the Authorities transforms the notification level into an alarm level (U_1 to U_3), putting into action the corresponding phase of the National Emergency Plan. In the case of N_R , the U_R alarm level is automatically triggered and the Governor of the province hosting the nuclear site immediately takes the 'reflex' protective actions (warning, sheltering and keep listening) in a pre-defined 'reflex' zone around the affected site. As soon as all the CGCCR's cells are in place and operational, the UR alarm level will be converted to an appropriate alarm level by the emergency director of the authority according to the evaluation of the situation and possible consequences. At that time the responsibility of the conduct of the operations returns to the Federal Minister of Home Affairs (or his representative).

b) National Master Plan for Organisation in the Event of Emergencies

The CGCCR is composed of the "Federal Co-ordination Committee" chaired by the Emergency Director of the Authorities, of the evaluation cell, of the measurement cell, of the information cell and the socio-economical cell, as indicated in the figure below.

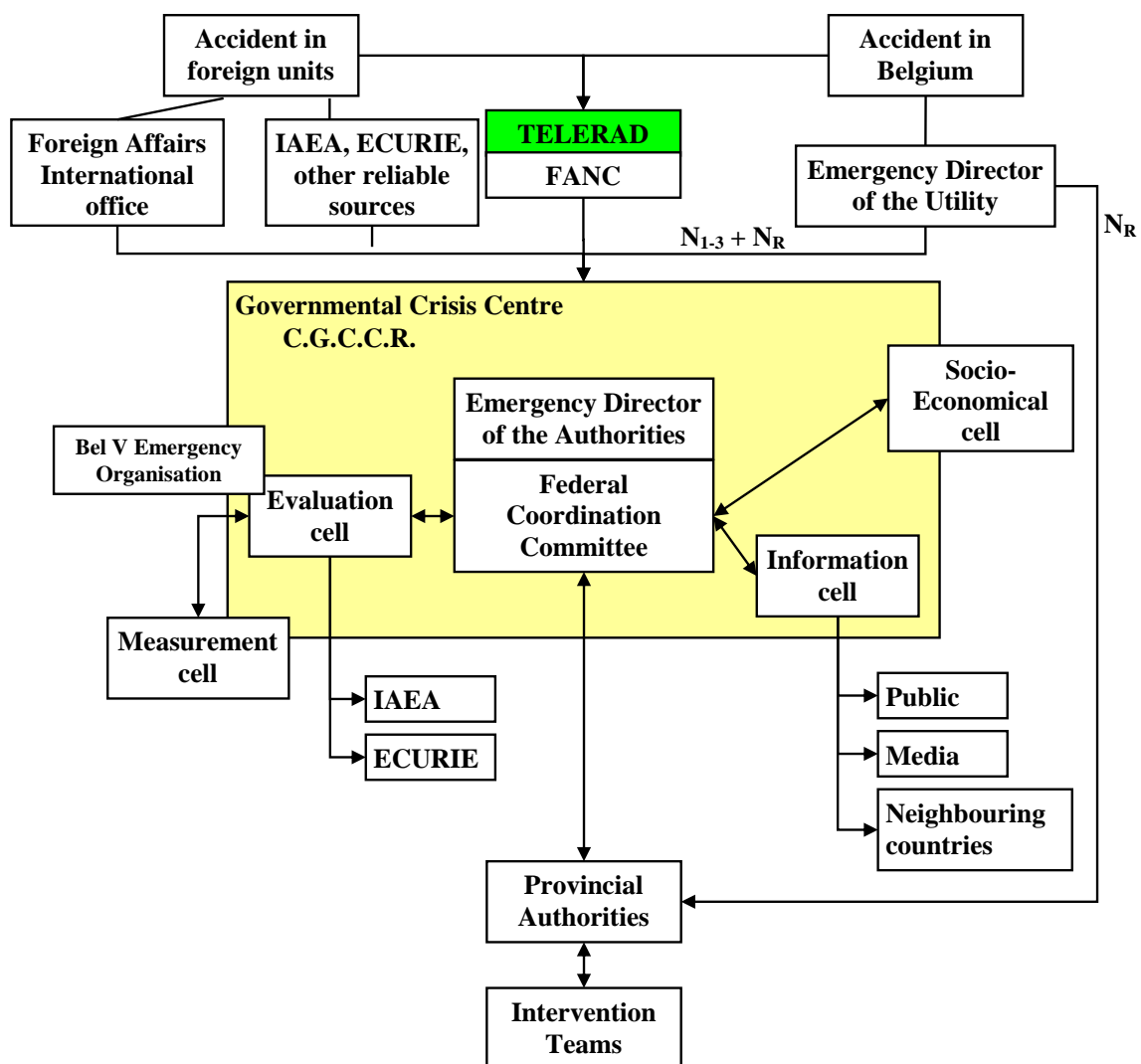


Figure 16 : EPP organisation for Belgium

In case of an accident abroad, the CGCCR, as National Warning Point (NWP), is informed by the Ministry of Foreign Affairs, the IAEA (through quick information exchange system EMERCON), the European Commission (through the European Commission Urgent Radiological Information Exchange system) or other reliable sources. The "Emergency Director" of the Authorities as National Competent

Authority for accidents Abroad (NCA-A) could also be informed by the IAEA and/or the EC. This information channel provides possible redundancy. In case of an accident in a Belgian installation, the operator's "Emergency Director" informs the CGCCR and supplies all the information that becomes known to him as the accident evolves.

The data received through Belgium's Telerad network for automatic radiological monitoring can also be accessed by the CGCCR. Telerad is a network with the principal aim to measure routinely the radioactivity and to make measurements in case of an accident occurring in a Belgian nuclear site or abroad. The monitoring of the territory consists in a measurement network having a 20 km mesh, measurement stations in the vicinity of the Belgian nuclear installations and along the Belgian border in the vicinity of nuclear power plants in neighbouring countries. Around the Belgian nuclear sites, the network is arranged in two rings: the first ring is on the site border and measures ambient radioactivity around the site, the second ring covers the near residential zone, between 3 and 8 km from the site, depending on the direction. Beginning of 2010 there were 199 stations for the measurement of the ambient dose rate in air, 7 stations for the measurement of iodine and β/γ in aerosols and 6 stations for the measurement of radiation in river water; 13 stations are complemented with a meteorological mast.

The figure below depicts the TELERAD network:

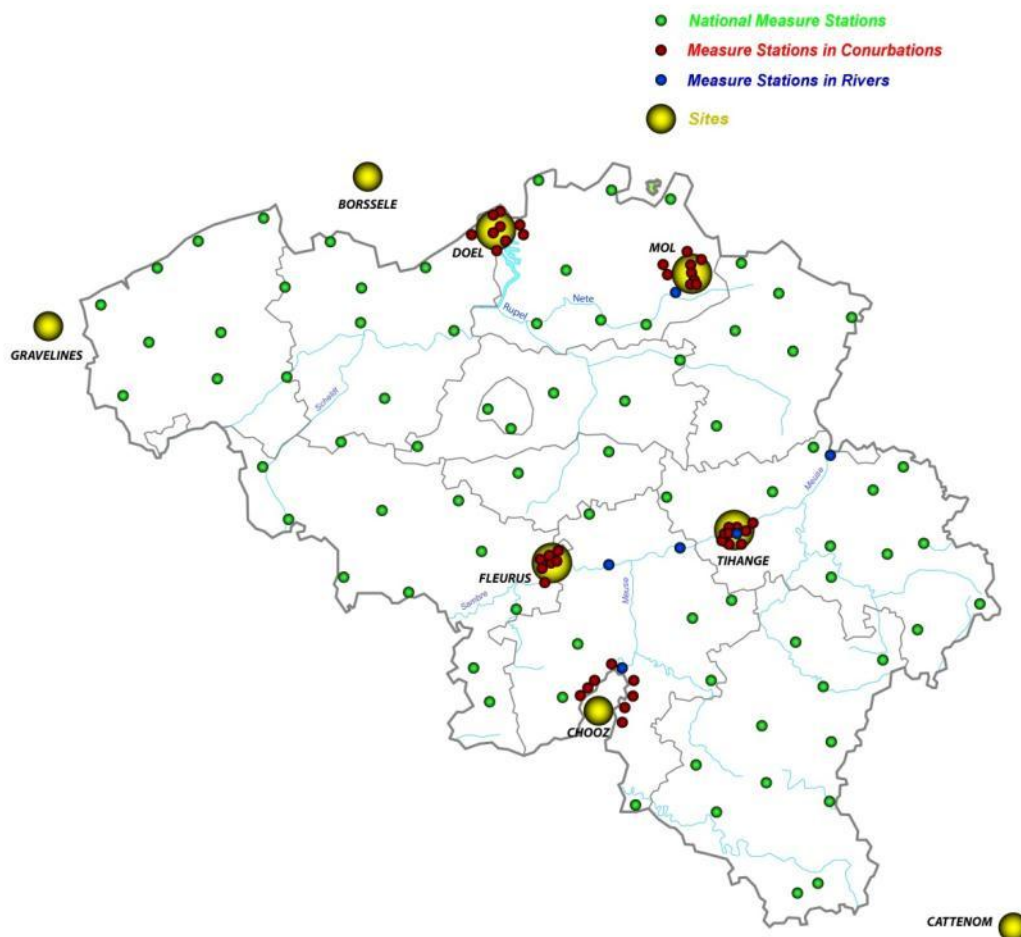


Figure 17 : TELERAD Network: location of the measuring stations

The TELERAD network has been completely refurbished in 2010-2012. New GM detectors have replaced the old detectors in the existing dose rate measuring stations except around the installation (first ring) where the existing detectors have been replaced by NaI scintillators. A number of stations has been added to the network in order to have a better coverage of the second ring around nuclear sites.

The Federal Co-ordination Committee is the official leader of the conduct of the operation in case of an emergency. It defines the general strategy to deal with the emergency, takes the basic decisions (need and extent of direct protective actions for the population and/or for the food chain or the drinking water supply) and assumes the political responsibilities. The Decision cell leans notably on the advices of the Evaluation and Socio-economical cells. The decisions taken are then transmitted for practical implementation and execution to the Provincial Crisis Centre, managing all the multidisciplinary intervention teams (fire brigades, civil protection, police, medical emergency services ...).

The evaluation cell is composed of representatives of the relevant departments (in particular the FANC which chairs the cell), the Federal Public Service of Public Health, the Federal Public Service of Foreign Affairs (for accidents abroad), the Department of Defence, the Royal Institute of Meteorology, and of experts of the Mol Nuclear Research Centre, the "Institut des Radioéléments", and of Bel V that supervises these installations, as well as of a representative of the operator of the facility. This cell gathers and evaluates all information received from the affected installation, the off-site radiological measurement results received from the Measurement Cell and information from institutions represented in the evaluation cell. It evaluates the installation status and its estimated time evolution in order to assess the real or potential impact of the event. Then, it advises the decision cell on protective actions for the protection of the population and the environment. This advice is elaborated on the basis of intervention reference levels, issued by the FANC (24 November 2003). The evaluation cell is also responsible for the preparation of the relevant information to be communicated to neighbouring countries and to the international organisations (European Commission, IAEA) in accordance with the Convention on Early Notification of a nuclear Accident and the "Ecurie" convention.

The measurement cell co-ordinates all the activities related to the gathering of field radiological information (external radiation in the air and from the deposits, samples measurements ...) transmitted either by the automatic radiological measurements network, TELERAD, or by the field teams. The measurement cell then transmits the collected and validated information to the evaluation cell.

The information cell is in charge of communications with the media and the population as well as with the neighbouring countries and specific target groups.

The socio-economical cell advises the Federal Co-ordination Committee on the feasibility and economic and social consequences of their decisions; it informs the Federal Co-ordination Committee about the follow-up and ensure the management of the post-accidental phase and an as prompt as possible return to normal life.

Depending on the scope, the cells which compose the CGCCR (Emergency and Coordination Committee, Evaluation Cell, Measurement Cell and Information Cell) participate in exercises of the emergency plans at the relevant facilities.

The Royal Decree of 17 October 2003 defines the emergency planning zones relative to the direct actions to protect the population (evacuation, sheltering, and iodine prophylaxis). These evacuation and sheltering zones have a 10 km radius around the nuclear plants; the stable iodine tablets pre-distribution zones extend to 20 km around the nuclear plants.

The intervention reference levels are set in the Decision of the FANC of 24 November 2003. They are 5 to 15 mSv expected total effective dose integrated over 24 hours e.g. taking into account all direct exposure pathways (cloud shine, inhalation and ground shine) for sheltering, 50 to 150 mSv expected total effective dose integrated over 7 days (1 week), i.e. by taking into account all direct exposure pathways (cloud shine, inhalation and ground shine) for evacuation. For intake of stable iodine, the intervention reference levels are 10 to 50 mSv thyroid equivalent dose for children less than 18 years and pregnant or breastfeeding women and 50 to 100 mSv for adults.

For off-site radiological calculations, focusing on the urgent protective actions, the licensee has to implement a radiological assessment model. For that purpose a dose/dispersion model developed by the Belgian Nuclear Research Centre (SCK•CEN) is used. The model is a segmented Gaussian plume model, based on the Belgian (also called Bultynck-Malet or SCK•CEN) turbulence typing scheme and the associated dispersion ('sigma') parameters ^[6]. These parameters were obtained using extended

⁶ H. Bultynck and L.M. Malet, Evaluation of atmospheric dilution factors for effluents diffused from an elevated continuous point source, TELLUS Vol 24, N°5 (1972).

tracer experiments on each site during the sixties/seventies. The calculation domain extends up to 50 km around the release point. For the Tihange site empirical correction factors were introduced to take the more complex topography into account. Calculations are done per time step of 10 minutes, extrapolations (projections) over time can be made as well. In addition to the dispersion model, a set of standard scenarios has been developed in order to perform quick assessments at early stages. In the latest version of the diffusion model ^[7], the parameters associated with the standard scenarios have been stored in a database allowing rapid projections for any of the pre-defined scenarios. In addition, simplified and user friendly tool and models are available to the evaluation cell and FANC-Bel V for cross-check validations and/or specific projections.

The exposure pathways considered for urgent protective actions are cloud shine dose, inhalation dose and ground shine dose (instantaneous and integrated up to one day and two weeks). Ingestion pathway would be covered by implementing measures on the food chain (food ban...).

Effective doses for adults and thyroid doses for adults and children are calculated. Deposition of iodine (limited to I-131) and caesium (limited to Cs-137) are also calculated. Related to forecasts, the total doses as well as the projected doses are calculated.

The National Emergency Plan is a continuously evolving issue on which is worked on a permanent basis. On the one hand this effort incorporates lessons learned from emergency exercises and aims at a steady progress in the development of standardized working procedures and tools for diagnostic purposes, radiation monitoring strategy and decision making on the other hand.

c) Internal and External Emergency Plans for Nuclear Installations, Training and Exercises, International Agreements

The emergency plan of each Belgian unit is systematically described in its Safety Analysis Report (chapter 13, § II.I.3) and has been approved at the time of licensing. In complement, an "internal emergency plan" details the instructions for all the actors.

These emergency plans take into account the related post-TMI actions.

In case of accident the unit's "Centre Opérationnel de Tranche" (COT - Tihange) – "Staffkamer (Doel) (i.e. the On Site Technical Centre) is activated and manages all the technical problems to control the accident and mitigate its consequences. At site level, the "Centre Opérationnel de Site" (COS - Tihange) – "Noodplankamer" (NPK - Doel) (i.e. the Emergency Operations Facility) manages the environmental impact, liaises with the CGCCR, and informs the media.

The nuclear power plant conducts internal exercises several times a year, and the General Directions of Civil Safety and of Crisis Centre of the Home Affairs Federal Public Service (FPS) organise one internal and one external exercise annually for each nuclear power plant and every two years for other sites.

Consistent with the intended objectives, the FPS involves in these exercises the various disciplines (fire brigade, medical help, police force, civil protection, measurement teams ...).

The operator is requested to draw up a scenario with which the objectives can be tested.

During the exercise, the information corresponding to the scenario is gradually forwarded to the various participants; the Training Centre full-scope simulator may in certain cases also be used on-line during exercise to provide information needed.

Information exchange at the international level is performed through the CGCCR, which has contacts with the competent Authorities of the neighbouring countries, and which is the "national contact point" for Convention on Early Notification of a Nuclear Accident (IAEA) and for the similar European Union system (ECURIE).

Agreements also exist at local and provincial level. The protocol Agreement between the province of "Noord Brabant" (The Netherlands) and the province of Antwerp (Belgium) provides for a direct line between the alarm station of Roosendaal (The Netherlands) and that of Antwerp, informing it as soon as the notification level N₂ is decided. This direct line is also used when certain accidents occur in the chemical industry (installations within the scope of the European post-Seveso Directive). A direct information exchange can also take place between the alarm station of Vlissingen (The Netherlands) and that of Ghent should an accident occur at the Borssele nuclear power plant. For the Chooz B and

⁷ A. Sohier, Expérience et évaluation des codes de calcul de doses actuels utilisés en temps de crise nucléaire, Annales de l'Association belge de Radioprotection, Vol 24, N° 4 (1999).

Tihange power stations, there are agreements between the Prefecture of the Ardennes department (France) and the province of Namur (Belgium).

In the frame of the agreement between the Government of the French Republic and the Government of the Kingdom of Belgium about the Chooz nuclear power plant and the exchange of information in case of incidents or accidents, a mutual alarm is foreseen between the two countries in case of an accident occurring in the nuclear plants in Tihange, Chooz or Gravelines. This alarm takes place between the CGCCR on the Belgian side and the CODISC ("Centre opérationnel de la Direction de la sécurité civile" which has now become the "COGIC", "Centre opérationnel de gestion interministérielle des crises") on the French side.

During the exercises of Chooz and of Gravelines that transborder collaboration is regularly tested at the local and national levels. In addition a direct exchange of technical and radiological information takes place between the organisations in charge of the expertise (IRSN on the French side, Bel V on the Belgian side) and in charge of the advice (Nuclear Safety Authority in France, Evaluation Cell of CGCCR in Belgium) and is quite successful. Based on these experiences, information exchanges have been developed as well as their implementation modalities between the French and Belgian parties involved with the view to be operational for further exercises and in case of incidents and accidents.

As regards independent evaluation in the event of an emergency, Bel V which oversees the affected installation sends a representative to that site, a representative to the evaluation cell of the CGCCR, and activates its own emergency plan cell. This cell has dedicated telephone and facsimile lines to the affected installation and to the evaluation cell. Based on the technical information supplied directly by its representatives and all the information about the unit that it has at its head office, Bel V proceeds with a technical analysis of the situation, assesses the radiological consequences from the releases indicated in the scenario, and produces release forecasts from the estimated situation of the unit.

These evaluations of the consequences to the environment are made either with the same computer codes as those of the operator, or with tools developed in Bel V, so as to allow a validation of the results provided by the licensee. These various computer codes have been compared in terms of assumptions and calculation methodologies.

On April 28, 2004 an agreement was signed between Luxembourg and Belgium concerning the exchange of information in case of incidents or accidents with potential radiological consequences. The following table gives an overview of some exercises (national and international) performed during the period 2010-2012 (only for the installations falling under the scope of the CNS):

Date	Site	Type	Objectives
21/04/2010	NPP Doel	National	Partial exercise, limited to the interaction and information exchange between the site emergency management team of the licensee and the federal evaluation cell CELEVAL. Scenario: LOCA. Mobilisation in real time. Use of actual meteorological conditions. Duration of the exercise about 6 hours.
27/04/2010	NPP Doel	Local	Evacuation test for the population around Doel NPP. About 500 volunteers were moved to a resort belonging to the Province East-Flanders where they (and their vehicles) were controlled for contamination, decontaminated when needed and registered. With the participation of the means and personnel of the civil protection, army, police, fire brigades, red cross ...
06/05/2010	NPP Chooz	International	Participation to a French exercise in order to test the bilateral agreement on information exchanges at different levels. Limited engagement of the Belgian measuring teams on the field. Scenario: IS-LOCA. Mobilisation in real time. Use of fictive meteorological conditions. Duration of the exercise about 8 hours.

Date	Site	Type	Objectives
08/07/2010	ECURIE level 3	International	<p>Table Top exercise aiming at testing information fluxes between EC and NWP, NCA(A) and NCA(D). Use of CoDecS-ECURIE.</p> <p>Scenario: Nuclear emergency at Brokdorpf NPP (Germany). Mobilisation in real time.</p> <p>Use of actual meteorological conditions.</p> <p>Duration of the exercise: 8h.</p>
15-19/11/2010	NPP Tihange	National	<p>Partial exercise, limited to the interaction and information exchange between the site emergency management team of the licensee and the federal evaluation cell CELEVAL.</p> <p>Scenario: LOCA.</p> <p>Mobilisation at a given time (pre-announced convening time).</p> <p>Use of actual meteorological conditions.</p> <p>Duration of the exercise about 6 hours.</p>
18/01/2011	NPP Gravelines	International	<p>Participation to a French exercise in order to test the bilateral agreement on information exchanges at different levels.</p> <p>Scenario: LOCA.</p> <p>Mobilisation in real time.</p> <p>Use of fictive meteorological conditions.</p> <p>Duration of the exercise about 8 hours.</p>
02-03/02/2011	ECURIE Level 3	International	<p>Table Top exercise aiming at testing information fluxes between EC and NWP, NCA(A) and NCA(D). Test of ECURIE alert receipt and message forwarding procedures. Test of EURDEP emergency mode data transmission.</p> <p>Scenario: nuclear emergency at Oskarshamn NPP (Sweden). Mobilisation in real time.</p> <p>Use of historical real meteorological conditions.</p> <p>Duration of the exercise: 36-48 hours.</p>
13/04/2011	ConvEx 2b	International	<p>Test of early notification procedures. Test for the submission of messages through the new USIE website.</p>
26/05/2011	NPP Tihange	National	<p>Partial exercise, limited to the interaction and information exchange between the site emergency management team of the licensee and the federal evaluation cell CELEVAL.</p> <p>Scenario: one fuel assembly immobilized partly above the water level during removal for refuelling Mobilisation at a given time (pre-announced convening time).</p> <p>Use of historical real meteorological conditions.</p> <p>Duration of the exercise about 6 hours.</p>
06/09/2011	NPP Doel	National	<p>Partial exercise, limited to the interaction and information exchange between the site emergency management team of the licensee and the federal evaluation cell CELEVAL.</p> <p>Scenario: LOCA.</p> <p>Mobilisation in real time.</p> <p>Use of fictive meteorological conditions.</p> <p>Duration of the exercise about 8 hours.</p>
12-13/10/2011	NPP Borssele	International	<p>Participation to a Dutch exercise in order to test the bilateral agreement on information exchanges at different levels.</p>

Date	Site	Type	Objectives
			<p>Scenario: nuclear emergency at Borssele NPP (Loss of external electrical power) followed by a LOCA.</p> <p>Mobilisation in real time.</p> <p>Use of historical real meteorological conditions.</p> <p>Duration of the exercise maximum 36 hours.</p>
29/03/2012	NPP Doel	National	<p>Partial exercise, limited to the interaction and information exchange between the site emergency management team of the licensee and the federal evaluation cell CELEVAL.</p> <p>Scenario: steam generator tube rupture with limited venting to the atmosphere (IS-LOCA).</p> <p>Mobilisation in real time.</p> <p>Use of historical real meteorological conditions.</p> <p>Duration of the exercise about 6 hours.</p>
27-28/06/2012	Cattenom (1 of 3)	International	<p>Participation to the first phase (threat) of an international (involving the department of Lorraine [FR], The GD of Luxemburg, the länder of Sarreland and Rhenanie-Palatinat [De] and the Wallon region [Be]) exercise in order to test the bilateral agreement on information exchanges at different levels.</p> <p>Scenario: LOCA.</p> <p>Mobilisation in real time.</p> <p>Use of fictive meteorological conditions.</p> <p>Duration of the exercise about 8 hours.</p>
20-21/11/2012	NPP Tihange	National	<p>Global exercise directed by controllers, with the participation of most response organisations, deployment of field intervention teams and interaction with the IAEA-IEC and Dutch local and national Authorities. Special emphasis was put on the coordination of mobile measurement teams and on the management of the media pressure, with the contribution of teachers and last year students of a journalist school, simulating the media and the public.</p> <p>Scenario: first day: contaminated primary circuit and rupture of tubes in the vapour generator (IS-LOCA).</p> <p>second day: leak of a gaseous effluents treatment reservoir.</p> <p>Mobilisation in real time on the first day.</p> <p>Use of historical real meteorological conditions.</p> <p>Duration of the exercise: about 36h (test of changing teams).</p>
05/12/2012	Cattenom (2 of 3)	International	<p>Participation to the second phase (emergency protective actions) of an international (involving the department of Lorraine [FR], The GD of Luxemburg, the länder of Sarreland and Rhenanie-Palatinat [De] and the Wallon region [Be]) exercise in order to test the bilateral agreement on information exchanges at different levels.</p> <p>Scenario: LOCA.</p> <p>Mobilisation in real time.</p> <p>Use of fictive meteorological conditions.</p> <p>Duration of the exercise about 8 hours.</p>
25-28/06/2013	Cattenom (3 of 3)	International	<p>Participation to the third phase (post-accident phase) of an international (involving the department of Lorraine [FR], The GD of Luxemburg, the länder of Sarreland and Rhenanie-Palatinat [De] and the Wallon region [Be]) exercise in order to test the bilateral agreement on information exchanges at different levels.</p>

Date	Site	Type	Objectives
			Scenario: LOCA. Mobilisation in real time. Use of fictive meteorological conditions. Duration of the exercise about 4 x 8 hours.

Table 8 : Overview of EPP exercises for the period 2010-2012

d) Information of the Public

The GRR-2001 specifies in its Article 72 all the obligations regarding training and information of the public pursuant to the Directive 89/618/ Euratom.

During the accident itself, information is supplied to the media by the information cell of the CGCCR. At local level the provincial emergency plan includes the ways to inform the population (sirens, police equipped with megaphones, radio and television) and to follow-up the instructions given to the population (iodine tablets, sheltering, evacuation ...).

II.L.3. SCK•CEN (research reactors)

The general rules for emergency preparedness for the SCK•CEN installation are the same as for the nuclear power plants. The SCK•CEN has a central emergency control room, equipped with the necessary information and communication systems and is located in a building without major nuclear infrastructure. The SCK•CEN has one vehicle fully equipped for radiation measurements in emergency situations. The measurement capacity can be increased using a second vehicle with manual measurement equipment. These measurement teams are available for the national crisis centre.

The organisation of the internal emergency plan is described in a general procedure. For each of the groups involved in the emergency plan a task description is available. Standard accident scenarios are developed for the major nuclear installation. These must allow recognizing and communicating the essential information and the potential consequences to the national crisis centre. According to the Belgian national nuclear emergency plan, these scenarios can lead to the various notifications levels N1, N2, N3 and NR. The level NR, which means the risk of a fast significant release of fission products can only occur for BR2 in case of severe damage to the fuel combined with containment by pass.

Exercises are held, in cooperation with the authorities and the other nuclear facilities in the neighbourhood. Every year, another company simulates the accident and takes the lead in the exercise. The measurement teams take also part in the exercises of the nuclear power plants.

Beside the internal emergency plan, the SCK•CEN is also involved in the national crisis centre. Experts participate in different evaluation cells.

II.M. Article 17. Siting

Each Contracting Party shall take the appropriate steps to ensure that appropriate procedures are established and implemented:

- (i) for evaluating all relevant site-related factors likely to affect the safety of a nuclear installation for its projected lifetime;
- (ii) for evaluating the likely safety impact of a proposed nuclear installation on individuals, society and the environment;
- (iii) for re-evaluating as necessary all relevant factors referred to in subparagraphs (i) and (ii) so as to ensure the continued safety acceptability of the nuclear installation;
- (iv) for consulting Contracting Parties in the vicinity of a proposed nuclear installation, insofar as they are likely to be affected by that installation and, upon request providing the necessary information to such Contracting Parties, in order to enable them to evaluate and make their own assessment of the likely safety
- (v) impact on their own territory of the nuclear installation

II.M.1. NPPs

a) *Characteristics taken into Account in the Sites Selection*

The Doel and Tihange nuclear sites were originally evaluated according to the requirements set by the US rules (Chapter 2 of the Safety Analysis Report, Standard Review Plan, 10 CFR 100).

These requirements apply to the phenomena of natural origin (earthquakes, floods, extreme temperatures...) and to the phenomena of human origin (industrial environment, transport...).

With regard to the natural phenomena:

- The geological and seismic characteristics of the sites and their environment were specifically investigated so as to identify the soil characteristics and the earthquake spectrums in order to define the design bases to be considered when dimensioning the structures and systems.
- The hydrological characteristics of the rivers Meuse (Tihange) and Scheldt (Antwerp) were surveyed, not only to quantify the risk of floods and possible loss of the heat sink, but also in order to develop the river flow models in order to assess the dilution of released liquid effluent.
- Meteorological and climatic surveys allowed defining the atmospheric diffusion and dispersion models to be used when assessing the short-term and long-term environmental impacts of atmospheric releases taking into account the local characteristics. These studies were complemented with demographic surveys in the vicinity of these sites.
- Concerning the population density around the sites, no detailed criterion was imposed originally. But the design of the installations made allowance for the existing situation: the "low population zone" of the USNRC rules is in fact within the site. Consequently the radiological consequences of incidents or accidents are calculated for the critical group living at the site border or in any other location outside the site where the calculated consequences are the largest.
- Due to the very high source terms imposed by the U.S. safety rules, the design of the Belgian units incorporates strict demands on the containment leak rate (double containment with a steel liner for the primary containment) and systems to prevent liquid or gaseous leaks through the containment penetrations.

With regard to the external events of human origin:

- Due to the population density in the vicinity of the sites, and also considering the impact that the local industrial activities may have on the power stations, specific requirements were adopted in 1975: protection against external accidents such as civil or military aircraft crash, gas explosion, toxic gas cloud, major fire.
- The Tihange 2 and 3 and Doel 3 and 4 units were equipped with ultimate emergency systems aimed at automatically tripping the reactor, keeping it in hot shutdown during three hours so that after that period of time it may be possible to bring the unit to cold shutdown and to

remove residual heat, after a design basis external accident as referred to above, or during any loss of the normal control room or any of the systems that are controlled from it.

- These ultimate emergency systems are called “bunkered systems” as they are installed in specifically reinforced buildings. They comprise an autonomous protection and instrumentation system supplied with electric power from dedicated emergency diesel-generator sets, as well as primary make-up (water with boric acid to control the reactivity) and steam generator feedwater systems.
- Measures were also taken to guarantee the emergency heat sink. At the Tihange site, the preferred option was to bore wells from where groundwater can be pumped, whereas at Doel three artificial lakes were created.
- Following the 2001 September 11 events, Electrabel and the Safety Authorities were brought to:
 - consider the eventuality of a voluntary aircraft crash on the Belgian Nuclear Power Plants,
 - identify which type of impact these plants would encounter,
 - determine the potential consequences of such impact,
 - consequently, adapt the in-depth defence strategy.
- From the studies performed on the potential consequences of an impact on each of the buildings of the plants of Doel and Tihange, it appears that:
 - the initial design of the last four units is good: no perforation of the external containment even with a Boeing 767 at a speed of 150 m/s,
 - the initial design of the reactor buildings of Tihange 1 and Doel 1 & 2 is less resistant than those of the more recent units: partial perforation of the external containment but without any consequence on the safety systems, even with a Boeing 767.
 - it is necessary to be able to fight a kerosene fire in order to avoid any damage at the structure of the building due to high temperature exposure. In accordance with the fire department and Bel V, new equipment were bought and are now operable (special fire fighting truck with high pressure foam pumps) and are approved by the regulatory body.

b) *Periodic Reassessment of the Site Characteristics*

Reassessments are systematically performed during the periodic safety reviews of each unit.

During the 1st periodic safety review of Doel 1 & 2, as external accidents had not been considered in the initial design, additional emergency systems were installed in a reinforced building (the Bunker).

For the Tihange site, the safe shutdown earthquake originally considered (in the early seventies) for Tihange 1 was of 0.1 g acceleration. This value was increased to 0.17 g following the Tihange 2 safety analysis (end of the seventies). As a consequence, the latter value was adopted for the site as a whole; it did not need to be modified when the Liège earthquake of 1983 was analysed. The seismic reassessment of Tihange 1 was performed during its 1st periodic safety review in 1985.

This resulted in a considerable number of reinforcements being made in certain buildings, and in the seismic qualification of the equipment being re-examined (using the methodology developed by the US Seismic Qualification Utility Group).

Also, a review of the protection of Tihange 1 against external accidents was performed: the probability was assessed that an aircraft crash would result in unacceptable radiological consequences; taking into account the specificities of the buildings, that probability was found sufficiently low.

During the periodic safety review of each of the units, studies are performed and, where necessary, measures are implemented to ensure that the residual risk following external accidents remains acceptable taking into account the environment of the site with respect to the risks resulting from transport (including by aircraft) and from industrial activities.

The protection against potential floods at Tihange NPP was reassessed in the framework of periodic safety reviews as well as the possible rise in temperature due to climate changes. This led to the decision to build a peripheral protection of the site, this action being currently conducted as part of the “Stress tests” action plan (see below).

c) Stress tests

Following the Fukushima Daiichi accident, the licensee was asked to conduct stress tests. Safety evaluation reports for the Doel and Tihange sites have been established by the licensee and reviewed by the FANC and Bel V and external experts. In the frame of the stress tests, an assessment of design bases, existing margins and cliff-edge effects was performed in relation to risks related to the Site Characteristics like earthquake, flooding and bad weather conditions,

An action plan was launched as a result of the assessment, including:

- Reinforcements of Structures, Systems and Components to improve their resistance against beyond design earthquakes;
- A site peripheral protection for Tihange, in relation to a upgraded design basis flood;
- Improvements of the protections against beyond-design-basis floods: in Doel, volumetric protections of sensitive buildings and adapted procedures; in Tihange, water supplies (involving pipings, pumps, additional electrical diesel generators, etc.) to the primary circuit, the steam generators and the spent-fuel pools, with adapted procedures and training;
- Improvements of the sewerage systems for protecting the sites against rains with return periods much larger than considered in the design.

Most actions are expected to be implemented by the end of 2014.

d) International Agreements

The necessity to inform the neighbouring countries when planning a nuclear installation is stipulated by Article 37 of the Euratom Treaty, and as a consequence is mandatory in Belgium (cf. Article 6 of the GRR-2001). The reports drawn up to meet this requirement have been transmitted to the European Commission as provided for in the licensing procedures for the Belgian power plants. After consultation of the "Article 37" group of experts, the Commission issued a favourable advice for the sites of Doel and Tihange. Direct information of the neighbouring countries which might undergo notable consequences on their territory is an obligation deriving from the Directive 85/337/EEC on the assessment of the effects of certain public and private projects on the environment.

II.M.2. SCK•CEN (research reactors)

a) Characteristics taken into Account in the Sites Selection

The installations of the SCK•CEN are located in the north-east of the province of Antwerp, which is one of the lesser populated regions of the northern part of Belgium. This was one of the major reasons for the choice of the location, together with the availability of sufficient free terrain.

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The site has a low risk for the occurrence of natural phenomena. However, as a consequence of the events at the Fukushima Daiichi plants, the risks for natural and human external phenomena were reviewed. Following conclusions were drawn:

- The site is located far from major rivers or from the sea, in a flat sandy area, such that the risk of flooding is very limited. However, very local flooding with a height up to 0.3 meter is possible due heavy rain combined with melting snow. Protection against this kind of flooding is under design
- The closest active seismic fault is located at a distance of about 80 km. At the occasion of the periodic safety review conducted in 1996, a seismic assessment of BR2 was made using a reference earthquake with a free field magnitude of 0.1g. This resulted in strengthening of a few components. With the periodic safety review of 2006, a similar analysis was made for BR1. For the safety review as a consequence of the Fukushima Daiichi accident, the reference acceleration was increased and the resistance of the reactors was studied. Although both reactors rely on natural convection cooling in emergency situation it was concluded that additional electrical power would be useful in case of a severely damaged installation.
- The risk of an airplane crash is also reassessed as a consequence of the Fukushima Daiichi accident. Direct damage to the fuel or other vulnerable components is not expected. However, the crash of a large airplane could lead to a kerosene fire. Sufficient fire fighting capabilities must be foreseen.

- The site is surrounded by pinewood trees. A forest fire during dry periods is considered as a risk. This was already recognized during the periodic safety review of 2006. The forest around the area is foreseen with additional fire hydrants such that the fire brigade can have sufficient water in the neighbourhood. Special precautions are taken during long dry periods. In addition, after the reassessment all trees within 16 meters from building will be cleared.

b) Stress tests

Following the Fukushima Daiichi accident, all "Class 1" nuclear installations (including the power reactors and the research reactors), were asked to conduct stress tests. The safety evaluation report for SCK has been established by the licensee and reviewed by the FANC and Bel V. No peer review was foreseen.

In the frame of the stress tests, an assessment of design bases, existing margins and cliff-edge effects was performed in relation to risks related to the site characteristics like earthquake, flooding and bad weather conditions. A graded approach was used.

The FANC National report was issued on April 16, 2013. Update of the SCK action plans is expected for July 1, 2013.

The main issues concerning siting are:

- A new Probabilistic seismic-hazard assessment study of the Mol-Dessel region was done by the Royal Observatory of Belgium. Following a graded approach, a return period of 1000 years (in place of 10000 years for NPP) was chosen. Despite the fact that the PGA level was substantially increased, enough margin was found for a large part of the Structures, Systems and Components important for safety. A seismic qualification will be done (action plan) for the remaining Structures, Systems and Components important for safety.
- Stress tests confirmed that the risk of flooding is very limited.
- A higher return period (minimum 1000 years) for rain will be considered.

II.N. Article 18. Design and Construction

Each Contracting Party shall take the appropriate steps to ensure that:

- (i) the design and construction of a nuclear installation provides for several reliable levels and methods of protection (defence in depth) against the release of radioactive materials, with a view to preventing the occurrence of accidents and to mitigating their radiological consequences should they occur;
- (ii) the technologies incorporated in the design and construction of a nuclear installation are proven by experience or qualified by testing or analysis;
- (iii) the design of a nuclear installation allows for reliable, stable and easily manageable operation, with specific consideration of human factors and the man-machine interface.

The design, as well as the major modifications following the successive periodic safety reviews of the Belgian nuclear power plants is described in Appendix 1 to the present Report.

II.N.1. NPPs

a) Rules followed during Design and Construction

The "Commission Spéciale des Radiations Ionisantes" (i.e. the Belgian nuclear safety Commission, now replaced by the Scientific Council of the FANC) decided in 1975 that the USNRC rules should be followed for the construction of the next four units (Doel 3 and 4, Tihange 2 and 3) and that some accidents of external origin should be considered in the design.

Accordingly, the design and safety analysis of these units have been done following the US NRC rules and all the associated documentation (regulatory guides, standard review plans, ASME Code, IEEE standards, ANSI, ANS, etc.) in order to ensure a consistent approach. 10 CFR 20 on radioprotection was not followed, as the corresponding topics are covered by the Euratom Directive on the basic safety standards, which is mandatory for all member States of the European Union. Compliance with the withheld US NRC rules is documented in the Safety analysis Report, deviations are identified and justified. For non-mandatory rules, the Safety Analysis Report documents how they have been implemented, in compliance with the safety objectives.

For safety-related pressure vessels, a specific derogation to the Belgian pressure vessel regulations ("Règlement général pour la protection du travail") was elaborated, in order to allow the use of the US rule based ASME Code sections III and XI. A few components not covered by the ASME specifications but covered by the Belgian regulations had still to comply with the Belgian regulations. A transposition of the ASME Code has been written to cover organisational aspects like the definition of an inspector, of the Authorised Inspection Agency (AIA), etc... That transposition of the ASME Code clarifies also the conditions under which other construction or in service inspection codes (like French or German codes) can be used. Their equivalence must be justified, justification which must be agreed by the AIA and by Bel V.

As mentioned above, the document of the Special Commission has also required that accidents of external origin be considered (i.e. aircraft crash, gas explosion, toxic gases, large fire).

The protection against explosions has been based on German rules. For the aircraft crash the bunkered structures have been designed to resist the impact of a civil airplane of about 90 tons at a speed of 85 m/s. It was also checked that the probability to go beyond the design criteria of the bunkered structures was smaller than 10^{-7} per reactor year. Toxic and explosive gas (external explosion) have also been considered and integrated in the design.

It has been shown that the probability to exceed the design criteria was, for each family of external accidents, smaller than 10^{-7} per reactor year and 10^{-6} per reactor year for all external accidents together.

The residual risk is a fortiori smaller, as exceeding the design criteria does not imply, with a probability equal to one, unacceptable radiological consequences.

b) Periodic Safety Reviews

(1) Rules followed up to 2007

The Royal Decree of Authorisation of each nuclear unit makes it mandatory to conduct periodic safety reviews. These safety reviews must "compare on the one hand the conditions of the installations and the implementation of the procedures that apply to them, and, on the other hand, the regulations, codes and practices in force in the United States and in the European Union".

The differences found must be identified, together with the necessity and possibility of remedial action and, as the case may be, the improvements that can be made and the time-schedule for their implementation".

The topics to be studied in these safety reviews are detailed in a report submitted by the licensee to the FANC; in this way the rules retained become obligatory.

The feedback of operational experience of nuclear power plants at the international level is also considered; in this respect the "Bulletins" and the "Generic Letters" of the USNRC, as well as information available from other regulatory bodies, are examined, if their follow-up has not yet been required in the frame of the permanent supervision during operation of the installation.

From this, one can conclude that all the new rules of the USNRC are not automatically applied in the Belgian plants, and that non-American rules, guides and practices can also be retained for implementation in Belgium.

The list of technical subjects examined during the successive periodic safety reviews is given in extenso in Appendix 5 to this Report.

(2) Additional rules followed from 2007 onwards

In 2007, the FANC has required that the future safety reviews of all nuclear units are carried out by using the IAEA Safety guide NS-G-2.10. Both the scope and the methodology are based on the approach adopted by the IAEA by the use of 14 Safety Factors, followed by a Global Assessment.

The objectives of the Safety Review are multiple. In the review, the Operator should assess the state of the installation and the organisation in relation with international legislation, standards and good practices. Furthermore, strong points and weaknesses should be identified, as well as compensating measures in the case that some weak points possibly cannot be modified. Finally, the assessment should show to what extent the safety requirements of the Defence in Depth (DiD) concept are fulfilled, in particular for the basic safety functions of reactivity control, fuel cooling and the confinement of radioactive material.

c) Application of the Defence in Depth Concept

The defence in depth concept is an integral part of the Framatome or Westinghouse nuclear power plants designs, and is also found in the US safety rules.

Accordingly, this concept has been systematically applied in all the Belgian nuclear power plants.

Furthermore, the design of all the additional systems to address external accidents adhered to the same principles, and in particular the single-failure criterion was applied. Compared to a conventional-design pressurised water reactor nuclear power plant, the additional systems installed to mitigate the consequences of an external accident in fact strengthen considerably the third level of the defence in depth approach, as they can help during certain internal accidents which might develop unfavourably.

In the framework of periodic safety reviews, for all units, a global evaluation of the safety during low-power and shutdown states is being performed in 2013.

d) Accident Prevention and Mitigation of Consequences

Accident prevention and mitigation of consequences are basic principles adhered to in the design of Belgian nuclear power plants.

In case of disturbance in the operation parameters of the plant, the control system will respond in order to bring the plant back to its nominal operation point.

In case of risk of reaching the safety limits, the reactor protection system will shut down the plant.

The engineered safety systems are activated to address the design basis accidents and achieve the safe shut down of the plant.

Consistent with the standard format of the Safety Analysis Reports, all the instrumentation and control systems are described in chapter 7, and incident and accident analyses are discussed in chapter 15.

We shall bear in mind that the four more recent Belgian units (Doel 3 and 4, Tihange 2 and 3) are three-loop 1 000 MWe units that are designed with three independent safety trains (instead of two interconnected trains in a traditional design).

Apart from the Doel 1 & 2 units, in which the primary containment is a metal sphere, the primary containment of all other units is a prestressed concrete structure with on the inside a steel liner. The secondary containment is in reinforced concrete at all units. The annular space between the two containments is put at negative pressure after an accident, so as to collect possible leaks. There is an internal recirculation and filtration system in the annular space and the air is filtered again prior to release via the stack.

During the 90's, probabilistic safety studies were carried out for all the Belgian units. These studies were either level 1 with analyses of scenarios that could present a risk to the containment integrity, or level 2 studies (in this case with no source term calculation).

These studies considered reactor operation at power as well as in shut down states.

The results showed, among other, the value of having protection systems against external accidents. Indeed, these systems can act also in the event of failure of the traditional engineered safety systems; this considerably reduces the probability that certain initiating events could develop to the point of contributing to a core melt.

The on-going update of all PSAs will lead to full Level 2 analyses for all plants, for power and shutdown states.

Apart from PSA studies, severe accident management guidelines have been introduced at all Belgian plants in order to strengthen the 4th level of defence-in-depth. They are subjected to periodic reviews. All Belgian plants of course dispose of adequate emergency operating facilities, in order to cope with major accidents, according to the principles of Defence-In-Depth. Stress Tests also lead to plant modifications, increasing the robustness of the plant with regard to extreme natural phenomena

e) Application of Proven or Qualified Technologies

The safety-related structures, systems and components are subject to qualification programmes to the environment in which they are situated and operated (normal, test, incident, accident). The same is applied regarding seismic qualification. The programmes are described in the sections 3.10 and 3.11 of the Safety Analysis Report, and are consistent with the relevant US rules. Significant efforts have been made in this field, with tests in large qualification loops or on high-capacity seismic tables.

The results of all these tests are included in the "Manufacturing Records" of the qualified equipment, and are summarised in synthetic reports for later use.

For the design codes used by vendors or architect-engineers, audits are conducted by Bel V to verify the qualification file and to examine the experimental bases on which the models and correlations of the code are founded.

Particular attention is given to verifying and validating the design code itself and the quality assurance programme applied to the use of the code

f) Requirements of Reliable, Stable and Easily Controllable Operation, taking into Account Human Factors and the Man-Machine Interface

In order to make the operation of their power stations easier and to increase their availability, the Belgian operators frequently apply the redundancy principle even to the normal control functions, so as to avoid spurious signals in the event of a failure. Similarly, they install additional components in standby that can be quickly started or connected, so as not to have to shut down the power station in the event of significant unavailability of the first components.

In the control room, operators are informed through display and alarm windows as soon as possible of any operational anomaly of the power station. The alarm windows have been colour-coded according to their importance. Normal operation and safeguard system panels are separated as much as possible.

A process computer is available for the operator, with dedicated pre-formatted screens to follow up particular system variables, or with alarm logs. Alarm cards are available in the control room for each

alarm, indicating to the operator the significance of the alarm, its origin (and possible causes), the automatic actions possibly initiated and the manual response, if any, that is required of the operator.

As a post-TMI action, following NUREG 0737, the control room and its ergonomics were reassessed. The instrumentation used for post-accidental operation was identified more clearly, and the notion of SPDS (Safety Parameter Display System) was implemented in the control room (or in a room adjacent to it).

In case of unavailability of the main control room (for example unacceptable habitability) a Remote Safety Panel, located in the bunker control room for the last four units or in an appropriate building for the former ones, is fitted with all the controls of the main systems necessary for bringing the reactor to cold shutdown. A specific set of procedures for the remote panel is present in the bunker control room (or equivalent location)

Moreover the bunker control room and the bunker specific equipment have the capability to bring the reactor to a safe state (fallback state) and to go safely to cold shutdown, in case of accident of external origin (aircraft crash, explosion and/or large fire,). Procedures covering these cases are also available in the bunker control room (or equivalent location).

In the probabilistic safety studies, the tasks expected of the operators are detailed and modelled during the accident as well as during the post-accidental phase when the safe status of the unit is being restored. Following this critical review the existing procedures are possibly amended to increase their efficiency and ease of use, or new procedures are written (for instance for the non-power states).

II.N.2. Research Reactors

The reactors BR1 and BR2 were designed and constructed between 1952 and 1962, before a dedicated nuclear regulation existed in Belgium. The reactors were licensed according the regulations on industrial installations. This licence was amended several times, with specific requirements for nuclear installations. In 1986 the old licence was replaced by a new one, a royal decree based on the actual nuclear safety regulations.

The design of the BR1 is based on the reactors X-10 of ORNL, USA and BEPO of UKAEA, Harwell. The reactor was designed for a thermal power of 4 MWth. After 1965, the maximum thermal power has not exceeded 1 MWth. This allows working with the auxiliary ventilation only and avoids the accumulation of Wigner energy in the graphite. A power level of 4 MWth is still possible. The main ventilation was tested in 2012. However, operation at 4 MWth would require, after a certain time of irradiation, the thermal annealing of the graphite. During the lifetime of the reactor no major modifications were made.

The design of BR2 is rather unique. The reactor is designed to have a high neutron flux (thermal and fast), without being a fast sodium cooled reactor. The design has never been repeated. A reactor that is comparable is the ATR reactor of Idaho National Laboratory, USA. The original design thermal power of BR2 was 50 MW. In 1973 the primary heat exchangers were replaced in order to allow a thermal power of more than 100 MW. However, this thermal power is not the limiting factor as long as the heat can be evacuated without a too high temperature on the fuel plates. The power of the reactor is limited by the fact that the maximum heat flux on the fuel plates must be lower than 470 W/cm² in routine operation and 600 W/cm² for special experimental conditions.

Both reactors were included in the complementary safety analysis after the Fukushima Daiichi accident. After scram, both reactors can rely on passive cooling. Improvement of the availability of electrical power after a severe accident is foreseen. This power is needed for the cooling of some experimental devices, instrumentation and measurements in order to have a correct overview of the installation and to make emergency interventions possible. For BR1 an additional protection tube is foreseen for one control rod, such that the reliability of the scram is increased in case of severe damage of the core due to an earthquake. For BR2, improvements are foreseen on the possibility to add water to the building and establish the natural convection.

II.O. Article 19. Operation

Each Contracting Party shall take the appropriate steps to ensure that:

- (i) the initial authorisation to operate a nuclear installation is based upon an appropriate safety analysis and a commissioning programme demonstrating that the installation, as constructed, is consistent with design and safety requirements;
- (ii) operational limits and conditions derived from the safety analysis, tests and operational experience are defined and revised as necessary for identifying safe boundaries for operation;
- (iii) operation, maintenance, inspection and testing of a nuclear installation are conducted in accordance with approved procedures;
- (iv) procedures are established for responding to anticipated operational occurrences and to accidents;
- (v) necessary engineering and technical support in all safety-related fields is available throughout the lifetime of a nuclear installation;
- (vi) incidents significant to safety are reported in a timely manner by the holder of the relevant licence to the regulatory body;
- (vii) programmes to collect and analyse operating experience are established, the results obtained and the conclusions drawn are acted upon and that existing mechanisms are used to share important experience with international bodies and with other operating organisations and regulatory bodies;
- (viii) the generation of radioactive waste resulting from the operation of a nuclear installation is kept to the minimum practicable for the process concerned, both in activity and in volume, and any necessary treatment and storage of spent fuel and waste directly related to the operation and on the same site as that of the nuclear installation take into consideration conditioning and disposal.

II.O.1. NPPs

a) Initial Authorisation and Commissioning

For the 7 operating NPPs, the Royal Decree of Authorisation was signed by the King after it has been examined in detail by the AIO (AVN, now Bel V), the "Commission Spéciale Radiations Ionisantes" (now replaced by the Scientific Council of the FANC) and the Safety Authorities (now the FANC).

The commissioning test programme was discussed and approved by the AIO (AVN), which followed the tests, evaluated the test results, verified the conformity to the design and issued the successive permits that allowed proceeding with the next step of the test programme.

This process was complete when AIO (AVN) authorised the operation of the unit at full power.

b) Operational Limits and Conditions

As described before, the Technical Specifications are approved in the frame of licensing (chapter 16 of the Safety Analysis Report). They specify the operational limits and conditions, the availability requirements of the systems, the tests and inspections, and the actions to be taken if the acceptance criteria are not met. This applies to any state of the nuclear power plant. Extensive backgrounds of the Technical Specifications exist and are available to the personnel.

There are procedures related to compliance with the Technical Specifications (T.S.) for maintenance activities during plant outage and plant operation. T.S requirements and limitations are explicitly addressed in the maintenance procedures. Independent checks of the strict compliance with of T.S during outages are carried out, both in the preparatory outage activities (work planning) as well as during the outage itself. These checks relate to equipment as well as to safety-related functions, like the integrity of the containment during refuelling, verification of the redundancy of the heat removal systems during RHR operation...

Modifications of the installations with a potential impact on nuclear safety must be approved by the Health Physics department before it can be implemented as explained in Article 14, section II.J.2.a. In

this respect, changes of procedures, of the Technical Specifications and of the Safety Analysis Report are identified and discussed.

c) Procedures for operation, maintenance, inspection and testing

A general description of the operation procedures is given in section 13.5 of the Safety Analysis Report.

The completeness (in format and contents) of the procedures has been examined based on Regulatory Guide 1.33 which lists the subjects for which procedures must be established. This examination was conducted in the scope of licensing and delivery of the installations by AVN.

During the commissioning tests, the relevant procedures that were used by the operators were verified for adequacy.

Document management is based on Electrabel guidelines and on the Internal Code for Nuclear Safety. Documents are classified into the following categories: policy-related procedures, operational procedures, instructions, supporting documents, help documents and witness documents. For policy-related procedures, operational procedures and instructions, more strict handling requirements have been established

d) Incident and Accident Procedures

A full set of incident and accident management procedures has been developed by the operator, with the help of the Architect Engineer and the designer of the Nuclear Steam Supply System. These procedures cover both power operations and shutdown modes.

These procedures are validated on a simulator and are used for operator training. Procedures are periodically reviewed and relevant experience feedback is integrated. Procedures backgrounds have been developed for some normal and incident procedures.

The Belgian NPPs, except Tihange 1, have implemented the Emergency Response Guidelines (ERG) approach developed by the Westinghouse Owners Group (WOG). These standard procedures have been adapted to the plant-specific elements and systems, especially the systems for protection against external events.

The ERG procedures are composed of 3 major elements: (1) the optimal recovery procedures (ORG: optimal recovery guidelines) which are event-based, (2) the critical safety function status trees and (3) the function restoration procedures (FRG: function restoration guidelines) which are both symptom-based, i.e. independent of the event scenario.

The ORG procedures, based on event scenarios with a probability of occurrence greater than $10^{-8}/y$, have as main objective to recover the plant and to bring it back to a known safe state (in general the cold shutdown with the RHR system connected). ORG procedures are characterized by a response directly connected to event scenarios, by a preliminary diagnostic and by a constant diagnostic within each specific procedure in order to allow possible reorientation.

The critical safety function status trees explicitly identify the status of the safety functions independent of the event scenario. The trees prioritize challenges to these functions and identify the appropriate FRG procedure to be used to respond to these challenges. The 6 defined critical safety functions are: subcriticality, core cooling, heat sink, integrity of the primary system, containment and primary water inventory.

The FRG procedures are used to restore any challenged critical safety function.

The ORG on one hand and the status trees and the FRG on the other hand are applied in parallel during an event: the first procedures are used by the operators crew (event-based approach) whereas the second ones are applied independently by a Shift Technical Adviser (symptom-based approach).

In conclusion, event-based and symptom-based procedures are used in parallel in Belgium by the NPP staff. The combination of a redundant approach (ORG <> FRG) associated with a human redundancy (operators crew <> shift technical adviser) allows to cover a larger scope of events, ensuring an optimized response for simple event scenarios.

Specific procedures have been written to give guidance to the operators after an earthquake that could occur during normal operation or in shutdown state.

Severe accident management procedures, inspired by the "Severe Accident Management Guidelines" developed by the Westinghouse Owners' Group, were implemented, adapted to the specificities of each unit. The training programme of the control room operators was developed in parallel.

For Tihange 1 the Framatome approach has been followed. The accident management procedures combine event-based and symptom-based approaches, using the surveillance of key safety functions or parameters.

Severe accident management procedures were developed like in the other units, on the basis of the Westinghouse Owner's Group Guidelines.

e) Engineering and Technology Support

The organisation and know-how of the operator, described in chapter 13 of the Safety Analysis Report, must be maintained throughout the useful life of the power station, and even after its definitive shutdown as long as this new status is not covered by a new licence.

The Engineering Department has the overall responsibility for the Technical Support Process. However, technical support activities are decentralized into several surveillance programmes, each programme being under the leadership of the department having the most comprehensive knowledge of the particular process. The allocation of technical support functions between the different site departments and external organizations is clearly established. The Engineering Department also acts as design authority.

On the corporate level, the sites receive technical support from the Asset Management and Strategy (AM&S) department. This department is, amongst others, in charge of the management of the periodic safety review, of large-scale projects common to Doel and Tihange and their coordination, of the monitoring of the ageing projects and of specific safety projects.

Some technical support activities are carried out in partnership with Tractebel Engineering (TE). The partnership translates into three levels of cooperation:

- Core assist: this is a strategic, permanent and structural partnership. In this framework, Electrabel entrusts activities to TE as its natural partner. Examples are safety and licensing (including studies, follow-up ...), fuel management, regulatory watch, FSAR update management.
- Core support: this is a close cooperation that applies to projects for which similar quality levels cannot be obtained from other suppliers. Examples are general assistance in operations and management of nuclear installations, plant life management studies
- Valuable supplier: This is an operational competitive customer/supplier relationship for activities that are outsourced to an external supplier, but not necessarily to TE.

TE has been in charge of the studies and their implementation during the periodic safety reviews, which take place on a periodic basis, of the steam generators replacement projects, power increase projects and of a large part of minor modifications projects, which allowed to maintain competence and knowledge of the installations. TE has also been participating in an integrated way to large programs like the Stress Tests (analysis and realization), the Long Term Operation project for the oldest plants, and the conformity with the WENRA Reference Levels... TE is also in charge of the follow-up of the provisioning of fuel reloads and of core management. Through its R&D projects, training actions and technological surveys, TE maintains a high competency in conformity with the state of the art. In order to reach these goals, TE participates in international research projects and is a member of various networks (or competency centres).

The design bases of the plants, i.e. the knowledge of the design of the plants and the reasons of the choices made in this design are an important part of the knowledge.

f) Notification of Significant Incident

Section 16.6 of the Safety Analysis Report lists the events that must be notified to Bel V and to the FANC, indicating the deadline for each notification.

The same section also specifies the cases where incident reports must be supplied to Bel V, and within which time period. In function of the significance of the events, the time period ranges from immediately to a month.

The use of INES is done via a convention between the Licensees, the FANC and Bel V. This convention stipulates in which circumstances and how INES is to be used. The licensee has to perform the INES-analysis according the latest INES manual, and this level has to be approved by Bel V and by the FANC. Depending on the INES-level, a specific notice is issued. For events of level 1 or higher, the FANC publishes a short notice on its website. For events of level 2 or higher, besides the

notice on the website of the FANC, the Licensee has to issue a press release about the event and the INES National Officer will notify the IAEA.

IRS reports are established by Bel V for the incidents it considers interesting for the international community.

Near misses are handled through the operational experience feedback process.

g) Operational Experience Feedback

At Electrabel, Operating Experience is supported in all activities and at all levels of the organization. Operating Experience is part of the Electrabel's continuous improvement programme.

A policy for operating experience has been established at Electrabel. Comprehensive programmes have been set up for detecting, processing and communicating operating issues in order to optimize the use of international, national and local experiences in operating nuclear power plants.

The Operating Experience (OE) process can be initiated by different input triggers:

- An event inside or outside the operating organization. An event is defined as any unwanted, undesirable change in the state of plant structures, systems, or components or in human/organizational conditions (health, behaviour, administrative controls, environment...) that exceeds established significance criteria.
- Findings from audits and self-assessments
- Findings from the task observation programme
- Findings from post job debriefings
- Ideas, insights with a potential to significantly improve plant performance.

The OE programme results in:

- Immediate corrective actions,
- Medium and long-term corrective actions and/or improvements.

The OE feedback programme interacts on different levels of issues, events and ideas throughout the organization:

- Events and near misses: these are events and issues that require a stringent, formal approach by means of event reports.
- Low level events: these are events, issues and good practices that are revealed during the task observation programme and post job debriefings. These inputs are used for immediate actions as well as for annual self-assessments.

In parallel, different learning cycles exist to ensure learning from internal and external faults and strengths. Operating experience input coming from different sources is bundled in order to reveal relationships that lead to identifying and eliminating error precursors and flawed defences and their underlying organizational weaknesses. The main goal of this exercise is not merely counting events but pattern recognition. This OE feedback occurs in five loops and findings of lower loops are used as input for higher loops:

- Loop 1: immediate feedback, corrective actions, direct solutions and coaching.
- Loop 2: tri-monthly feedback of the performed observations (number, spread, quality) to different teams and services.
- Loop 3: annual self-assessments by the operational and maintenance teams. This bottom-up approach, supported by the immediate management, aims to define the next year's focus on different domains (technical, training, human performance, ...).
- Loop 4: annual self-assessments and management reviews on intermediate level (within departments and/or services) aim to identify improvement areas on a (sub)process or organizational level and to identify weak points by systematically comparing real process outputs with management expectations, requirements of the regulator and authorities, and expectations from the nuclear sector. Per department a more hierarchical or transversal, horizontal approach is chosen.
- Loop 5: annual management reviews on plant level of each process.

The information related to operating experience is accessible to all plant personnel, both on the intranet and in the document management system. The use of the available operating experience information is integrated into the different department processes and methods, in order to evaluate their own performance, to identify hidden weaknesses and to pro-actively avoid events

II.O.2. Research Reactors

a) Operational Limits and Conditions

The operational limits and conditions are described in the respective safety analysis report. A number of basic OLC's are defined in the licence.

These are for the BR1:

- The maximum temperature of the cladding of the fuel,
- The maximum temperature of the graphite,
- The maximum Wigner energy,
- The maximum burn up of the fuel and
- The maximum death time of the control rods.

These are for the BR2:

- the tightness of the containment building,
- the maximum allowed fluence of the control rod guide tubes,
- the maximum allowed heat flux on the fuel plates and
- the maximum allowed fluence of the beryllium matrix.

Further OLC's are detailed in the safety analysis report of the reactors. There is a significant difference between these two types of OLC's. Those mentioned in the licence cannot be changed without a licence amendment. This requires a royal decree. An OLC formulated in the safety analysis report can be changed according to the designated procedures for modifications

b) Modifications

In 2008, the FANC published guidance about the treatment of modifications. The categorization and the treatment of modifications are described in section II.J.1 a) of the present report. Based on this guidance, the SCK•CEN developed a procedure for the practical treatment of modifications. This procedure is valid for all the installations, including the reactors BR1 and BR2. However, experimental devices are not considered as modifications. Special procedures exist for the approval of experiments.

The number of modifications for the BR1 is very limited. The general SCK•CEN procedure for modifications is used. An important modification must be submitted to the internal SCK•CEN advisory committee for the safety of installations. For modifications of the BR2, there is a dedicated procedure. All requests are submitted to an internal committee for approval. During the meeting, the decision whether the modification is significant or not is also taken.

Experiments are not considered as modifications and a dedicated approval procedure exists. For the BR1, new experiments are approved by the health physics department, in some cases following an advice of the SCK•CEN committee on the safety of installations. All information is transmitted to Bel V. The experiments for the BR2 have to follow a specific three stage approval (principle, design and construction). A fourth stage is also foreseen to discuss the return of experience and possible problems.

c) Reporting of Events

For reporting unusual events a convention with the authorities exists. A number of criteria about the delay time for communicating events are defined. Belgium is also member of the Incident Reporting Systems for Research Reactors. A number of events regarding the BR1 and the BR2 are reported in the IRSRR. Besides this reporting, there is also guidance of the FANC on the use of the INES scale for the SCK•CEN installations.

d) Documentation

The design and construction of both the BR1 and the BR2 date from more than 50 year ago. All persons having knowledge about the original design of the reactors have gone. During the last periodic safety review it was recognized that an action plan was necessary to keep the design documentation and the corresponding knowledge in good state. The action plan initiated by SCK•CEN was completed in 2012.

e) Maintenance

For the BR1, a yearly maintenance plan is foreseen. This maintenance is mainly focused on the control rod mechanisms, the ventilation system, including the air filters, and the diesel generator. Beside this maintenance a two monthly inspection plan is executed. For BR2, the maintenance is done during the longer shutdowns. For every shutdown a detailed task plan is made. The list of tasks

comprises repairs, preventive regular maintenance and modernization of components which were approved as modification. A very profound maintenance programme was executed during the replacement of the second matrix.

II.O.3. Generation of Radioactive Waste

See the Belgian report in the frame of the Joint Convention.

II.O.4. Temporary Storage of Used Fuel

See the Belgian report in the frame of the Joint Convention.

III. Appendix 1 - Description of the Nuclear Installations: Power Plants

NOT INCLUDED IN THIS VERSION

IV. Appendix 2 : Description of the BR1 and BR2 Research Reactors

NOT INCLUDED IN THIS VERSION

V. Appendix 3 : List of Acronyms

AIA	Authorised Inspection Agency.
AIO	Authorised Inspection Organisation.
ALARA	As Low As Reasonably Achievable.
ANS	American Nuclear Standards.
ANSI	American National Standards Institute.
ASME	American Society of Mechanical Engineers.
ASSET	Assessment of Safety Significant Events Team (IAEA).
AVN	Association Vinçotte Nuclear.
BS	Basic Standards.
CGCCR	Comité Gouvernemental de Coordination et de Crise, (i.e. the Governmental. Centre for Co-ordination and Emergencies).
CIPR/ICPR	Commission Internationale de Protection Radiologique (i.e. International Commission for Radiological Protection).
CNRA	Committee of Nuclear Regulatory Activities (NEA/OECD).
CNT	Centrale Nucléaire de Tihange (i.e. Tihange Nuclear Power Plant)
CSNI	Committee on the Safety of Nuclear Installations (NEA/OECD).
ECURIE	European Community Urgent Radiological Information Exchange.
EDF	Electricité de France.
ENSREG	European Nuclear Safety Regulators Group
EU	European Union.
FANC	Federal Agency for Nuclear Control.
FBFC	Franco-Belge de Fabrication de Combustible (i.e. Franco-Belgian Company for Fuel Manufacturing).
FINAS	Fuel Incident Notification and Analysis System (NEA/OECD).
FPS	Federal Public Service
FRAREG	FRAmatome REGulators
FRG	Function Restoration Guidelines.
FSAR	Final Safety Analysis Report.
GRR-2001	General Regulations regarding the protection of the public, workers and the environment against the hazards of ionizing radiation, laid down by Royal Decree of 20 July 2001
GRR-1963	General Regulations regarding the protection of the public, the workers and the environment against the hazards of ionizing radiation, laid down by Royal Decree of 28 February 1963.
HPD	Health Physics Department.
IAEA	International Atomic Energy Agency.
IEEE	Institute of Electrical and Electronics Engineers.
INES	International Nuclear and Radiological Event Scale (IAEA).
INPO	Institute of Nuclear Power Operations.
INSAG	International Nuclear Safety Advisory Group.
IRE	Institut des Radio-éléments.
IRRT	International Regulatory Review Team (IAEA).
IRS	Incident Reporting System (NEA/OECD-IAEA).
KCD	Kerncentrale Doel (i.e. Doel Nuclear Power Station).
MOX	Mixed-oxide UO ₂ -PuO ₂ .
NDA	Non Destructive Analyse.
NDTT	Non-destructive Testing Technology.
NEA (OECD)	Nuclear Energy Agency (OECD).
NERS	Network of Regulators of countries with Small nuclear programmes
NORM	Naturally Occurring Radioactive Material.
NPP	Nuclear Power Plant.
NRWG	Nuclear Regulators Working Group.
NUSS	Nuclear Safety Standards programme (IAEA).

NUSSC	Nuclear Safety Standards Committee (IAEA).
OEF	Operational Experience Feedback.
ONDRAF/NIRAS	Organisme National pour les Déchets Radioactifs et les Matières Fissiles Enrichies/ Nationale Instelling voor Radioactive Afval en verrijkte Spleijstoffen (i.e. Belgian Agency for Radioactive Waste and Enriched Fissile Materials).
ORG	Optimal Recovery Guidelines.
OSART	Operational Safety Review Team (IAEA).
PAMS	Post Accident Monitoring System.
PSR	Periodic Safety Review
Q.M.	Quality Monitored.
RASSC	Radioprotection Safety Standard Committee.
R.D.	Royal Decree.
RGPT	Règlement Général pour la Protection du Travail (i.e. Belgium's Occupational Health & Safety Regulations).
RHR	Residual Heat Removal.
RHRS	Residual Heat Removal System.
SCK•CEN	Studiecentrum voor Kernenergie, Nuclear Research Centre / Centre d'Etude de l'Energie Nucléaires, situated at Mol, Belgium.
SENA	Société d'Energie Nucléaire Franco-Belges des Ardennes.
SPDS	Safety Parameter Display System.
SPRI	Service de Protection contre les Radiations Ionisantes (i.e. Department of Protection against Ionising Radiation).
SSE	Safe Shutdown Earthquake.
STA	Shift Technical Advisor.
STAR	Stop-Think-Act-Review.
TE	Tractebel Engineering.
TMI	Three Mile Island.
TRANSSC	Transport Safety Standard Committee.
TRC	Technical Responsibility Centre (Bel V).
USNRC	United State Nuclear Regulatory Commission
VGB	Vereinigung der Grosskesselbetreiber
WANO	World Association of Nuclear Operators.
WASSC	Waste Safety Standards Committee (AIEA).
WENRA	Western European Nuclear Regulator's Association.
CNT	Centrale Nucléaire de Tihange (i.e. Tihange Nuclear Power Plant Site).

Table 9 : List of Acronyms

VI. Appendix 4 : List of the Web Sites of the Different Nuclear Actors in Belgium

VI.A. Regulatory Body

Federal Agency for Nuclear Control:	http://www.fanc.fgov.be	(site in French and Dutch)
Bel V	http://www.belv.be	(site in French, Dutch and English)

VI.B. Licences, Architect-engineers, Research Centres

Electrabel:	http://www.electrabel.com	(site in French, Dutch and English)
Tractebel Engineering:	http://www.tractebel-engineering.com	(site in English)
SCK•CEN:	http://www.sckcen.be	(site in English)
Belgonucleaire:	http://www.belgonucleaire.be	(site in French, Dutch and English)
Belgoprocess:	http://www.belgoprocess.be	(site in English)
ONDRAF/NIRAS:	http://www.nirond.be	(site in French, Dutch, English and German)

VI.C. Associations

Belgian Nuclear Society:	http://www.bnsorg.eu/	(site in English)
Belgian Association for Radiation Protection (BVS/ABR)	http://www.bvsabr.be	(site in French and Dutch)

VI.D. Others

WENRA (Western European Nuclear Regulators Association)	http://www.wenra.org
ENSREG (European Nuclear Safety Regulators Group)	http://www.ensreg.eu

VII. Appendix 5 : Subjects examined during the Periodic (ten yearly) Safety Review

VII.A. Subjects examined during the First Safety Reviews of the Doel 1 & 2 and Tihange 1 Units

The following subjects have been examined:

- protection against accidents of external origin and industrial risks
- re-definition of the design earthquake
- high-energy line break
- fire protection
- flooding, of internal or external origin
- high winds and extreme climatic conditions
- differential settlement between structures
- systems having safety-related functions to shut down the reactor, for core cooling and for evacuation of residual power:
 - reactor protection system
 - safety systems: emergency feedwater supply to the steam generators, shutdown cooling system, safety injection, spray or internal ventilation inside containment, emergency control room and auxiliary shutdown panel.
 - steam relief to atmosphere
 - ultimate heat sink
 - safety compressed-air
 - emergency electrical power
 - resistance and integrity of various systems
 - safety systems instrumentation
 - primary system leak detection
 - detection of inadequate core cooling
 - seismic and environmental qualification of safety systems
- primary system integrity:
 - protection against cold and hot overpressure
 - protection against pressurised thermal shock
 - pressure vessel venting
 - integrity of primary pump seals
 - leak detection
 - boric-acid induced corrosion
 - list of actually incurred transients
- nuclear auxiliary building: protection against post-accident radiation
- inspection of structures and equipment (mechanical, electrical, civil works)
- test programme
- technical specifications
- operation organisation
- quality management
- spent fuel handling and storage
- gaseous effluent treatment and ventilation systems
- isolation and leak-tightness of primary and secondary containments
- hydrogen control inside containment
- operation experience feedback
- accident analysis review
- radiation protection and ALARA
- post-accident sampling in the reactor building
- updating of documentation, including amendment of the Safety Analysis Report.

VII.B. Subjects examined during the First Safety Reviews of the Doel 3, 4 and Tihange 2, 3 Units, and Second Safety Review of Tihange 1

- conformity to the design bases: re-evaluation of the environment
- protection of electric safety circuits against lightning
- verification of extreme climatic conditions
- impact of the modifications made to the installations on the original "High Energy Line Break" (HELB) study
- loadings combinations on the structures
- anchorage of safety equipment
- use of the results of the qualification of mechanical equipment : components with a limited lifetime
- verification of the post-accident operability of pneumatic actuators
- dimensioning of miniflow lines of safety related centrifugal pumps
- post-TMI II.D.1 recommendation (mechanical resistance of the pressuriser discharge line)
- instability of the pressuriser safety valves during passage of the water plug
- qualification of the relief and block valves of the pressuriser
- taking into account secondary effects in the calculation of pipe supports in "Level D"
- thermal environment of electric equipment
- qualification of electric connectors: containment penetrations
- post-TMI II.F.2 recommendation (RM chains)
- follow-up of the US rules and practices
- general procedure for reloads safety justification
- follow-up of operational transients
- shift of the set point of the pressuriser safety valves
- pressure vessel embrittlement
- thermal ageing of stainless steel
- primary pumps: re-evaluation of the axial bearing
- risk of recirculation sump clogging during accidents
- containment spray water chemistry
- measurement of the containment free volume
- depressurisation of the safety injection accumulators
- availability of the LHSI pumps during recirculation
- manual initiation of the primary containment spray
- sub cooling measurement with core thermocouples to be qualified in the context of post-TMI II.F.2 recommendation
- verification of the response time of sensors
- protection of diesel groups in case of emergency signal
- availability of diesel groups during the sequence "SI signal followed by the complete loss of external electric grid"
- over speed protection of the emergency diesels
- availability of motors under degraded voltage conditions
- verification of the diesels loads
- loss of low voltage busses: procedures
- evaluation of the tightness of pool joints
- evaluation of the fire detection and protection
- ALARA policy
- post-TMI II.B.2 recommendation (post accident accessibility)
- revision of the programme for the training and licensing of the personnel
- re-evaluation of the tightness tests of the recirculation lines
- functional tests of the shock-absorbers
- assessment of the periodic tests of pumps, valves and check-valves
- test console for logic and analogic protection signals
- global tests
- welding of the safe-ends on the pressure vessel nozzles
- pressure vessel inspection: underclad defects in the nozzles

- impact of the stainless steel cladding on the pressure vessel inspections with u.s.
- wear of the control rods
- corrosion of the reactor baffle screws
- corrosion of the guide tube pins
- follow-up of the internal structures of the pressure vessels by analysis of neutronic noise
- inspection of the steam generators: tube sheet — evacuation of the risk of under clad cracks
- welding of the partition plate on the water box on the tube sheet and the bottom of the steam generators
- steam generators: weld between the upper ring and the transition cone
- corrosion problems of valve bolts
- control of the pipe whip restraints
- internal corrosion of the SI accumulators
- post-earthquake procedure
- evolution of the ASME Code section XI
- ASME code section XI: appendices 7 and 8 (ultrasonic inspections)
- steam generator problems: limitation of the primary/secondary leak
- evaluation of the conclusions of generic studies of accidents not considered in the original design
- consideration of severe accidents
- probabilistic safety analysis
- re-evaluation of the Technical Specifications
- assessment of the implementation of the Q.A. programme
- software quality assurance
- quality management: Safety Evaluation Committee
- feedback of operating experience from Belgian and foreign plants
- assessment of incidents and synthesis of their causes
- evaluation of the modifications which can impact safety
- analysis of the influence of the emergency systems
- evaluation of voluntary inspections
- operator aids: shutdown mode
- operator aids during accidents
- primary breaks in modes 3 and 4
- thermal stratification in the pressuriser surge line
- thermal stratification in the main feedwater lines and their connection on the steam generator
- check valves: generic problems

VII.C. Subjects examined during the Second Ten-yearly Safety Reviews of Doel 1 and 2

- ageing of electric equipment
- ageing of mechanical equipment
- ageing of the pressure vessel and of the primary circuit
- ageing of concrete structures
- ageing of the steam generators
- pressure vessel irradiation
- availability of the recirculation function
- antisiphoning system of the fuel pools
- seismic qualification
- qualification of safety related equipment
- qualification of high energy lines
- thermal stratification in the pressuriser surge line
- classification of safety-related equipment
- thermal stratification of feedwater lines
- qualification of the auxiliary feedwater system
- secondary overpressure
- loadings combinations in the reactor building cells
- implementation of ASME 1992
- re-evaluation of the Technical Specifications
- fire protection re-evaluation
- toxic gases protection reassessment
- improvement of the availability of the safety diesels
- dismantling
- ALARA
- software QA
- overlapping of tests for safety instrumentation
- quality assurance
- valving systems
- corrosion due to boron
- lightning protection
- operational transients
- protection of motors (under voltage)
- response time of radiological protection chains
- integrity of underground lines
- shielding of the radiological protection chains
- feedback of operating experience
- in service inspection
- procedures after earthquakes
- post accident procedures
- severe accidents
- probabilistic safety analysis
- reassessment of accidents
- transport container for spent fuel assemblies
- set point statistical study
- re-evaluation of the environment
- inter-systems LOCA
- radiological consequences
- operational problems: follow-up of the pressure vessel internals

VII.D. Subjects examined during the Second Safety Reviews of Doel 3 and Tihange 2, subjects to be examined during the Second Safety Reviews of Doel 4 and Tihange 3, and subjects to be examined during the Third Safety Reviews of Doel 1 & 2, and Tihange 1

- follow-up of US rules and practices
- definition of a source term for the reference accident
- post-'92 evolution of ASME XI Code OM
- re-evaluation of the conformity of the Single Failure Proof cranes with current standards
- re-evaluation of the Technical Specifications for the waste treatment building (WAB) at the Doel site
- re-evaluation of the Technical Specifications of Tihange 1
- re-evaluation of the Technical Specifications of Doel 1 & 2
- evolution of the environment and its impact
- re-evaluation of the impact of extreme climate conditions
- re-evaluation of the seismic level on the basis of recent investigations
- risk related to external flooding
- risk related to internal flooding
- systematic approach to assess the fire and explosion risk
- re-evaluation of ultimate heat sink (wells) at the Tihange site
- update of the PSA models
- safety analysis for shutdown modes
- follow-up of knowledge with respect to severe accidents
- analysis of the safety impact of flow dissymmetry between primary loops
- evaluation of main discrepancies with respect to the Position Paper on the application of the single failure criterion for the oldest units only :
 - electrical support systems (Doel 1 & 2)
 - safety related systems (Doel 1 & 2)
 - heat sink (Tihange 1)
 - plant air (Tihange 1)
- updating accident procedures
- procedure for incidents during fuel handling
- procedure for loss of ultimate heat sink
- updating of incident procedures
- evaluation of PAMS measuring uncertainties
- availability of safety related components
- leak tightness of feedwater isolation valves
- follow-up of prestressing of the primary containment
- re-evaluation of the safety related ventilation
- reassessment of containment isolation
- pressurizing, of isolated piping in containment during accident conditions
- reassessment of ventilation for emergency building (Tihange 2)
- reassessment of ventilation for waste treatment building
- structural integrity reassessment of emergency buildings
- tests and criteria for safety related valves pumps, and diesels (Doel 1 & 2, and Tihange 1).
- evaluation of radiation exposure of plant operators during an accident
- isolation of normal feedwater (Tihange 1)
- optimization of containment spray lay-out (Tihange 1)
- containment spray additive (D12)
- application of ASME XI, Appendix OM to liquid discharging spring loaded safety valves
- verification of the efficiency of safety related heat exchangers
- follow-up of the pressure vessel embrittlement and protection against cold overpressure
- follow-up of ageing of guide tube split pins, of radial guides of the reactor vessel internals, of baffle bolts, of cast elbows, of safety related equipment, of temperature measurement probes in the primary loop by-pass, of CVCS heat exchangers and of elastomer supports
- follow-up of equipment fatigue (including thermal stratification)

- follow-up of corrosion phenomena in piping and line mounted equipment
- renovation of I/C systems and safety related components
- renovation of structures and buildings
- renovation of fire protection systems
- training of personnel and knowledge management
- design basis retrieval
- optimisation of ALARA policy
- qualification of software systems against smoke

VIII. Appendix 6 – Belgian Action Plan as a result of the European Stress test process

External Hazards: Earthquake

Seismic resistance of SSCs		As a result of qualified plant walkdowns (SQUG) and margin assessment (SMR), /improvement of the seismic resistance of several SSC	2012-2013
Re-evaluation of the seismic hazard		State-of-the-art probabilistic-seismic hazard re-evaluation (PSHA) of the site DBE & characterization of the site BDBE	2014
Sensibilization campaign to seismic alertness	Tihange + Doel	Continuation of efforts towards fostering awareness of potential seismic interaction inside facilities (scaffoldings,...)	2012
Risk mitigation of internal flooding from circulation water circuit		Improvement of procedures after earthquake: quick local check of flooding (risk) and stop CW pumps accordingly	2012
Secondary effect of earthquake – Increase autonomy	Tihange 1	Assessment of earthquake impact on a fuel tank (fire, flood / resistance)	2012

External Hazards: Flooding

Enhanced protection Against flooding	Tihange	Acceleration of actions resulting from PSR study for new Design Basis Flood: Peripheral protection of the site Strengthening of NCM (robustness)	2014 2011-2012
	Doel	Perimetric protection of relevant safety buildings (e.g. mobile barriers) Additional reinforcements of river embankments	2012-2013 2012
Enhanced operation management (procedures)	Tihange	Accelerated implementation of emergency preparedness strategy, organisation and procedures about flooding	2012-2013
	Doel	Increase frequency of periodic inspections of embankments (height, erosion)	2012
	Doel	Implementation of procedures for mobile barriers	2012-2013
Induced Internal hazards	Tihange	Internal hazards potentially induced by the flooding (fire, explosion) should be examined and additional measures should be taken where needed	2013
Emergency preparedness and response	Tihange	For the flooding risk, further improvement of the emergency preparedness strategy and organization, including corresponding procedures, should be implemented	2012
		Further robustness improvement of current emergency preparedness strategy for specific	2012

aspects (flooding alert system, communication, onsite transport, training, ...)

External Hazards: Extreme weather conditions

Enhanced protection		Reassessments of sewer system capacity	2012
Against extreme		Evaluation of protection against lightning	2011-
Weather		(new standard NBN EN 62305)	2013
	Tihange + Doel	Reassessments of sewer system capacity should cover both short-duration heavy rains and long lasting rains for return periods far above 100 years. Depending on results, potential improvements of sewer system are to be identified.	2013
		Tornadoes: confirm robustness of second-level systems of Doel 1 & 2 and Tihange 1 for beyond design tornadoes with wind speed exceeding 250 km/h (70 m/s)	2013

Table 10: External Events

Loss of safety functions : Loss of Offsite Power

EDG autonomy	Tihange + Doel	Procedures to minimize the diesel consumption	2012
		Procedure to anticipate the make-up of oil for the diesels	2013
Offsite power optimization	Tihange + Doel	Make a feasibility study to ensure a better separation of the high-voltage lines	2013
		Agreement with grid manager for ensuring the prioritization of the external supply to NPPs	2013

Loss of safety functions : Station Black-Out

Reactor building confinement	Tihange + Doel	Assessment to verify whether all the containment penetrations can be closed in due time and whether the containment isolation systems remain functional	2013
Operational procedures	Tihange + Doel	To define a global strategy in the case of a « total SBO »	2013
Shutdown states & midloop operation	Tihange 3	Feasibility study to ensure make up for the primary system in case of primary system open	2012
Instrumentation & monitoring	Tihange + Doel	To add/check SFP level measurements	2012-2013
	Tihange	Diesel generators for resupplying the I&C	2013
Specifications of NCM/ On-site resistant storage of NCM	Tihange + Doel	To justify the operability of the NCM on the basis of technical data (design, operation, alignment and connections, periodic testing, preventive maintenance, etc.)	2012
		Account of the adverse conditions the NCM may be subject to (through technical	2013

		characteristics and/or protection)	
SG protection	Tihange + Doel	To assess the potential overflowing or drying-out of the SGs due to the loss of ultimate compressed air	2013
AFW TP protection	Tihange + Doel	To assess the operability of the AFW turbine-driven pump due to the loss of ventilation in the turbine-driven pump room	2013- 2014

Loss of safety functions : Loss of the primary and alternate UHS

Operational procedures	Tihange + Doel	To define a global strategy in case of loss of all heat sinks (how to manage the overpressure in the containment)	2013
Backup heat sink	Tihange	To integrate the use of the new groundwater of the site of Tihange in the supply of NCM equipment	2013
Specifications of NCM	Tihange + Doel	To justify the operability of the NCM on the basis of technical data (design, operation, alignment and connections, periodic testing, preventive maintenance, etc.)	2012

Table 11 : Design issues

Severe accident management

Enhanced emergency management (PIU)	Tihange + Doel	Enhance the organisation and logistics of the internal emergency plan to include "multi-unit" events:	
		description of the new organization	2012
		implementation of the new organization	2013
		Post-accident fixing of contamination and the treatment of potentially large volumes of contaminated water	2013
	Tihange	NEW site operation centre ("COS")	2013
SAM mitigation - Design	Tihange + Doel	Filtered containment venting system on each unit – from preliminary study to installation	2012- 2017
		Feasibility study: additional water injection into the reactor pit + additional containment spray	2013
H2 risk	Tihange + Doel	Assessment of the residual risk of hydrogen production and accumulation in spent fuel pool buildings	2012
SAM – R&D	Tihange + Doel	Follow-up of R&D activities related to the corium-concrete interaction & steam explosion issues	Continuous
SAM – Improvement Guidelines	Doel	Improvement of SAMG: decision support tools, long term monitoring and exit guidelines,...	2013
SAM – Improvement Guidelines	Tihange + Doel	Improvement of SAMG: to include OEF Fukushima when WOG SAMG are revised	2014

SAM – Training	Tihange + Doel	Increase consistency between Tihange and Doel NPP on SAMG training for operators	2013
SAM – Control of releases	Tihange + Doel	Need to identify effective means to control pH inside containment	2013
SAM – Power supply	Tihange + Doel	Optimal battery load shedding strategy + calculation and decision tool	2013
Optimization of NCM	Tihange + Doel	Evaluation of the need to extend the NCM based on the analysis of the extensive damage mitigation guidelines (“EDMG”)	2013

Table 12 : Severe Accident Management and Recovery



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