

# **Belgian stress tests for nuclear plants, excluding power reactors**

## **Specific issues and main results**

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**Scientific meeting ABR  
CNS & BESTA  
Bel V – June 13, 2014**

*There are many lessons that we must all take away from the accident at Fukushima, but some of the most valuable extend beyond the technical aspects and are embedded in human and organizational behaviors. Among these is **safety culture**.*

Allison M. Macfarlane, chairman USNRC,  
INSAG forum, Vienna, September 17, 2012

# ***Why You Haven't Heard About Onagawa Nuclear Power Station after the Earthquake and Tsunami of March 11, 2011 (A. Ryu and N. Meshkati, University of Southern California, February 26, 2014)***

## **Fukushima Daiichi NPP**

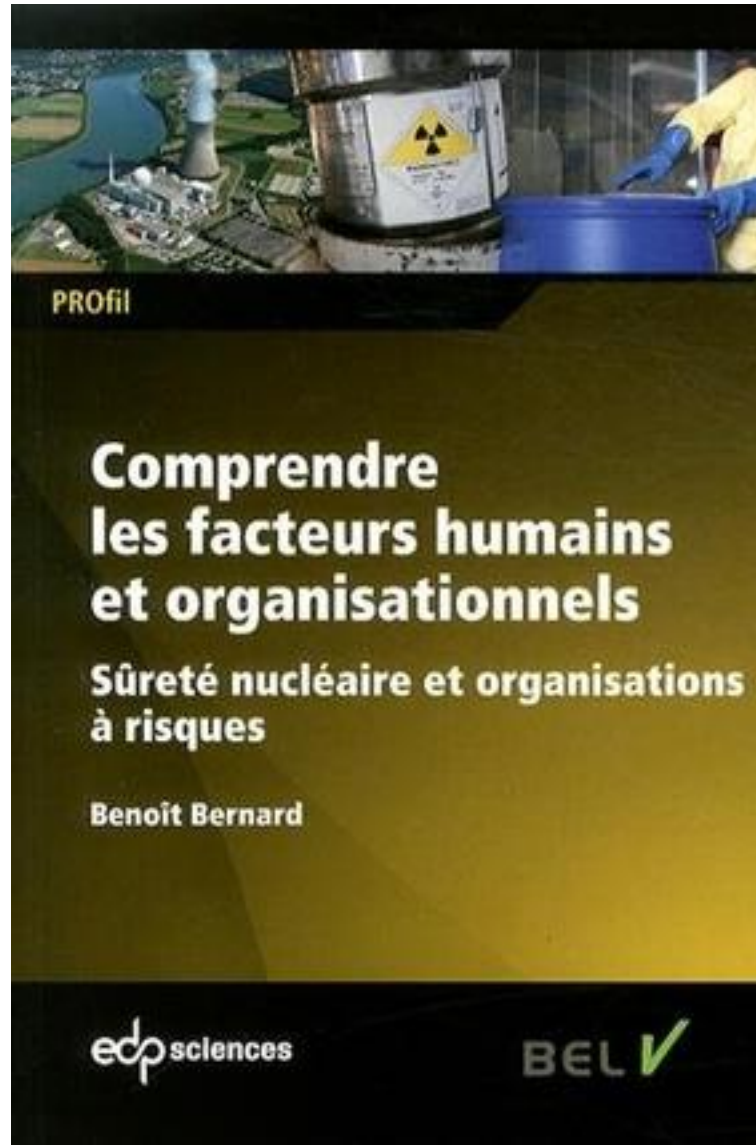
**(Tokyo Electric Power Company - Tepco)**

- BWR Mark 1
- 183km from epicenter (M9.0)
- PGA max=0.56g (DBE=0.45g)
- NPP height = 10 m
- Tsunami height=13.1m (DBTH=5.7m)
- INES 7
- No strict protocol implementation against extreme events
- ***When I headed the plant, the thought of a tsunami never crossed my mind***

## **Onagawa NPP**

**(Tohoku Electric Power Company - Japco)**

- BWR Mark 1
- 123km from epicenter (M9.0)
- PGA max=0.62g (DBE=0.61g)
- NPP height = 14.7m
- Tsunami height=14.3m (DBTH=13.6m)
- INES 1
- Strict protocol implementation against extreme events
- ***If you do not think about tsunamis in Tohoku, what are you thinking?***



# Belgium Stress Tests for NNPP (**BESTA**)

A=Alpha particles=2N + 2P=NNPP

- **Introduction**
- **Timing**
- **Specifications**
- **Scope**
- **Specific questions**
- **National Report**
- **Conclusion**

# ST for other nuclear plants is a decision of the Belgian parliament

- **11 March, 2011:** Fukushima accident
- **24-25 March, 2011:** European Council decided that *the safety of all EU nuclear plants should be reviewed, on the basis of a comprehensive and transparent risk and safety assessment ("stress tests")*
- **April 21, 2011:** « stress tests » specifications-proposal by the WENRA (Western European Nuclear Regulator's Association) task force
- **May 17, 2011:** « Belgian Stress tests » specifications - Applicable to power reactors, AFCN-FANC (Federal Agency for Nuclear Control)
- **June 16, 2011:** « Chambre des représentant-Résolution relative aux modalités des stress tests et leurs conséquences sur les installations nucléaires »:
  - Adoption of the Belgian Stress tests » specifications - Applicable to power reactors
  - FANC must propose specifications for other class 1 installations
  - Belgium wants to promote at the European level the need for supplementary specifications related to the non-natural events (terrorism, airplane crash, cyber-attack, etc.)
- **June 22, 2011:** « Belgian Stress tests » specifications - Applicable to all nuclear plants, excluding power reactors

# DEFINITION

Stress test is a targeted reassessment of the safety **margins** of nuclear power plants in the light of the events which occurred at Fukushima : **extreme** natural events challenging the plant **safety functions** and leading to a **severe** accident

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# Belgium ST Timing

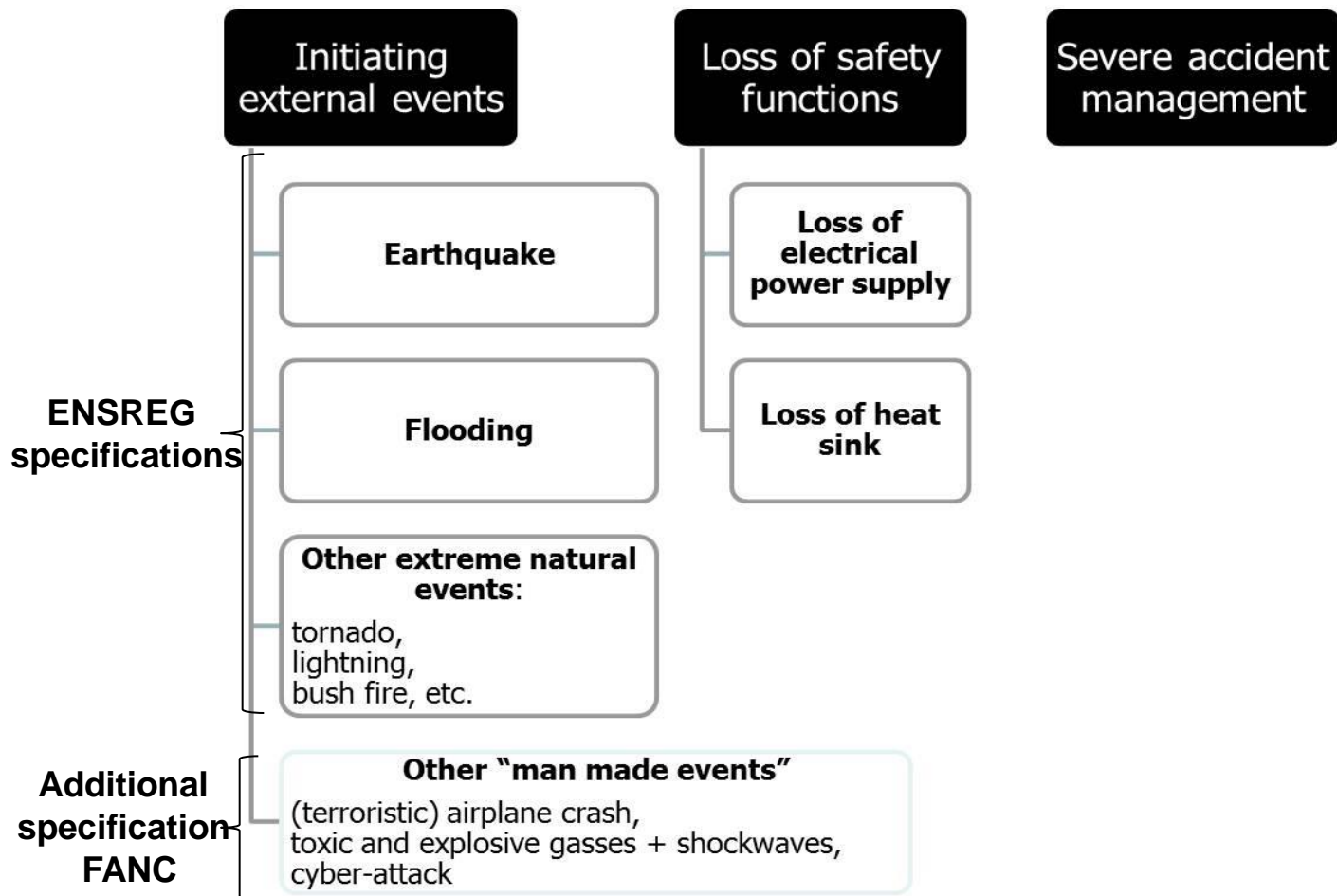
Item	ST power reactors (BEST)	ST other installations (BESTA)
Kick-off meeting	May 27, 2011	September 14, 2011
Quick wins	June 30, 2011	September 30, 2011
Inspection quick wins	September 2011	October 2011
Draft methodology	July 15, 2011	November 15, 2011
Licensees Progress report	August 15, 2011	December 15, 2011
National Progress report	September 15, 2011	February 15, 2012
Final report licensees	October 31, 2011	June 30, 2012
National Final report	December 31, 2011	March 1, 2013
Consolidated Action Plan	December 20, 2012	July 1, 2013

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# Non power reactors assessment

- **Licensee assessment :**
  - essentially the same as for NPPs
  - except the need for the licensee to redefine the concept of **severe accident**
- **National assessment :**
  - FANC+Bel V
  - essentially the same as BEST
- **Need for coherence** between different licensees
- **Graded approach**
- **No ENSREG (European Nuclear Safety Regulators Group) Peer Review & Country Visits**

# BESTA specifications



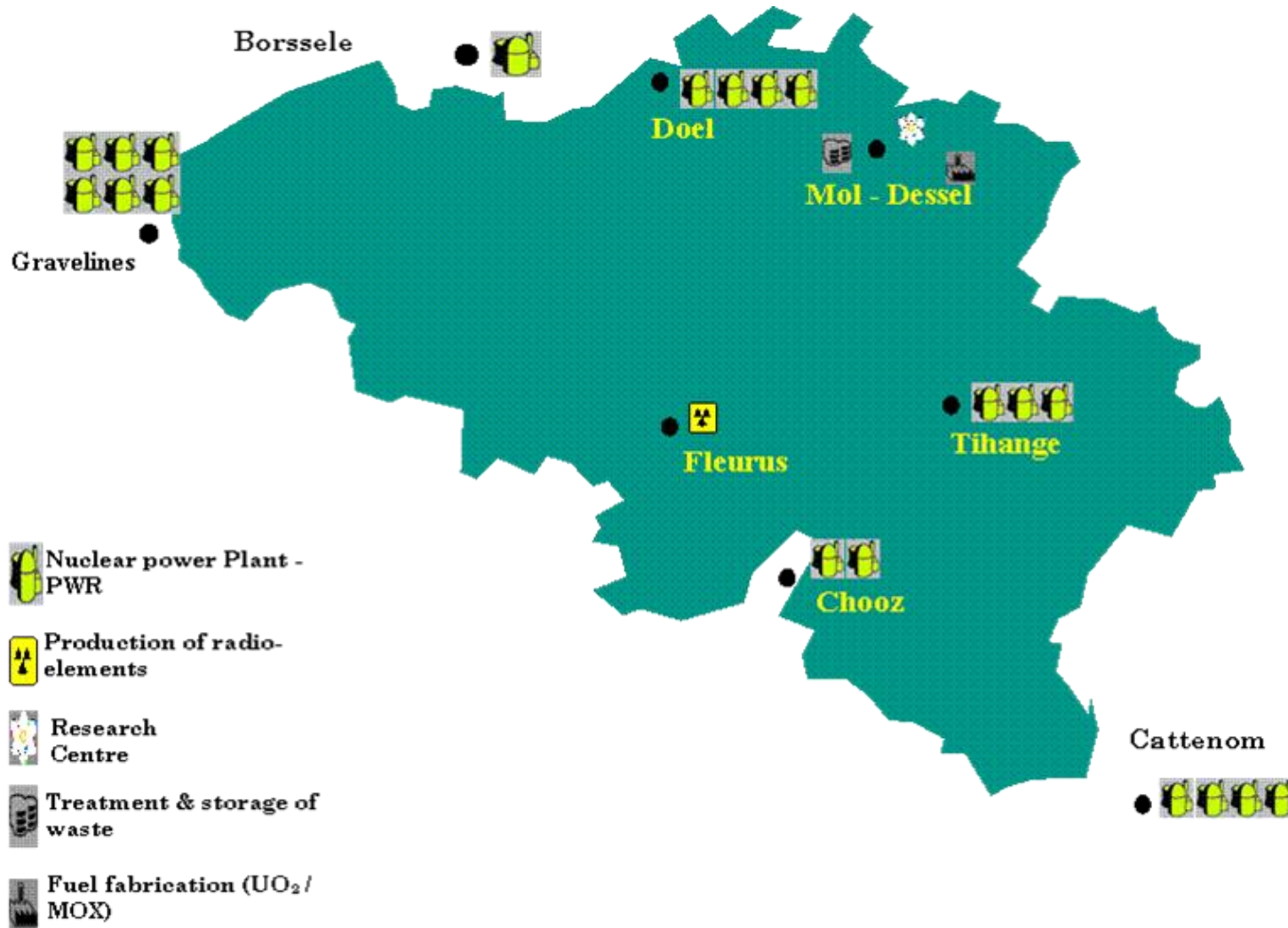
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# 6 class 1 non-power reactors installations

## Large variety in installations & risks

- **SCK.CEN** (Studiecentrum voor Kernenergie – Mol)
- **BP** (Belgoproces – Mol/Dessel)
- **IRE** (Institut National des Radioéléments – Fleurus)
- **WAB – Doel** (water en afvalbehandelingsgebouw van de kerncentrale van Doel)
- **FBFC** (Franco-Belge de Fabrication du Combustible – Dessel)
- **IRMM** (Institute for Reference Materials and Measurements – Geel)

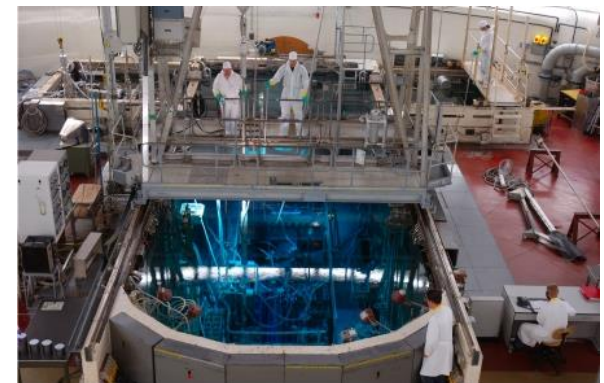
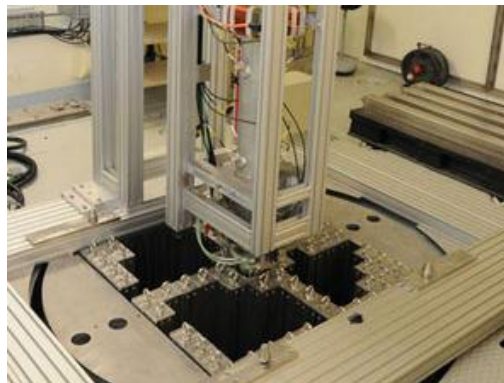
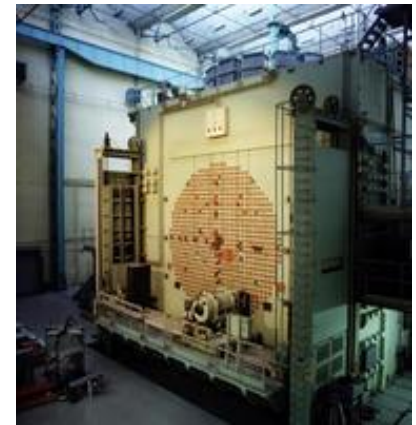
# Nuclear sites in Belgium



# SCK.CEN

## SCOPE

- **BR1 reactor**
  - 4MW-natural U-graphite moderated-air cooled
- **BR2 reactor**
  - 120 MW-HEU-Be/water moderated-water cooled
- **VENUS/GUINEVERE**
  - Zero power reactor (critical and subcritical)
- **LHMA hot cells**
- **Radiochemistry labs**
- **Calibration building**
- **Central Buffer zone**





# Belgoprocess

## SCOPE

- **16 waste storage-treatment buildings**
  - liquid, solid wastes
  - high, medium, low activity
  - temporary storage of conditioned waste (spent fuel, etc.)
  - wastes treatment



# IRE

## SCOPE

- **B6 isotope (fission) production building**
  - Mo-99/Tc-99m
  - I-131
  - Sr-90/Y-90
- **B17 waste storage building**
- **Supporting installations**
  - Buildings B4, B10, B12



# WAB Doel

## SCOPE

- **Installations in WAB Building**
  - Doel NPP's waste storage (except spent fuel)
  - Doel NPP's waste treatment





# FBFC International

## SCOPE

- building 5M (MOX)
- Other buildings: shutdown & decommissioning



# IRMM

## SCOPE

- Mass spectrometry building



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# Fundamental safety functions

- **Control of reactivity** : SCK.CEN, BP, IRE, FBFC, IRMM
- **Cooling of radioactive material** : SCK.CEN (research reactors), BP (vitrified waste storage)
- **Confinement of radioactive material** : all installations

# Graded approach

- **NPP risk >> Nuclear facilities risk**
  - High pressure and high temperature during normal operation
  - Large amount of residual heat to be removed after shutdown
  - Major radioactive source term (order of magnitude difference)
- **Design requirements for NPP >> Nuclear facilities (no DBE, no DBF, etc.)**
- **Stress test specifications should be “translated” for other nuclear facilities**
- **Principle of graded approach also to be used for stress test**
- **Example : Earthquakes**
  - New PSHA of all class I sites (NPPs and other installations)
  - Recurrence interval (return period) of  $10^3$  years vs  $10^4$  years for NPP
- **Avoid graded approach « squared »**



# **Need to translate concepts of severe accident, loss of safety functions and key-equipment to non-NPPs**

- **Stress test specifications were originally written with Fukushima accident sequence (= NPP) in mind**
- **Recommended to translate concepts of severe accident, loss of safety functions to non-NPP**
  - **Severe accident for NPPs clearly defined as core melt, damage to fuel in fuel pools,... : is this relevant for non-NPP?**
  - **Loss of safety or support functions: is loss of cooling or loss of electrical power relevant for all nuclear facilities?**
- **Preliminary scoping step needed in stress test methodology for non-NPP**

# No “official” definition of Severe accident for non-NPP

- **Severe accident (NPP):** *accident conditions more severe than a design basis accident and involving significant core degradation* [IAEA Safety glossary]
- **Severe accident (non-NPP):** pragmatic definition
  - loss of confinement
  - dose/contamination to population and environment > 5 mSv

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# National report

- **Bel V: 1 Safety Evaluation Report/ installation**
- **FANC: Public National Report based on Bel V Safety Evaluation Reports**
  - supplementary actions requirements
  - supplementary actions recommendations
  - generic actions (>1 installation)
  - specific actions (1 installation)



# Earthquake

- **No Design basis earthquake (DBE)**
- **New PSHA (ROB) for all nuclear sites**
  - PGA up to 400% higher than previous studies
  - No uniform methodology used for Design Basis Earthquake (DBE), Review Level Earthquake (RLE), number of seismic zones, transfer functions, etc...
  - Return period for DBE = 1000 years (vs 10 000 years for NPP)
- **Generic Requirements & Recommendations (R&R)**
  - To reevaluate fire risk after an earthquake
  - To study seismic resistance of fire detection, firefighting and fire compartmentation
- **Specific R&R**
  - More detailed resistance calculation of some buildings
  - Seismic qualification of structures, systems and components (SSC) of the natural convection system of a research reactor
  - Seismic qualification of emergency diesels

# Flooding

- **No Design basis flood (DBF)**
- **The unique mechanism for site flooding is heavy rainfalls (except WAB Doel)**
- **No generic R&R**
- **Specific R&R**
  - **Reinforcement of water evacuation systems (pumps, sewers, etc.)**
  - **Study of the rise of the groundwater**

# Very bad weather conditions

- **Design basis strong winds, heavy rainfalls, snow**
- **No design basis tornado**
- **Generic R&R**
  - **heavy rainfalls: to use a return period of minimum 1000 years in place of 200 years / to study water accumulation on the roofs**
  - **strong winds and Tornados: more detailed evaluation needed**
  - **Ligthning: the Belgium norm used (NBN-EN62305-2) is no foreseen for nuclear installations**
- **Specific R&R**
  - **To install a water level detection system and a pump in the underground level of an installation where the fire protection system is located**
  - **Measures to protect electrical devices when water comes into the buidings**
  - **Procedures to remove snow from the roofs**

# Bush or forest fires

- **Not foreseen in the design**
- **No official guidelines in Belgium**
- **No generic R&R**
- **Specific R&R**
  - **Revaluation of the minimal distance between buildings and trees**
  - **To take into account non classified building (fire propagators)**
  - **Upgrade of extinguishing water network**
  - **Upgrade of roofing**



# Aircraft crash

- **Deterministic**
- **3 categories**
  - General aviation (CESNA)
  - Commercial aviation (Boeing 767)
  - Military aviation (F-16)
- **Not foreseen in the design**
- **Not required from probabilistic studies ( $< 10^{-6}$ /year)**
- **Impossibility to upgrade buildings against commercial and military aviation**
- **Generic R&R**
  - General aviation crash does not cause unacceptable consequences to the population and environment
  - A general action plan must be developed to fight against kerosene fires

# Toxic and explosive gases and blast wave

- **Not foreseen in the Design Basis**
- **A priori no risk of diffusion of radioactive materials in the environment**
- **No detection of toxic gases**
- **Generic R&R**
  - Briefing with public emergency services to develop adequate procedures
  - To study transport risk (channels, roads, railways)
- **Specific R&R**
  - Procedure for ventilation
  - To prevent LPG trucks traffic
  - Internal sources (gas tanks, etc.)

# Cyber-attacks

- **Not foreseen in the DB**
- **Loss of control not foreseen**
- **Generic R&R**
  - **Periodic IT audits (every 18 months)**
- **Specific R&R**
  - **More transparent segregation politic**

# **Station Black Out (SBO)**

## **Loss of Ultimate Heat Sinks (LUHS)**

- **Only for reactors (BR1, BR2) and BP vitrified waste storage building of BP**
- **Natural water convection cooling (BR2)**
- **Natural Air convection cooling (BR1, BP)**
- **Generic R&R**
  - Protocol with electricity providers
  - Procedure to safe state
  - Control of fuel/oil for diesels
  - Higher autonomy for UPS systems
- **Specific R&R**
  - Loss of dynamic confinement
  - Use of non conventional means (mobile diesels, etc.)
  - To perform studies of consequences of loss of cooling of wastes
  - Tests of natural convection systems
  - Manual control of valves needed to establish natural convection
  - Procedure to connect mobile diesels
  - Verification of batteries autonomies

# Severe accident management

- **Severe accident**
  - loss of confinement
  - dose/contamination to population and environment > 1-10 mSv
- **Generic R&R**
  - **To develop, with the civil authorities, strategies to fight against large fires (kerosene, etc.)**
  - Site evacuation
  - Contained water evacuation (fire)
  - To increase mobile and individual lighting devices (manual load)
  - To increase robustness of communication means
  - Filtering of air for firefighters
  - **Multi-units/multi-sites accident management**
- **Specific R&R**
  - Restart of control systems after perturbation
  - More homogeneous storage of individual protections means
  - Justification of operational off-site control center localization
  - Seismic qualification of 1 operational control center (mobile or not)
  - Time for mobilization during night and week-end
  - Fixation of contamination
  - Study of large graphite fires
  - Emergency instrumentation/control for reactors
  - Mobile diesels
  - Measurements apparatus of contamination

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- **Consolidated Action plan of licensees on July 1, 2013**
- **The FANC/Bel V follow-up programme of the action plans implementation**
- **Philosophical difficulties encountered to cope with a “negative” new way of thinking : the searching of the point of rupture**
- **Safety culture**