TAKING INTO ACCOUNT CHEMICAL SAFETY FOR FRENCH BASIC NUCLEAR INSTALLATIONS

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Abstract - Among nuclear installations, some fuel cycle facilities present a high level of chemical hazards. In France, the TSN law of the 13 June 2006 requires taking into account all the risks generated by a basic nuclear installation (BNI). But, as most of the implementing regulatory texts are under development at this time, part of the previous regulation settled down in the 1990s is still applying: the order of the 31 December 1999 concerning technical regulation in order to prevent and to limit hazards generated by nuclear facilities; the decree of the 4 May 1995 and the order of the 26 November 1999 that deal with BNI discharges. Moreover, some parts of BNI or of nuclear sites can be submitted to the general regulation concerning chemical hazards, which is part of the environment code. As a result, even if the TSN law and its implementing decree Nr 2007-1557 of the 2 November 2007 settle clearly that safety of BNI is not only radiological, but must take into account chemical hazards, the latter aspects are still under development. Moreover the application of the existing regulation, even if complex, has helped to assess chemical risks inside BNI and nuclear sites.

Introduction

A lot of fuel cycle facilities (FCF) have the specificity, among nuclear installations, to use chemical substances in great amounts, with al the risks and hazards linked to: toxicity, corrosive aspect, explosion, fire, etc. Consequently chemical risks must be assessed for FCF as well as radiological ones. In France the law Nr 2006-686 of the 13 June 2006 [5] concerning transparency and nuclear safety (known as the "TSN law") requires to take into account all the risks generated by a basic nuclear installation (BNI). However most of the regulation requiring to take into account chemical risks was settled down in the 1990s on the basis of the previous general regulation concerning BNI, the decree Nr 63-1228 of the 11 December 1963 [1].

1. French regulation concerning chemical hazards – the order of the 31 December 1999

The French regulation in force dealing with chemical hazards is mostly based on the order of the 31 December 1999 [2] which applies to civil basic nuclear installations (BNI). This order lays down technical regulation in order to prevent and to limit hazards generated by nuclear facilities and that

[56] ASN : Autorité de sûreté nucléaire = French nuclear safety authority
DRC : ASN directorate in charge of nuclear waste, research facilities (including research reactors) and fuel cycle facilities

could have an impact on people living or working around, public security, public health, agriculture, environment or monuments. The order of the 31 December 1999 [2] deals with practical measures to take concerning:

- Noise and vibrations,
- Gaseous pollution,
- Water pollution,
- Waste management,
- Traffic inside nuclear sites,
- Load handling,
- Management of radiological, chemical, toxic, flammable, corrosive or explosive substances,
- Electrical devices,
- Lightning,
- Fire,
- Nuclear hazards.

The order parts actually dealing with chemical hazards are:

- Title III – prevention of air pollution (articles 10 and 11), that refers to the regulation concerning BNI releases (see next part) ;
- Title IV – prevention of water pollution (articles 12 to 19), that :
- Also refers to the regulation concerning BNI releases (article 12) ;
- Deals with toxic, radioactive, flammable, corrosive or explosive liquids ;

Puts constrains on liquid storages (article 14), as for example minimum volumes of retentions under tanks, or no presence of tanks of incompatible substances above the same retention;

Puts constrains on transfer areas (article 15) and on pipes (article 16);

- Requires that liquid waste do not be able to damage sewer networks (article 18) ;
- Requires that the operator takes all measures to prevent accidental leaks or releases (article 19).
- Title VI – prevention of other risks (articles 28 to 47), that :
- Deals with handling and transports inside nuclear sites (articles 28 and 29) of all dangerous substances ;
- Requires a continuous confinement of nuclear substances (article 30) ;
- Requires written operating instructions especially for installations containing toxic, radioactive, flammable, corrosive or explosive substances (article 31) ;
- Requires periodical assessments for these installations (article 40) ;
- Deals with fire prevention and measures to put out fire (articles 41 to 44).

This regulatory text is still on application. However the TSN law [5] has now put in force to take into account all the risks generated by BNI, radiological and non-radiological. This will be developed in an

order called the “BNI order”, and more particularly in ASN decisions as the one concerning the environment protection that will be issued before the end of the year.

2. French regulation concerning BNI discharges – the decree of the 4 May 1995 and the order of the 26 November 1999

The decree of the 4 May 1995 [3] settles down the general regulation concerning discharges of civil BNI. Its article 1 requires specific authorizations for gaseous and liquid radioactive releases.

Its article 2 settles down specific rules for parts of BNI or installations classified for the environment protection (ICPE)[57] operating inside nuclear sites, that are submitted to the ICPE regulation which is part of the environment code. This article 2 deals with some chemical risks.

The article 7 of the decree of the 4 May 1995 [3] says that radioactive and non radioactive liquid discharges of some substances into underground waters are forbidden.

The rest of the decree deals with administrative procedures to follow to deliver a discharge authorization. Concerning installations submitted to what-is-called “authorization procedure” to be allowed to operate, which is the case of BNI, the article 11 says that the discharge authorization is an inter-ministerial order containing specific limitations that must take into account regional water-uses planning, that deals with chemical pollution of waters, and radioprotection. With the TSN law [5], the administrative form of the discharge authorization has now changed into ASN prescriptions that have to be countersigned by ministers in charge of nuclear safety

The TSN law [5] requires also to take into account all the risks generated by a BNI, radiological and non-radiological. But as there is still no new regulation replacing the decree of the 4 May 1995 [3], the content of the authorization is described by the article 11 of the decree of the 4 May 1995 and its application order, the order of the 26 November 1999 [4].

The order of the 26 November 1999 [4] settles downs the content of limitations concerning water supplies and liquid and gaseous discharges of BNI. It deals with radiological and non-radiological releases. Chemical releases are dealt with:

In article 10 for gaseous releases;

In article 17 for liquid releases.

The order of the 26 November 1999 [4] also settles down basic technical measures that operators have to put in place, as for example:

Gaseous discharges must come out a facility through chimneys, except very specific justifications (article 11-I);

All radioactive gaseous discharges must be treated or filtrated before release (article 11-III);

[57] installations using or storing chemical substances. These installations are divided in different types according to their potentially dangerous aspects : the less dangerous installations are “declared installations” ; the other ones are “authorized installations”, inside which the higher possible classifications are the “SEVESO type” and the “SEVESO II type”.

There must be separated networks to prevent mixing of different types of liquid waste (articles 18 and 19).

3. Other regulatory documents taking into account chemical hazards: internal urgency plan (PUI), and intervention particular plan (PPI)

Similarly to requirements of the decree of the 11 December 1963 [1], the article 20 of the "Procedures decree" [6] requires that every BNI has an internal urgency plan (PUI). The PUI describes organization, means and methods of intervention that are planned by the operator to manage accidental scenarios in order to protect its staff, the public and the environment, and in order to preserve or to restore the BNI safety.

Moreover the decree Nr 2005-1158 of the 13 September 2005 [7], that is not specific to the nuclear industry, requires that each industrial site containing at least one BNI has an intervention particular plan (PPI). The PPI is developed by the local administrative authorities, under the control of the Prefect that is the local State representative. The PPI describes measures and means needed to manage specific risks during the occurence of incidents or accidents whose consequences can get out of the physical limits of an industrial site. The PPI contains:

A general description of the industrial site;

The geographical application area of the PPI, listing all the concerned municipalities;

The information and protection measures planned for populations and, if necessary, description of evacuation plans with possible accommodation locations;

The measures that the operator has to take to immediately alert the local authorities and to inform them concerning the situation evolution;

The measures that the operator has to take concerning the protection of the population living or working around its site;

The diffusion of warning for the populations living or working around the site;

If necessary, the measures for warning and informing the authorities of a neighbor State;

General planned measures concerning the long-term environment cleaning after the occurrence of a major accident.

Both PUI and PPI are developed on the basis of the design assessment of the BNI, that must take into account all the risks inherent to the BNI and accidental scenarios. Consequently, PUI and PPI take into account, when it is appropriate, the chemical risks that can generate incidental and accidental conditions that need specific management.

4. Some other French regulation concerning chemical hazards – the environment code

The regulation listed above is specific to BNI, except the decree of the 13 September 2005 [7]. But some parts of BNI or of nuclear sites can be submitted to a more general regulation concerning environment protection: the environment code [8]. This code settles down a classification of uses of chemical substances, that takes into account possible dangerous aspects (toxic, corrosive, etc.) of the substances related to quantities used or stored.

Linked to this classification, the environment code settles down regulation concerning installations using or storing chemical substances, classifying these installations in different types of installations classified for the environment protection (ICPE) according to their potentially dangerous aspects: the less dangerous installations are “declared installations” ; the other ones are “authorized installations”, inside which the higher possible classifications are the “SEVESO type” and the “SEVESO II type”.

The main types of ICPE that operate inside nuclear sites are:

Fuel storages for electricity generators,

Uses or storages of great amounts of chemical products that can be corrosive or toxic.

Because of amounts of chemical substances, some parts of BNI or of nuclear sites can also be submitted to the SEVESO II European directive, even if there is no or no more radioactive materials, as for example the Phenix and the Superphenix reactors because of sodium that was used as coolant.

Even though taking into account of the different French regulations that can apply to a BNI may reveal to be sometimes quite difficult, the use of the environment code classification of ICPE and of uses of chemical substances helps to find out which chemical parameters must be taken into account in addition to nuclear risks, in order to assess major risks that can be generated by BNI or nuclear sites. Examples are given here after.

5. Example Nr 1 of chemical risks taken into account for French nuclear sites : the Tricastin site

The Tricastin civil AREVA site hosts several BNI:

The Comurhex facility that processes chemical transformation of natural uranium;

The TU5/W facility that processes chemical transformation of uranium coming from retreatment process;

The Eurodif plant that enriches uranium up to 5% of uranium 235, and that will be replaced by the GB II facility;

The Socatri plant that treats uranium liquid waste coming from the Eurodif and GB II facilities.

All the operators are parts of the AREVA group.

The processes used inside the facilities are chemical ones, with no great radiological or critical issues. In particular, the Comurhex, TU5/W, Eurodif and GB II plants use fluorine components to create UF_6.

The amounts of fluorine substances present in the Eurodif plant are enough to make the facility also classified as ICPE (as “SEVESO II type” installation, in fact).

Assessing the major accident that could occur in the Tricastin site has required to examine:

Criticality accidents that could occur in the Eurodif and GB II plants, more precisely inside the storages of enriched uranium;

Massive leaks of uranium substances, from any BNI;

Massive leaks of fluorine substances stored or used in the Comurhex, TU5/W, Eurodif and GB II facilities, and that could also generate HF gas;

Uncontrolled hydrolysis of UF6, that could also generate HF gas.

At the end of the assessing process, it has appeared that the major accident that could occur in the Tricastin site, that is also called "design basis accident", is a plane crash on the UF_6 storage of the Eurodif plant (or the GB II plant, when the Eurodif plant will be under decommissioning), that would generate massive leaks of fluorine substances. These uncontrolled releases would then generate enough HF gas to corrode many equipments or materials inside the site, and to touch seriously many people inside the site. In fact, in such a case, the evacuation zone would be a circle of about 6.6-km radius around the Eurodif plant, which includes the whole Tricastin site. The uncontrolled releases would also generate releases of great amounts of uranium that could have significant impacts (mostly chemical, because uranium is chemically toxic more than radiological) on environment or on health

The consequences of a criticality accident are very weak compared to the chemical risk.

Because of the consequences it could have, a leak of fluorine substances is a major safety issue. That is why the major safety measures put in place in the Tricastin site deal with containment of chemical products. And the release authorizations concerning the site have specifications dealing with HF releases in air.

6. Example Nr 2 of chemical risks taken into account for French nuclear sites: the La Hague site

The La Hague site contains the nuclear fuel reprocessing plants. Reprocessing is a chemical process of liquid-liquid extraction leading to separate uranium and plutonium form the fission products, and to recover the nuclear matter. As the raw materials of its process are spent nuclear fuels, criticality and radioprotection are two major issues on the site.

But the process also uses very strong acids (HNO_3 at $pH < 1$), highly concentrated sodium hydroxyde, hydrazine, hydroxylamine, tributylphosphate, dodecane and other solvents. All these products can generate chemical issues that can become safety matters.

First, the storage of these chemical products must be safe, because they can corrode equipments or materials, and/or because they can become explosive if they are not safely controlled, and/or because their impact on environment cannot be neglected. As a result any uncontrolled release of these products must be prevented. As a consequence, some chemical storages in La Hague are classified as ICPE, even as "SEVESO II type" installations.

Second, the major accidental scenarios of chemical matters, that can be defined taking into account compositions of spent fuels and presence of the chemical products listed above are as follow:

Unwanted mixing of incompatible products, that can explode;

Solvent fire;

Explosion because of unwanted generation of explosive components like nitride or azide;

Uncontrolled redox reaction outside the process scope, that can generate plutonium precipitation in one part of the process, possibly leading to a criticality reaction;

Fire of some fuels components containing graphite or magnesium.

Third, existence of potentially dangerous chemical products in one part of an installation makes it not easy to operate in incidental or accidental conditions, or can create worst situations to manage.

As a result chemical hazards are taken into account:
While working out incidental and accidental scenarios;

In the general operating rules of the site, for the need of maintenance of equipments, or for the management of incidental or accidental conditions;

In discharges authorization.

7. Conclusion

The French regulation in force concerning chemical hazards inside BNI or nuclear sites is at the moment a mix between previous regulation settled down in the 1990s, and the new regulation based on the TSN law. This TSN law clearly requires taking into account all the risks generated by a BNI, which is a progress compared to the previous regulation that was not that precise.

The general regulation dealing with chemical hazards, settled down in the environment code, can also have to be taken into account in some cases, mostly for FCF because some of them use dangerous chemical substances in great amounts.

As a result, the regulation in force concerning chemical hazards inside nuclear sites can look quite complex, because it refers to several texts not necessarily linked to each other. But it still has helped taking into account chemical hazards in the BNI that had really some. However it must be said that chemical hazards were plainly taken into account mostly for buildings classified as part of BNI or when they were linked to radiological hazards. Other buildings existing on nuclear sites, but not part of BNI (classified as ICPE, for example) were often not designed to resist events like earthquake, even if they contain chemical products.

The regulation still under development, mostly the BNI order, is expected to help to take this kind of risks into account more accurately and more simply. The feedback from the Fukushima nuclear accident of March 2011 is also expected to help on this subject, because it requires to consider accidental situations that are beyond design, or that were not considered in the design because involving installations or buildings considered as of “minor interest” as they are not active part of the nuclear process.

References

[1] Decree Nr 63-1228 of the 11 December 1963 dealing with general regulation concerning basic nuclear installations

[2] Order of the 31 December 1999 concerning technical regulation in order to prevent and limit hazards generated by basic nuclear installations and that could have an impact on people living or working around, public security, public health, agriculture, environment and monuments

[3] Decree Nr 95-540 of 4 May 1995 concerning releases of basic nuclear installations

[4] Order of the 26 November 1999 concerning water supply and liquid and gaseous releases of basic nuclear installations

[5] Law Nr 2006-686 of the 13 June 2006 concerning transparency and nuclear safety, known as the “TSN law”

[6] Decree Nr 2007-1557 of the 2 November 2007 concerning basic nuclear installations, known as the “Procedures decree”

[7] Decree Nr 2005-1158 of the 13 September 2005 concerning intervention particular plans required for some types of installations

[8] Environment code – articles L.521-1 to L.521.24 concerning chemical risks

Bibliography

- Draft of the order concerning general regulation for BNI (known as the “BNI order”)

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French regulation concerning chemical risks in nuclear facilities

The French regulation in force is a mix between "new" regulation (in force since 2006) and the previous regulation (written in the 1990s).

The "new" regulation :

The "TSN law" of the 13 June 2006 that gives a clear regulatory body to the nuclear safety. It deals with safety, radioprotection, and with protection of the following interests : pubic security, public health, public safety, nature protection, environment protection.

⇒ It requires to have an integrated approach of all risks that could be generated by a facility.

⇒ Same requirement in the implementing regulatory text called the "Procedures Decree" of the 2 November 2007

French regulation concerning chemical risks in nuclear facilities

But some implementing texts of the TSN law are still under development.

=> The new regulation has to cohabit with the previous one.

French regulation concerning chemical risks in nuclear facilities

The "previous" regulation, still in force :

- Specific to nuclear installations : the order of the 31 December 1999 and some texts regulating releases
- General regulation concerning chemical risks : the parts of the environment code dedicated to chemical industries

The regulation specific to nuclear facilities is largely inspired by the regulation concerning chemical industries (first written in the 1970s).

French regulation concerning chemical risks in nuclear facilities

The order of the 31 December 1999

= technical regulation in order to prevent and to limit hazards generated by nuclear facilities and that could have an impact on people living or working around, public security, public health, agriculture, environment or monuments.

It deals with practical measures to take concerning :

- ❑Noise and vibrations
- ❑Gaseous pollution
- ❑Water pollution
- ❑Waste management
- ❑Traffic inside nuclear sites
- ❑Load handling
- ❑Management of radiological, chemical, toxic, flammable, corrosive or explosive substances
- ❑Electrical devices
- ❑Lightning
- ❑Fire
- ❑Nuclear hazards (criticality, radiation protection)

French regulation concerning chemical risks in nuclear facilities

Complementary to the order of the 31 December 1999 : the regulation concerning releases of nuclear installations

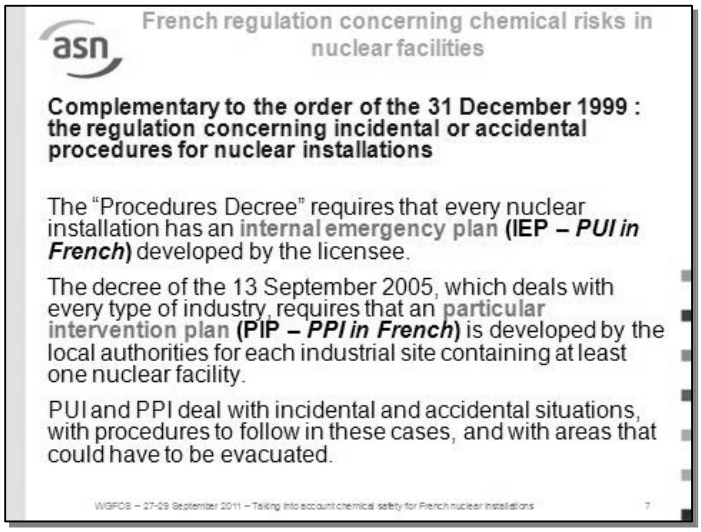
General text : the decree of the 4 May 1995 :

General principles and administrative procedures

Implementing text : the order of the 26 November 1999 :

Settles downs the content of limitations concerning water supplies and liquid and gaseous discharges

Deals with radiological and chemical releases


French regulation concerning chemical risks in nuclear facilities
Complementary to the order of the 31 December 1999 : the regulation concerning incidental or accidental procedures for nuclear installations
The "Procedures Decree" requires that every nuclear installation has an internal emergency plan (IEP – PUI in French) developed by the licensee.
The decree of the 13 September 2005, which deals with every type of industry, requires that an particular intervention plan (PIP – PPI in French) is developed by the local authorities for each industrial site containing at least one nuclear facility.
PUI and PPI deal with incidental and accidental situations, with procedures to follow in these cases, and with areas that could have to be evacuated.
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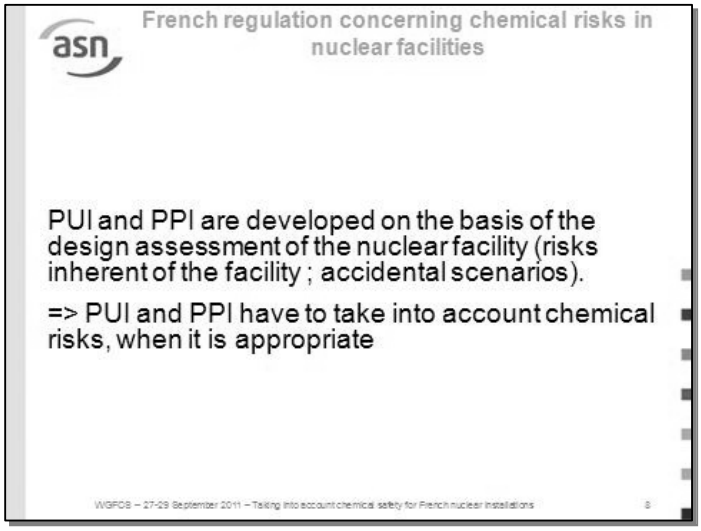
French regulation concerning chemical risks in nuclear facilities
PUI and PPI are developed on the basis of the design assessment of the nuclear facility (risks inherent of the facility ; accidental scenarios).
=> PUI and PPI have to take into account chemical risks, when it is appropriate
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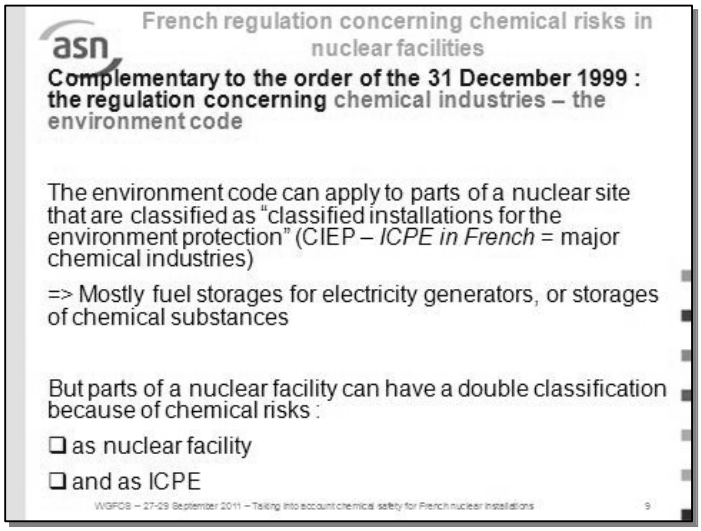
French regulation concerning chemical risks in nuclear facilities
Complementary to the order of the 31 December 1999 : the regulation concerning chemical industries – the environment code
The environment code can apply to parts of a nuclear site that are classified as "classified installations for the environment protection" (CIEP – ICPE in French = major chemical industries)
=> Mostly fuel storages for electricity generators, or storages of chemical substances
But parts of a nuclear facility can have a double classification because of chemical risks :
as nuclear facility
and as ICPE
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EXAMPLES

Example of the Tricastin site

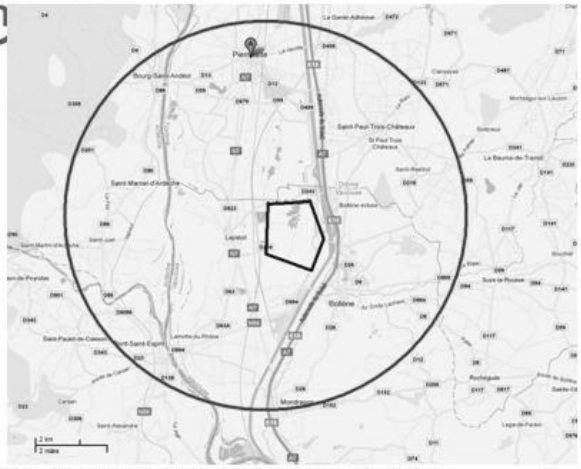
Several nuclear facilities dealing with uranium chemistry and uranium enrichment

Possible accidental situations :

- ❑ criticality accident because of enriched uranium
- ❑ chemical accident because of the use of fluorine substances to create UF_6

The review of these possible accidents has concluded that the most serious accident on this site would be an air crash on the Eurodif UF_6 storage : it would generate a massive uncontrolled leak of UF_6 that would combine with the air to create great amounts of HF (very corrosive).

=> Evacuation zone = circle of 6.6-km radius



Example of the La Hague site

Nuclear fuel reprocessing facilities (liquid-liquid extraction process)

Raw materials : spent nuclear fuels => criticality risks + highly radioactive materials

+ Use of chemical products : very strong acids (HNO3 at pH<1), highly concentrated NaOH, solvents…

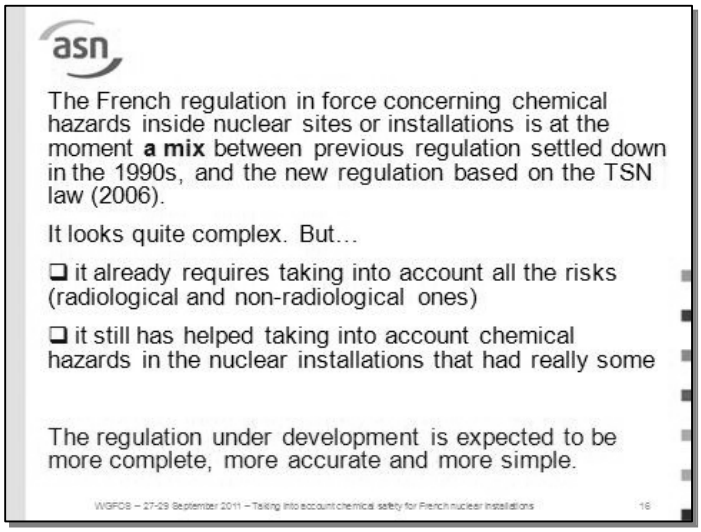
=> Major accidental scenarios :

- ❑ Unwanted mixing of incompatible products, that can explode
- ❑ Solvent fire
- ❑ Explosion because of unwanted generation of explosive components like nitride or azide
- ❑ Uncontrolled red-ox reaction outside the process scope, that can generate plutonium precipitation in one part of the process, possibly leading to a criticality reaction
- ❑ Fire of some fuels components containing graphite or magnesium

Example of the La Hague site

In addition, existence of potentially dangerous chemical products in one part of an installation makes it not easy to operate in incidental or accidental conditions, or can create worst situations to manage.

CONCLUSION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The French regulation in force concerning chemical hazards inside nuclear sites or installations is at the moment **a mix** between previous regulation settled down in the 1990s, and the new regulation based on the TSN law (2006).
It looks quite complex. But…
❑ it already requires taking into account all the risks (radiological and non-radiological ones)
❑ it still has helped taking into account chemical hazards in the nuclear installations that had really some
The regulation under development is expected to be more complete, more accurate and more simple.
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Thank you for your attention
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