IRSN
INSTITUT
DE RADIOPROTECTION
ET DE SÛRETÉ NUCLÉAIRE

Enhancing nuclear safety

DATABASE DEDICATED TO NUCLEAR CRITICALITY EVENTS THAT OCCURRED IN FUEL CYCLE FACILITIES

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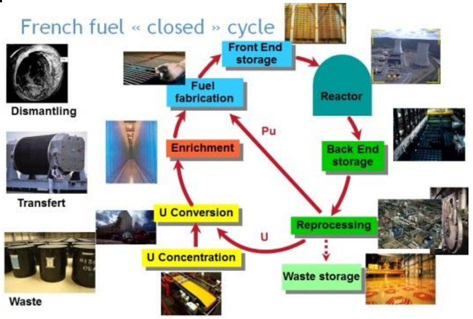
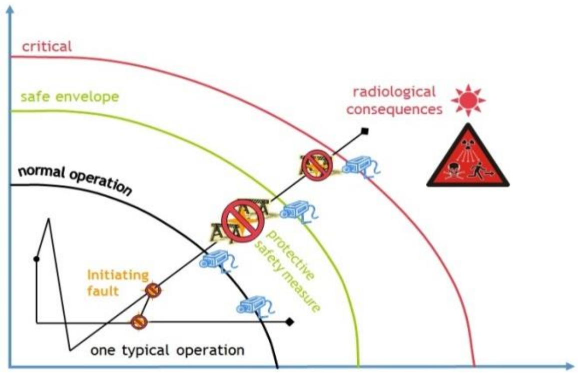
NCSD 2017, September 10-15, Carlsbad, NM, USA

CONTENTS

IRSN Nuclear criticality safety guide

- NCS analysis for fuel cycle facilities considers normal operating conditions and potential abnormal situations.





➔ Strict limits on <u>"operating" parameters</u>, to ensure the control of the nuclear criticality risks in these facilities.

- NCS safety analysis (safety margins) *vs* true life in facilities ?

- IRSN criticality department wrote a criticality <u>safety guide</u> for fuel cycle facilities ➔ <u>collect</u> most of the problems (theoretical or not) associated with those parameters related to the NCS.

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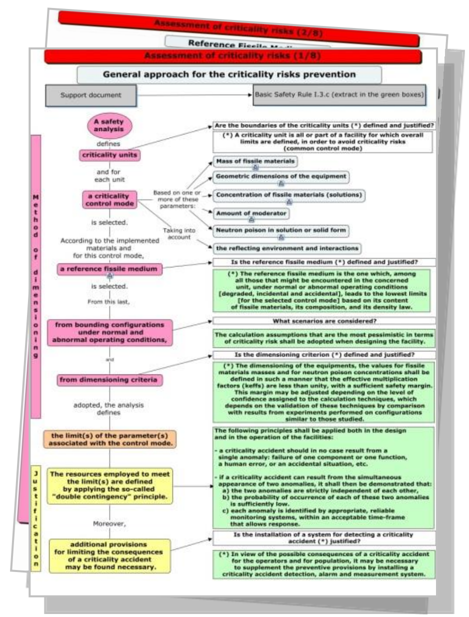
- The first part of the criticality safety guide provides a brief description of the criticality safety approach by presenting the general principles and key points for the criticality safety analysis, according to the concept of “defense in depth”.

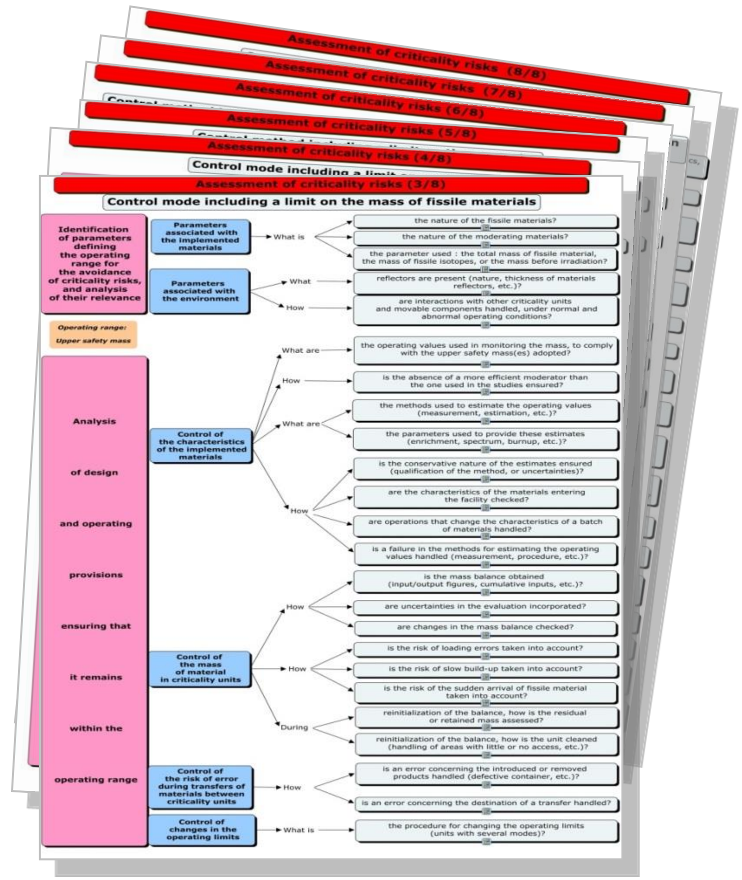


IRSN Nuclear criticality safety guide

- The second part is dedicated to formalize basic issues related to the NCS analysis.

- Several questions are presented in diagrams and classified by criticality control mode and for the reference fissile medium.

- Diagrams show the parameters to be considered in the analysis, some questions illustrating the most current failures to be investigated, and the typical sequences associated with these failures.



➔ **Importance of lessons learned**

Lessons learned: a way to enhance safety

The plant operator must have the responsability of its facility

If an event occurs in a fuel cycle facility

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Declaration to the French nuclear safety authority

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- Context
- Timing
- Configuration
- Detection
- Origin
- Safety functions affected
- Consequences
- Corrective actions

- <u>Importance of controls and measures to be taken</u>
  (design control, drafting specific documents, training of staff)

Lessons learned: a way to enhance safety

- In this context, one of the roles of IRSN (TSO of the French nuclear safety authority) is to follow the safety level of fuel cycle facilities in order to get a more detailed knowledge.

➔ To collect the experience feedback from events occurring in fuel cycle facilities.

➔ Periodic safety reviews give many experience on feedback.

Periodic safety reviews

- Periodic safety reviews of each nuclear fuel cycle facility are performed every ten years.

➔ Part of this work is based on the analysis of the feedback and lessons learned from the events that occurred during the past period.

➔ Provides lessons about the operating conditions of the facility and highlights malfunctions that occurred during operations, maintenance or restart after a shutdown.

Objective: improve the existing safety provisions of the part of the facility concerned, and even to extend this improvement to other parts of the facility.

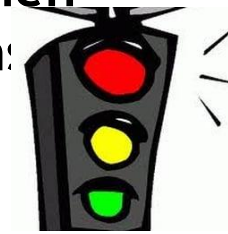
Collecting feedback

- Necessary to <u>collect as much information as possible</u> about the events that occurred in the facilities.

➔ Concerns the <u>context</u> of the events (origin), their <u>causes</u> (analysis of failures), their <u>consequences</u> (real and potential) and their possible reproducibility.

- Classification of events with such criteria makes it possible to <u>compare</u> the information and to <u>identify</u> possible common points between the events.

➔ **Identifying the weak signals of these events and to suggest, when appropriate, to reinforce or improve the existing safety provisions**



Database dedicated to nuclear criticality events

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- IRSN criticality department has developed a <u>specific "criticality events" database</u> dedicated to the analysis of nuclear criticality events occurring in fuel cycle facilities.

- This specific database is updated regularly on the basis of the reported events in the fuel cycle facilities and events are analyzed by engineers of the IRSN criticality department.

- At this time, about 600 events identified (since 1980 - ~40 facilities) are described and analyzed in this database.

- This "criticality events" database allows, from the point of view of nuclear criticality safety, <u>analyzing events</u> that occur in a fuel cycle facility.

Database dedicated to nuclear criticality events

- The sorting phase is based on the use of the following classification criteria:
  - *General information about the event and the fuel cycle facility concerned:*
    - date and title of the event,
    - name of the fuel cycle facility,
    - classification of the event on the INES scale;

  - *Specific information on the fuel cycle facility affected by the event:*
    - name of the plant or functional units containing the criticality unit involved in the event,
    - description of the criticality unit (cell, glovebox, equipment, container …) and the process (reconditioning fissile material, handling fissile solution ...) involved in the event;

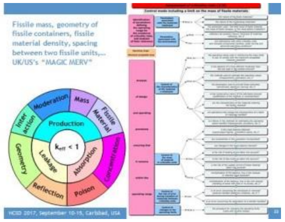
Database dedicated to nuclear criticality events

- *Specific information on the occurrence of the event:*
  - story,
  - description of the causes,
  - description of the failures,
  - detection of the event;
- *Information on the provisions for nuclear criticality safety:*
  - description of the means of control used in the criticality unit (passive and active engineered controls, administrative controls ...),
  - description of the faulty control means;
- *Information on the consequences of the event:*
  - analysis of the consequence (s) actual or potential,
  - margin analysis (safety margins) compared to a configuration leading to a critical state (keff equal to one);
- *Information on the measures taken following the event:* description of curative, corrective and preventive measures.

Database dedicated to nuclear criticality events

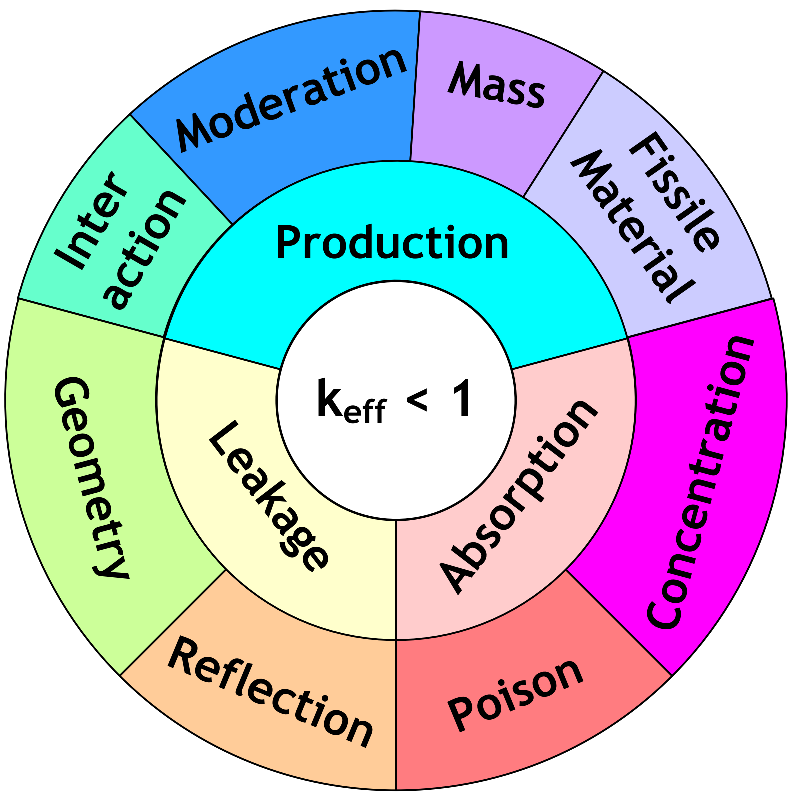
- All these criteria are used to classify events and group them by family.

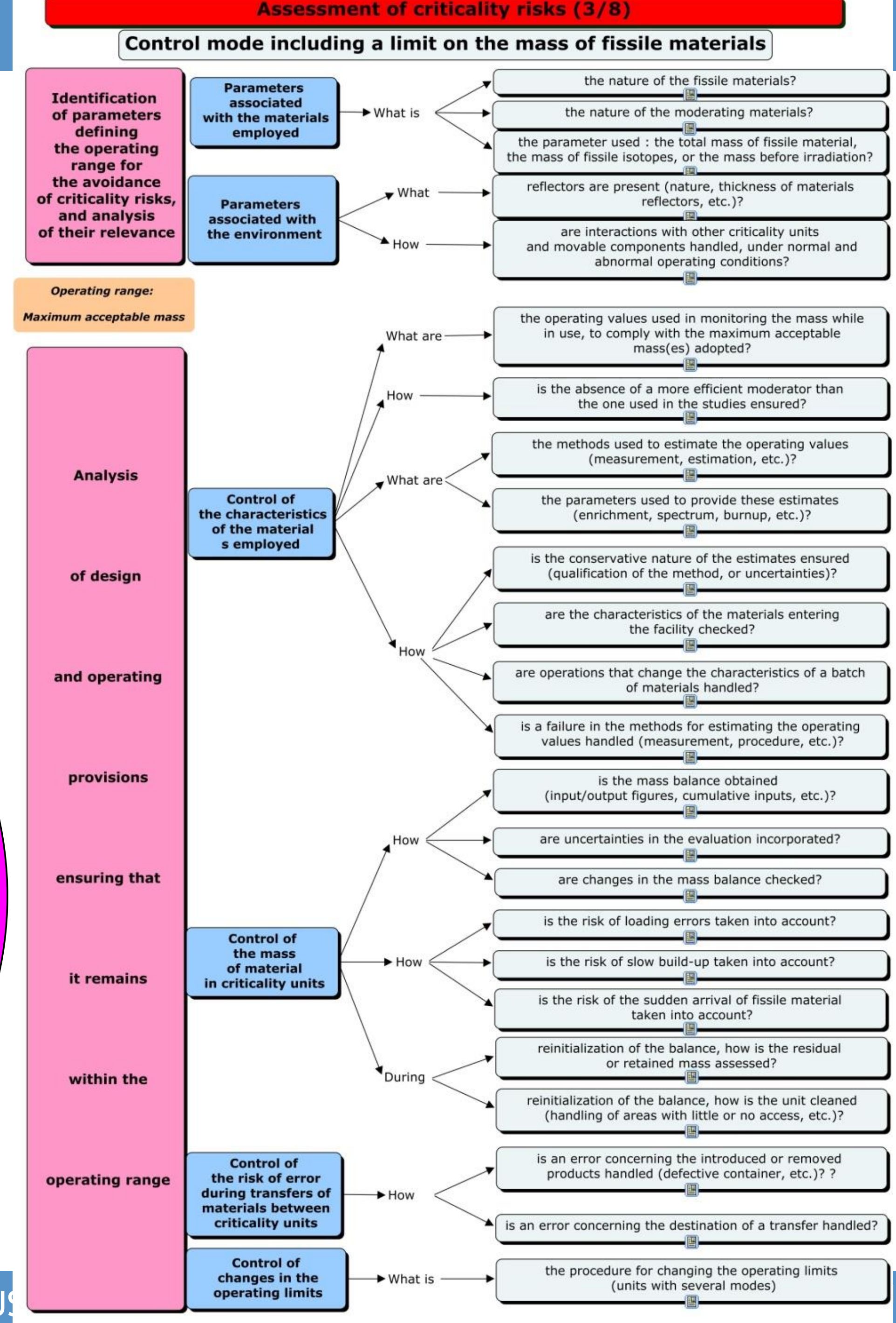
- In order to establish a link between these events and the diagrams of the criticality safety guide, with questions and typical sequences, the IRSN criticality department decided <u>to add three additional criteria for the classification of events</u>:
  - Control mode of the criticality unit concerned by the event (including the fissile medium reference);
  - Failures associated with the control mode concerned;
  - Typical sequence associated with the failure.

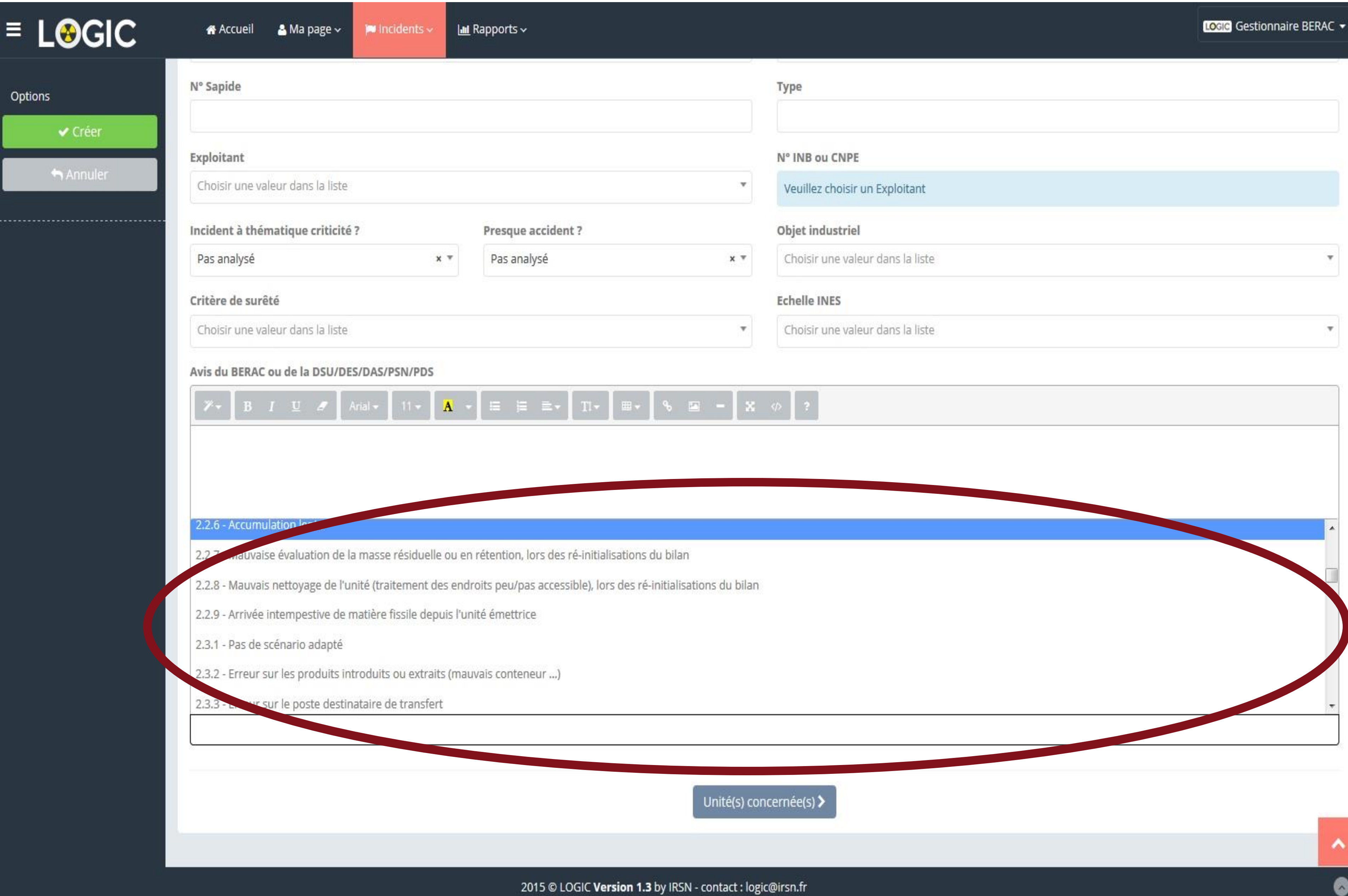


- These criteria are derived from a previously completed list on the basis of the diagrams of the criticality safety guide.

Fissile mass, geometry of fissile containers, fissile material density, spacing between two fissile units,… UK/US's "MAGIC MERV"






LOGIC
Accueil
Ma page
Incidents
Rapports
Gestionnaire BERAC
Options
Créer
Annuler
N° Sapide
Type
Exploitant
Choisir une valeur dans la liste
N° INB ou CNPE
Veuillez choisir un Exploitant
Incident à thématique criticité ?
Pas analysé
Presque accident ?
Pas analysé
Objet industriel
Choisir une valeur dans la liste
Critère de sûreté
Choisir une valeur dans la liste
Echelle INES
Choisir une valeur dans la liste
Avis du BERAC ou de la DSU/DES/DAS/PSN/PDS
Arial
11
2.2.6 - Accumulation
mauvaise évaluation de la masse résiduelle ou en rétention, lors des ré-initialisations du bilan
2.2.8 - Mauvais nettoyage de l'unité (traitement des endroits peu/pas accessible), lors des ré-initialisations du bilan
2.2.9 - Arrivée intempestive de matière fissile depuis l'unité émettrice
2.3.1 - Pas de scénario adapté
2.3.2 - Erreur sur les produits introduits ou extraits (mauvais conteneur ...)
sur le poste destinataire de transfert
Unité(s) concernée(s)
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Under the analysis of an event, it is possible to classify it, according to several typical sequences associated with the same criticality control mode or with multiple criticality control modes.

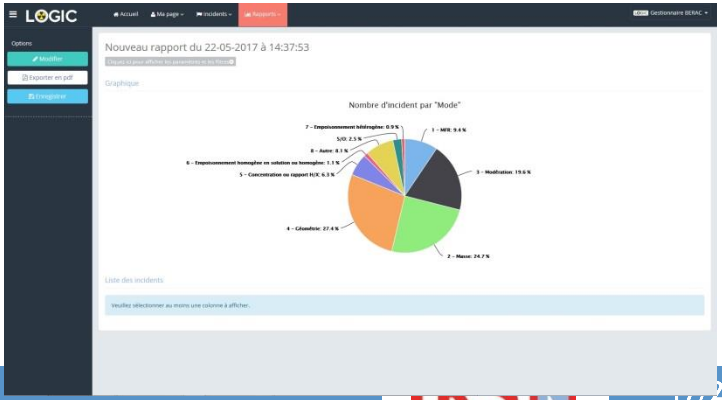
Link between the “criticality events” database and the typical sequences identified in the IRSN Criticality Safety Guide.

Lessons learned from the criticality events database

- For example, since 2010 it may be noted that events mostly concern operations <u>performed punctually and not initially provided</u> for in the design of the facility concerned, and which required the establishment of a special procedure.

  ➔ **absence or weakness of practice and lack of communication were aggravating factors.**

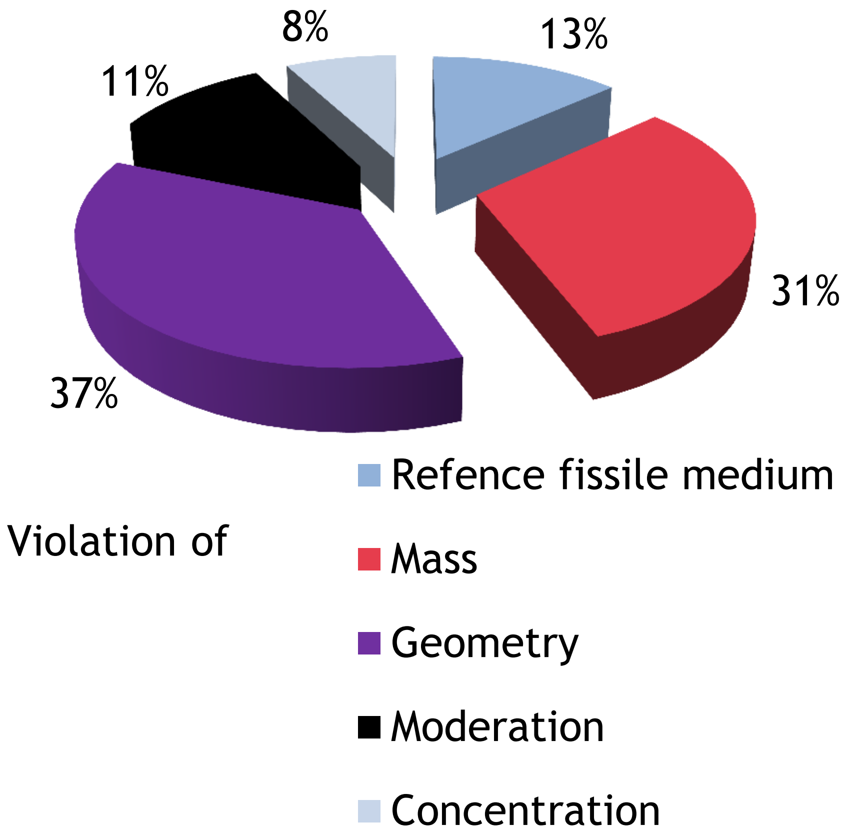
- Some events are due to a hardware failure (breakage, failure or malfunction of any component), that have lead a build-up of fissile material outside of the equipment concerned.



Lessons learned from the criticality events database

- Events affecting the geometry control mode represent a significant part of the events:
  - leakages of liquid or powder of fissile material,
  - falls or positioning errors of objects (containers with fissile material)

- Events affecting the limits of the quantities of fissile material ("mass control mode") represent a third of the events:
  - excess of the quantities of fissile material
  - lack of control of equipments weight or containers weight



Lessons learned from the criticality events database

- The "criticality events" database was also <u>used to help assessing safety during the periodic safety review (~ 2000 → 2015)</u> of both fuel fabrication and fuel reprocessing facility.

- <u>For fuel fabrication facilities:</u>
  → Many events have concerned the abnormal presence of fissile material or moderating materials in the process venting system.
  → Events have also concerned the overfilling of fissile material or the non-compliance of products in vacuum cleaners, during their filling.

- IRSN has recommended that the operator carry out a specific analysis of the risk related to accumulation of fissile material in all the ventilation networks of the facility, with the objective to enhance the control program and to make additional provisions.

Lessons learned from the criticality events database

- <u>For fuel reprocessing facility:</u>
  ➔ many events occurred following uncontrolled transfer of solution with fissile material.
  ➔ Recommendations to enhance the operations which include locking / unlocking conditions of equipment (such as valves) and the identification of all locks required to control the criticality risk (padlock).

- Some events resulted from a malfunction during a restart of the process following a scheduled shutdown, or a maintenance operation.
  ➔ Improve assessment of the risks of uncontrolled transfer of fissile material due to a non-compliance (e.g. closed or opened valve by oversight after maintenance operation) or an error (wrong choice during several transfer).

Conclusion

- The joint production of the IRSN criticality safety guide and the "criticality events" database improves nuclear criticality safety analysis for fuel cycle facilities.

- This work allows integrating lessons learned to better understand criticality events, with the aim to prevent such similar events that could be reproduced in fuel cycle facilities.

- Possible improvements: additional criteria for classifying events ?
  ➔ Majority of the events occur due to lacks of preparation or due to errors during operations in facilities (e.g. maintenance).

- Which are the failures on the lines of defense associated with these operations ? (root causes)
  ➔ Identify lines of defense to be reinforced or added…

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Thank you for your attention

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