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Proceedings of the Nuclear Energy Agency International Workshop on Chemical Hazards in Fuel Cycle Facilities Nuclear Processing

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NUCLEAR ENERGY AGENCY
COMMITTEE ON THE SAFETY OF NUCLEAR INSTALLATIONS

Proceedings of the Nuclear Energy Agency International Workshop on Chemical Hazards in Fuel Cycle Facilities Nuclear Processing

Boulogne-Billancourt, France, 17-19 April 2018.

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ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

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NUCLEAR ENERGY AGENCY

The OECD Nuclear Energy Agency (NEA) was established on 1 February 1958. Current NEA membership consists of 33 countries: Argentina, Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, Norway, Poland, Portugal, Romania, Russia, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The European Commission and the International Atomic Energy Agency also take part in the work of the Agency.

The mission of the NEA is:

– to assist its member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally sound and economical use of nuclear energy for peaceful purposes;

– to provide authoritative assessments and to forge common understandings on key issues as input to government decisions on nuclear energy policy and to broader OECD analyses in areas such as energy and the sustainable development of low-carbon economies.

Specific areas of competence of the NEA include the safety and regulation of nuclear activities, radioactive waste management and decommissioning, radiological protection, nuclear science, economic and technical analyses of the nuclear fuel cycle, nuclear law and liability, and public information. The NEA Data Bank provides nuclear data and computer program services for participating countries.

Committee on the Safety of Nuclear Installations

The Committee on the Safety of Nuclear Installations (CSNI) is responsible for the Nuclear Energy Agency (NEA) programmes and activities that support maintaining and advancing the scientific and technical knowledge base of the safety of nuclear installations.

The Committee constitutes a forum for the exchange of technical information and for collaboration between organisations, which can contribute, from their respective backgrounds in research, development and engineering, to its activities. It has regard to the exchange of information between member countries and safety R&D programmes of various sizes in order to keep all member countries involved in and abreast of developments in technical safety matters.

The Committee reviews the state of knowledge on important topics of nuclear safety science and techniques and of safety assessments, and ensures that operating experience is appropriately accounted for in its activities. It initiates and conducts programmes identified by these reviews and assessments in order to confirm safety, overcome discrepancies, develop improvements and reach consensus on technical issues of common interest. It promotes the co-ordination of work in different member countries that serve to maintain and enhance competence in nuclear safety matters, including the establishment of joint undertakings (e.g. joint research and data projects), and assists in the feedback of the results to participating organisations. The Committee ensures that valuable end-products of the technical reviews and analyses are provided to members in a timely manner, and made publicly available when appropriate, to support broader nuclear safety.

The Committee focuses primarily on the safety aspects of existing power reactors, other nuclear installations and new power reactors; it also considers the safety implications of scientific and technical developments of future reactor technologies and designs. Further, the scope for the Committee includes human and organisational research activities and technical developments that affect nuclear safety.

Acknowledgements

Gratitude is expressed to the Workshop Organising Committee, the Session Chairpersons and the workshop participants for their efforts and co-operation.

Workshop Organising Committee

Name	**Organisation, country**
Véronique Lhomme	IRSN, France
Marc Philippe	IRSN, France
Craig Erlanger	NRC, United States
Marilyn Diaz-Maldonado	NRC, United States
Kenji Mori	S/NRA/R, Japan
Mitsuhiro Takanashi	S/NRA/R, Japan
Sarah Eaton	CNSC, Canada
Olli Nevander	NEA, International

Session Chairpersons

M. Diaz-Maldonado, US NRC
S. Eaton, CNSC
V. Lhomme, IRSN
C. Erlanger, US NRC
M. Takanashi, S/NRA/R
O. Nevander, NEA

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Executive summary

Chemical hazards are an important subject for Fuel Cycle facilities, including various chemical processes and substances such as explosions and healthy risks. On 17-18 April 2018, the Nuclear Energy Agency (NEA) Committee on the Safety of Nuclear Installations (CSNI) Working Group on Fuel Cycle Safety (WGFCS) held the International Workshop on Chemical Hazards in Fuel Cycle Facilities Nuclear Processing at the NEA offices in Boulogne-Billancourt, France. During the workshop, a total of 14 presentations were given in 4 sessions. Within the framework of this workshop, a technical visit to the Atomic Energy Commission's (CEA's) Saclay Nuclear Research Centre, which is 20 kilometres from Paris, was organised on Thursday 19 April.

The Boulogne workshop focused on methods to ensure that fuel cycle facilities (FCFs) are designed and operated in a manner that prevents or mitigates the risks of hazardous chemical exposure, corrosion, fire, explosion and contamination. Many of the safety principles related to ensuring chemical safety under discussion during the Boulogne workshop were already agreed in previous workshops in Toronto, Canada in 2011 and in Aomori, Japan in 2016.

During the Boulogne workshop, it was noted that several FCFs have different chemical hazard categorisations under relevant legislation, requiring more detailed assessments of safety. FCFs are using modern methods and tools for quantifying chemical hazards, from the Quantitative Risk Assessment (QRA) to detailed calculation codes, e.g. computational fluid dynamics (CFD). It was agreed at the Boulogne workshop that a wide variety of chemical hazards, associated with nuclear fuel processing and different from the hazards in NPPs, should be taken into account in the design, construction, operation and decommissioning of FCFs. The workshop concluded that the following issues are important in the provision of safety measures and in the assessment of chemical risks:

- Radiological and chemical releases from the facilities situated on the same site should be taken into account in the emergency procedures of FCFs.
- FCFs should have precise detection systems, suitable protection devices and adequate operation and emergency procedures for all chemical and radioactive leakages.
- FCFs should have an effective process for assessing the lessons learnt on operating experiences of events involving chemicals (releases of chemicals, explosions, toxic fires, etc.). The process for assessing lessons learnt of chemical release events of other FCFs could be arranged by adequate participation in the FINAS database. In addition to recognising necessary design and operation modifications, this process – useful for identifying R&D needs in support of safety assessments sufficiently in advance – is also crucial ("longer-term anticipation").
- Co-operation between various national regulatory organisations is necessary to ensure the use of a graded approach to safety in the preparation of safety measures against the various chemical hazards in FCFs.

During the panel and discussions, the following questions arose, related to sharing the operational experiences of FCFs:

- Is there a need for comparison of procedures and methods for FCFs with the equivalent methods in use for NPPs? Can insights from the FINAS database be used in this work?
- Operating experience shows that problems in the modification process are very often leading to and causing the events. This raises the question: Is the use of the FINAS database adequate guided for the collection of events related to chemical hazards? Is there a need to improve the use of the FINAS database and even use other sources of information (e.g. chemical event databases) in the assessment of chemical hazards in the modification and design processes of FCFs? Necessary improvements to the FINAS database can be discussed during meetings of the CSNI Working Group on Fuel Cycle Facilities (WGFCS) in the near future.
- Is there a need for work to compare qualitative and quantitative assessment (e.g. assessment on probability of events and their consequences) for chemical hazards? Is there a need to compare exposure standards used in the nuclear industry as well as in the chemical industry?

The questions above could be among the key subjects for international workshops of FCFs arranged by the WGFCS and the International Atomic Energy Agency in the near future.

List of abbreviations and acronyms

AEGL	Acute exposure guideline levels (for airborne chemicals)
ASN	Autorité de Sûreté Nucléaire (France)
CEA	Commissariat à l'énergie atomique et aux énergies alternatives (France)
CFD	Computational fluid dynamics
CNSC	Canadian Nuclear Safety Commission
CSN	Consejo de Seguridad Nuclear (Spain)
CSNI	Committee on the Safety of Nuclear Installations (NEA)
EDF	Électricité de France
EOPs	Emergency operating procedures
FCF	Fuel cycle facility
FINAS	Fuel Incident Notification and Analysis System
HLLW	High- and low-level waste
IAEA	International Atomic Energy Agency
IRSN	Institut de radioprotection et de sûreté nucléaire (France)
NEA	Nuclear Energy Agency
NPP	Nuclear power plant
NRA	Nuclear Regulation Authority (Japan)
NRC	Nuclear Regulatory Commission (United States)
OECD	Organisation for Economic Co-operation and Development
QRA	Quantitative risk assessment
SNF	Spent nuclear fuel
S/NRA/R	Regulatory Standard and Research Department, Secretariat of Nuclear Regulation Authority (Japan)
WGFCS	Working Group on Fuel Cycle Safety (NEA CSNI)

1. Introduction

This is a summary report for the Nuclear Energy Agency (NEA) Committee on the Safety of Nuclear Installations (CSNI) Working Group on Fuel Cycle Safety (WGFCS) International Workshop on Chemical Hazards in Fuel Cycle Facilities Nuclear Processing held in Boulogne-Billancourt, France, on 17-19 April 2018. It describes the presentations in the workshop and conclusions drawn during the discussions and closing panel. During the workshop, a total of 14 presentations were given to 31 participants in 4 technical sessions:

- regulations, standards, requirements and guidance for chemical safety for FCFs;
- consideration of chemical hazards for the design, commissioning, operation and decommissioning of FCFs;
- emergency preparedness and response in case of accidental situations due to chemical hazards in FCFs;
- operating experience feedback on managing chemical hazards in FCFs.

The discussions on chemical hazards were based on work done in two previous workshops of the WGFCS, namely, the Toronto, Canada workshop in September 2011 and the workshop in Aomori, Japan in November 2016.

The main objective of this workshop was to bring together specialists involved in FCF safety in order to discuss chemical hazards associated with nuclear fuel processing. The objectives of the workshop were to review national activities, safety and regulatory approaches for managing chemical hazards at FCFs, the effectiveness of these activities, and areas for improvement. The scope of FCFs covered included uranium conversion facilities, uranium enrichment facilities, all types of fuel fabrication facilities, irradiated material processing facilities and waste management operations.

FCFs employ many diverse technologies with large variations in physical and chemical forms of the processed materials. These imply a wide variety of chemical hazards, different from the hazards in NPPs, which are to be taken into account in design, construction, operation and decommissioning of FCFs.

The hazardous chemical substances used in the production processes may be toxic, corrosive, combustible, reactive or explosive, and disturbances may lead to specific chemical releases and personnel exposures.

These chemical, personnel and industrial hazards and their consequences need extra care and the conventional occupational safety and health requirements related to these hazards must be taken into consideration by utilities and regulators, when looking at the general safety of FCFs.

2. Previous workshops

2.1. Toronto workshop in September 2011

In Toronto, Canada, on 27-29 September 2011, the workshop on "Safety Assessment of Fuel Cycle Facilities – Regulatory Approaches and Industry Perspectives" (NEA, 2013) drew several broad conclusions related to chemical hazards as follows:

- Participants recognised the importance of the impact of chemical hazards on safety assessment of fuel cycle facilities (FCFs) in addition to radiation hazards, especially when we are trying to keep good reputation and safety records of the nuclear industry.
- Participants felt that there is a need for improved co-ordination between various regulatory bodies within each country, especially in the area of chemical hazards. It may be beneficial to benchmark with other facility types within the nuclear industries (such as NPPs) as well as outside (such as the petrochemical industry) to identify cross-learning opportunities in managing various types of chemicals.

In the Toronto workshop (NEA, 2013) it was noted that the IAEA mandate does not include chemical hazards, unless it leads to radiation hazards. Therefore, it is even more important that the CSNI WGFCS should continue to support technical workshops in the area on chemical hazards. It was also noted in the Toronto workshop that there is a need for an international reference library of chemical hazards related to FCFs.

2.2. Aomori workshop in November 2016

FCFs have a large variety of physical and chemical forms of processed materials, and therefore many of the actions presented at the NEA Workshop on Developments in Fuel Cycle Facilities after the Fukushima Daiichi Nuclear Power Station Accident (or Aomori workshop) were suitable only for specific facilities. The Aomori workshop in 2016 (NEA, 2018) pointed out new requirements, good practices and new research on chemical hazards, and applications of these with a graded approach for FCFs. Applications of a graded approach will be used for FCFs in assessing the requirements and methods to mitigate the effects of exposure of the various chemical substances and their combinations to radioactive substances during accidents.

Furthermore, it was noted in the Aomori workshop (NEA, 2018) that differences in national legislation and regulatory approaches do not change the responsibility of FCF operators to provide a full assessment of chemical hazards including the combination of these hazards with nuclear and radiological risks. This means that all chemical forms and concentrations of radioactive and toxic substances, major physical processes and exposure pathways and their consequences are identified and analysed in a comprehensive safety case for FCF.

3. Workshop sessions and technical visit

3.1. Opening – Introduction and objectives of the workshop

The opening session was chaired by Mr Takanashi (S/NRA/R) and Mr Erlanger (US NRC). In the opening session, Mr Nevander from the Nuclear Energy Agency (NEA) gave a short overview on the NEA objectives and goals for the workshop. Next, Mr Bodenez, the Deputy Head of the Technical Risks Department in the Ministry of Ecological and Solidarity Transition of the French Government highlighted examples of industrial accidents throughout the world and made a statement on the legal framework on the prevention of chemical accidents in Europe as well as an overview of the international co-operation frameworks.

3.2. Session 1: Regulations, standards, requirements and guidance for chemical safety for FCFs

Session 1 was chaired by Ms Diaz-Maldonado of the US NRC, and there were five presentations on the regulations, standards, requirements and guidance used in member countries. These presentations gave insights on the different regulatory approaches used to regulate chemical hazards, especially in the Canada, France, Japan and the United States. A discussion took place on the need to develop a best practices document that highlights the different regulatory approaches of participating countries/organisations.

The radiological and associated chemical or toxicological releases to the environment are collectively termed the 'environmental impact' of the fuel cycle facility (FCF). It was noted that ensuring the function of confinement and control for radioactive material in FCF can be dependent on the effective management of various chemical reactions. The rapid progression and limited grace period of some scenarios leading to toxicological consequences or contamination by soluble radioactive material is a specific feature of certain types of FCFs. Regulations and standards require that associated chemical and industrial hazards shall be analysed and taken into account in deriving appropriate design criteria and identifying preventive or mitigative controls for the FCFs.

It was also recognised that there are different risk practices used by organisations in participating countries. All appear to be effective. During Session 1, a need was identified for more a detailed safety assessment and evaluation of qualitative vs quantitative safety analyses. More discussion addressing these types of analyses is necessary. The discussions and different presentations showed that only very few countries have some prescriptive criteria or exposure limits stated in their national regulations. The chemical exposure limits vary and are chosen according to the studied situations and parameters. Further understanding of the basis of exposure limits used by participating countries/organisations is needed.

3.3. Session 2: Consideration of chemical hazards for the design, commissioning, operation and decommissioning of FCFs

The second session was chaired by Ms Eaton of the Canadian Nuclear Safety Commission (CNSC) and included two presentations:

The first one concerned the development of a methodology relating to the identification and assessment of reactive chemical hazards of sorption systems in spent nuclear fuel (SNF) reprocessing plants, including modelling of the chemical reactions involved that could lead to explosion risks and potential radiological consequences for the workers, the public and the environment.

The second one pointed out the understanding of radiolytic mechanisms and other parameters, which influence the material under normal and accidental/extreme conditions. The modelling contributions (e.g. multi-scale modelling, fast free radical reactions, reactivity, and speciation) were recognised as requiring backup from experimental qualification and test results.

During the discussion it was noted that the analysing and updating of possible chemical hazards is an important part of the safety assessment, including/especially when modifications and upgrades are made to the processes. The categorisation of modifications and the building of clear administrative paths to get problems and deviations recognised during modification into processing are important parts of the management system of FCFs. Good procedures for the administration of modifications are important and need to be clear, including systems for categorising modifications, resolving problems and for identifying deviations. It was agreed that it is important to prevent events relating to chemical process modifications with applicable requirements, internal and external reviews of FCFs and lessons learnt on reported chemical events.

3.4. Session 3: Emergency preparedness and response in case of accidental situation due to chemical hazards in FCFs

The third session was chaired by Ms Lhomme, of the French Radioprotection and Nuclear Safety Institute (IRSN) and two presentations on accident management measures were provided in this session.

The presentation given by the IRSN described a new R&D programme to re-examine the High and Low Level Waste (HLLW) storage tanks loss-of-coolant accident to improve knowledge of ruthenium behaviour during the accident phases from evaporation up to dryness and associated risk control measures.

Then, a representative from Sellafield Ltd presented the grab cards produced by the Emergency Management Technical Team at Sellafield Ltd for chemical hazards in order to provide timely and technically underpinned advice for the responders to be able to protect the workforce and public, whilst minimising environmental consequences and aid in recovery.

In this session, the use of the emergency response handbook and procedures for general guidance of actions and use of computer modelling for predicting the routes of plumes of chemical releases was discussed. It was noted that the online modelling of routes of plumes is not widely used in FCFs. It was also noted that chemical events cause damage to health and the environment in a much shorter timescale (it takes only some seconds to harm a person) compared to the radioactivity accidents.

The annual emergency exercises and prepared and analysed action lists for accidents in procedures of FCFs were recognised to be effective tools for such situations. It was agreed that comprehensive, dedicated detection and monitoring equipment for various chemical releases was necessary for various emergency situations to initiate the countermeasures.

3.5. Session 4: Operating experience feedback on managing chemical hazards in FCFs

The fourth session was chaired by Mr Erlanger of the US NRC and there were four presentations on using operating experience feedback in member countries for the WGFCS provided in this session.

FINAS can be utilised to provide illustrative examples, trending on events involving chemical hazards and to develop lessons learnt to be shared with all the participating countries. Participating countries/organisations, based on operating experience, have a need for research in particular areas related to chemical hazards in FCFs, e.g. red oil explosions and limits to control or prevent accidents.

During Session 4, the different practices used by participating countries to regulate or manage chemical hazards were discussed. There seems to be a need to develop a high level best practices document that highlights areas to be mindful of when managing chemical hazards.

The following aspects were recognised as conclusions of the fourth session:

- Several FCFs fall within high chemical hazard categories, requiring more detailed assessments of safety.
- FCFs are using modern methods and tools for quantifying chemical hazards, from Quantitative Risk Assessment (QRA) to detailed computational fluid dynamics (CFD). However, the symptom and state based models and procedure development methodologies used in NPPs could be applied to the emergency operating procedures and emergency plans for chemical hazards of FCFs.
- Acute Exposure Guideline Levels for Airborne Chemicals (AEGL) for harmful chemicals are necessary to be used as a basis for design against of chemical hazards.

3.6. Final panel discussion on sessions

The panel discussion was chaired by M. Takanashi (NRA) and O. Nevander (OECD/NEA) and the four panellists were M. Philippe (IRSN), R. Gater (IAEA), W. Kwan (Sellafield Ltd) and C. Erlanger (US NRC).

The final panel discussion confirmed many of the subjects recognised during the workshop sessions. It was agreed that the workshop presentations pointed out some difficult topics relating to chemical safety, such as the chemistry that leads to releases of hydrogen and ruthenium. These are problems of complexity, meaning that they are problems in FCF operation because they are so complex. For example, hydrogen is produced by corrosion as well as radiolysis. Some of the radiolysis reactions that produce hydrogen are reversible; almost all corrosion phenomena are irreversible. Technically, hydrogen gas can expand to occupy all of the volume available to it. It may be better to restrict it to as small a volume as possible, and keep flushing it away. Therefore, there is need for more knowledge about hydrogen production processes and more knowledge on means for hydrogen removal without negative impacts in other areas.

Furthermore, the importance of R&D in support of safety assessments has been remembered. Indeed, it is crucial to identify R&D needs sufficiently in advance ("longer-term anticipation"), taking into account the feedback from previous safety assessments (gaps to be identified), the operating experience from FCFs including chemical hazards,

the expected future evolutions of the process or facilities and technology and scientific monitoring. Actually, it is also important to periodically identify main topics for which state-of-the-art or knowledge syntheses would be necessary to identify new research needs. Modelling in the field of the evaluation of chemical risks (i.e. thermal stability of chemicals, thermal runaway reactions, etc.) was also stressed. Nevertheless, this approach requires a full understanding of the phenomenology and reaction mechanism. In addition, the importance of knowing the effect of irradiation on solutions or materials with regard to the chemical hazards and not to content oneself on testing simulants was emphasised. Finally, a thorough evaluation of chemical hazards associated with the decommissioning activities is also necessary because the different processes used for cleaning use new chemicals and reagents which may lead to new risks.

It was also noted that these types of difficult technological problems require the sharing of expertise and ideas between many people of different subject disciplines; such as chemists, physicists and engineers in different fields. This kind of work requires an effective management system with internal prioritising of tasks with coherent principles and in the same order and schedule in all disciplines. The existing national regulations and standards may not help operators or different regulators of chemicals and radioactivity to co-operate, but this co-operation is necessary for effective actions. It is obvious that information available for minimising the risks should be shared between facilities with similar risks. Furthermore, facilities could pool their data and their effort in the interests of safety. This could be done in spite of the competition between operators and research organisations, especially, when co-operative work between FCFs could be arranged through international organisations such as the NEA and the IAEA.

3.7. Technical visit to Saclay site

The workshop ended on 19 April, with a visit to Saclay laboratories near Paris, France. Saclay is the largest CEA site, in terms of numbers of people in France. Having a long history, it has one research reactor, a new medical facility called Neurospin, several accelerators plus several laboratories operated by the IRSN. The group visited the IRSN's experimental facilities and means and especially TOSQUAN, which is used to reproduce thermohydraulic conditions simulating accident scenarios that may occur in a containment vessel and to assess the effect of mitigation measures, such as the internal spray system in the containment vessel. Also test facility STARMANIA, which is intended for studying the aeraulic and mechanical behaviour of compartmentalisation and containment equipment, subjected to pressure and temperature in nuclear facilities (fire, rupture of steam pipes, post-earthquake conditions, etc.) was visited. The group also visited some of the CEA's laboratories from the Nuclear Activities Direction of Saclay/Physico-Chemistry Department.

4. Conclusion and recommendations

The Nuclear Energy Agency (NEA) International Workshop on Chemical Hazards in Fuel Cycle Facilities Nuclear Processing, held in Boulogne in 2018 was organised by the Committee on the Safety of Nuclear Installations (CSNI) Working Group on Fuel Cycle Safety (WGFCS). Workshop focused on methods to ensure that fuel cycle facilities (FCFs) are designed and operated in a manner that controls and minimises the risks of hazardous chemical exposure, corrosion, fire, explosion and contamination associated with nuclear fuel processing.

In previous workshops in Toronto, Canada in 2011 and in Aomori, Japan in 2016, it was already noted that all chemical forms and concentrations of radioactive and toxic substances, major physical processes and exposure pathways and their consequences need to be identified and assessed in a comprehensive safety case of the FCF. Furthermore, it was agreed that these analyses on estimated source terms of radiological and chemical releases to the environment and their trajectories make the measures described in the emergency operating procedures (EOPs) more effective.

During the Boulogne workshop and its discussions, it was noted that several FCFs fall within high chemical hazard categories, and thus require more detailed assessments of safety. FCFs are using modern methods and tools for quantifying chemical hazards, from quantitative risk assessment (QRA) to detailed calculation codes, e.g. computational fluid dynamics (CFD). Some are freely available, but adequate validation data may be missing for some of these codes. Calculation codes and models for releases to the atmosphere include a great deal of uncertainties. It was recognised that acute exposure guideline levels (AEGLs) are now used by some operators for quantifying emergency exposure criteria from chemical accidents.

It was agreed in the Boulogne workshop that a wide variety of chemical hazards (different from the possible hazards in NPPs), should be taken into account in the design, construction, operation and decommissioning of FCFs. The workshop concluded that the following issues are important in the preparation of safety actions and in the assessment of the risk of the chemical hazards:

- Radiological and chemical releases from the facilities situated at the same site should be taken into account in the emergency procedures.
- FCFs should have precise detection measurements, suitable protection devices and adequate operation and emergency procedures for all radioactive leaks and associated chemical releases.
- FCFs should have an effective process for assessing the lessons learnt on operating experiences of chemical release events. The process for assessing lessons learnt for chemical release events of other FCFs could be arranged through adequate contribution to the FINAS database. In addition to recognising necessary design and operation modifications, this process is useful for identifying R&D needs in support of safety assessments sufficiently in advance (“longer-term anticipation”).
- Co-operation between various national regulatory organisations is necessary to ensure a graded approach to safety in the protection from the various chemical hazards of FCFs.

During the panel and discussions of the workshop the following questions related to sharing operational experiences of FCFs were noted:

- Is there a need for comparison of procedures and methods for FCFs with the equivalent methods in use for NPPs? Can insights from the FINAS database be used in this work?
- Operating experience shows that problems in the modification process are very often leading to and causing the events. This raises the question: Is the use of the FINAS database adequate guidance for chemical hazards? Is there a need to improve the use of the FINAS database in the assessment of chemical hazards in the modification and design processes of FCFs?
- Is there a need for work to compare qualitative and quantitative assessment (e.g. assessment on probability of events and their consequences)? Is there a need to compare exposure standards used in the nuclear industry as well as in the chemical industry?

It was agreed in the Boulogne workshop that the reasonable application of sophisticated safety procedures and resource-demanding assessment methods of NPPs for large variations of FCFs will be one of the key challenges at the international level in the future. The use of a graded approach together with lessons learnt in terms of events in the FINAS database could be one of answer for these challenges.

5. References

NEA (2013), "Safety Assessment of Fuel Cycle Facilities – Regulatory Approaches and Industry Perspectives", Proceedings from the NEA CSNI Workshop held in Toronto, Canada on 27-29 September 2011; NEA/CSNI/R(2012)4, OECD, Paris.

NEA (2018), "Developments in Fuel Cycle Facilities after the Fukushima Daiichi Nuclear Power Station Accident", Proceedings from the NEA CSNI Workshop held in Aomori City, Japan on 15-17 November 2016; NEA/CSNI/R(2017)12, OECD, Paris.

Appendix A - List of participants

Family name	First name	Organisation or company
BECKER	Gaëtan	Orano
BODENEZ	Philippe	Ministry of Sustainable Development
BOURROUS	Soleiman	IRSN
BULIT	Jean-Marc	IRSN
CANTREL	Laurent	IRSN
CARLVIK	Nicklas	Westinghouse Electric Sweden AB
DE ALMEIDA	Lucie	IRSN
DELIME	Brice	ASN
DIAZ MALDONADO	Marilyn	US NRC
DUMAS	Agnès	IRSN
EATON	Sarah Jane	CNSC
ERLANGER	Craig	US NRC
GATER	Ramon	IAEA

Family name	First name	Organisation or company
GUILLARD	Michel	IRSN
HEMIMOU	Youcef	ASN
KWAN	William	Sellafield Ltd
LHOMME	Véronique	IRSN
LOSINGER	Mathieu	Orano
MOISAN	Lionel	Orano
MONFORT	Marguerite	CEA
MORI	Kenji	S/NRA/R
MULYE	Hemendra	CNSC
NERISSON	Philippe	IRSN
NEVANDER	Olli Vilhelm	OECD/NEA
ORTEGA RICO	Angelica	IRSN
PHILIPPE	Marc	IRSN
PLUNTZ	Laurène	IRSN
RODIN	Alexey	SECNRS
ROUX-SERRET	Véronique	Orano
TAKANASHI	Mitsuhiro	S/NRA/R
YAMAGUCHI	Akinori	S/NRA/R

Appendix B - Technical programme of the workshop

17 April 2018 - NEA building, room BB1

9:30 – 10:30

Opening Session - Chairpersons: M. Takanashi (S/NRA/R), C. Erlanger (USNRC)

NEA objectives and goals for the workshop - O. Nevander (NEA)

Prevention of risks in chemical facilities in France - P. Bodenez (Head of Department of accidental hazards, General Directorate of prevention of risks, Ministry of Ecological and solidarity-based Transition)

Practical arrangements of the workshop – O. Nevander (NEA)

10:50 – 13:00

Session 1: Regulations, standards, requirements and guidance for chemical safety for FCF's, Chair: M. Diaz-Maldonado, US/NRC

(5) Chemical Hazards and the IAEA Safety Standards, R. Gater (IAEA)

(8) French framework regulation related to chemical hazards in nuclear Fuel Cycle Facilities, B. Delime (ASN) and Y. Hemimou (ASN)

(15) Chemical Safety Requirements in the United States For Commercial Fuel Cycle Facilities, M. Diaz-Maldonado (US NRC) -

(1) Chemical Effects and their Evaluation Methods for Accidental Release of Uranium Hexafluoride, K. Mori (S/NRA/R)

(9) Assessment of Risks to Human Health and the Environment of Hazardous Substances in Nuclear Fuel Cycle Facilities in Canada, H. Mulye (CNSC)

14:15 – 15:15

Session 2: Consideration of chemical hazards for the design, commissioning, operation and decommissioning of FCFs, Chair: S. Eaton, Canada, CNSC

(6) Estimation of reactive chemical hazards of sorption systems for reprocessing SNF, A. Rodin (SEC NRS)

(13) Radiolysis and safety concerns in nuclear fuel cycle, M. Philippe (IRSN)

15:40-16:40

Session 3: Emergency preparedness and response in case of accidental situation due to chemical hazards in FCFs, Chair: V. Lhomme, France, IRSN

(2) R&D programme on volatilisation and transport behaviour of ruthenium under a loss of cooling accident on high level liquid waste (HLLW) storage tanks in reprocessing plants and mitigation strategies, Ph. Nérisson (IRSN)

(12) Grab cards for chemical hazards at Sellafield Ltd, W. Kwan (Sellafield Ltd)

16:40 – 17:30

Session 4: Operating experience feedback on managing chemical hazards in FCFs, Chair: C. Erlanger, US NRC

(3) Reassessment of explosion risks associated with red oils in French reprocessing plants and related R&D and first results, A. Ortega Rico (IRSN)

(4) Reassessment of chemical hazards for the first periodic safety reviews of AREVA NC La Hague reprocessing plants – the corrosion ageing of FP evaporators' case, L. Almeida (IRSN)

17:30 - 17:50

Closing Discussion of first day

18 April 2018 NEA building, room BB1

10:00 – 11:00

Session 4: Operating experience feedback on managing chemical hazards in FCFs, Chair: C. Erlanger, US NRC

(10) The Operating Experience Feedback of Chemical Hazards in Canada, S. Eaton (CNSC)

(14) Comparison of U.S. Operating Experience from Nuclear Fuel Cycle Facilities and Commercial Industrial Plants, C. Erlanger (US NRC)

11:10 – 12:00

FINAL PANEL DISCUSSIONS - Chairs: M. Takanashi, O. Nevander

Panel:

M. Philippe

R. Gater

W. Kwan

C. Erlanger

Appendix C - Conference papers

The Papers (Appendix C) presented during the workshop can be found on the NEA website.