Research Needs in the Domain of Severe Accidents

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Abstract

The objectives of SARNET are to define common research programmes and to develop common computer tools and methodologies for safety assessment. To reach these objectives several elements or work programmes (WP) are established. One of them is the WP 'Severe Accident Research Priorities' (SARP) with the aims to harmonize and to re-orient research programmes, to define new ones, and to close a resolved issue on a common basis. This action will make use notably of (1) the outcome of the EURSAFE action, i.e., the results of the Phenomena Identification and Ranking Tables (PIRT) on severe accidents, (2) the results of the qualification and benchmarking activities on ASTEC, (3) the results of reactor calculations carried out in the other activities, and (4) the outcome of the research performed in the three thematic sub domains of SARNET (corium, containment, source term).

The main outcome of EURSAFE was a list of 21 topics which includes precise recommendations for experimental programmes and code developments and forms the basis of the work of the SARP. Also the methodology applied in EURSAFE to consider both risk potential and the severe accident issues where large uncertainties still subsist will be adopted. The analyses of the progress of research and developmental activities will be in close cooperation with the management team and the coordinators of the WPs. These analyses will consider whether (1) any research issue is resolved due to reduction of uncertainties or gain of scientific insights, (2) any new issue has to be added to the list of needed research, (3) any new process or phenomena have to be included in the general PIRT list taking into account the safety relevance and lack of knowledge, and (4) a new accident management programme has to be developed to cope with unresolved problems. Furthermore a strategy plan will be elaborated to ensure a wide consensus with the end users requirements and the objectives of SARNET research activities.

A Introduction

The objectives and work scope of SARNET have been comprehensively described in the previous presentation "Overview of SARNET deployment and progress". The SARNET work program is based on the result of EURSAFE, which was a thematic network with a duration of two years starting 1st December 2001 and finishing 30th November 2003. The main outcome of EURSAFE was a list of 21 areas of needed research in the domain of severe accidents, which includes precise recommendations for experimental programmes and code development. To further develop this list as a living document the work package "Severe Accident Research Priorities (SARP)" has been established.

This presentation describes

- The objectives and the work scope of the work package SARP.
- The methodology applied in EURSAFE to establish an internationally agreed list of needed research items.
- Main results of work performed.
- The strategy to fulfil the objectives of the work package.

This first ERMSAR should be focused on the main results of SARNET, the identification of items where the knowledge has been considerably improved and further experimental research or model development (R&D) is not necessary, taking into account the limited resources available. Furthermore it should identify research areas which need reorientation to fulfill the objectives of the work package and last but not least the identification of needed research not being covered by the SARNET work program.

The final panel discussion of ERSAR should highlight these issues to support the optimal use of national and international effort for research in the domain of severe accident.

B Objectives and work scope of the work package SARP

The objectives of SARP are defined as:

Prioritise the research to be performed in the field of severe accident phenomena and management, notably using the results of EURSAFE, ASTEC work packages, and Level 2 PSA work packages.

The working scope as outlined in the “Description of Work” is:

- Agree on methodology.
- Review issues resulting from EURSAFE not appropriately covered by SARNET.
- Analyse research and development progress and results from Level 2 PSA studies.
- Review issues ranking.
- Review potential experimental and theoretical programmes to address these issues.
- Make recommendations for research and development programme revision

The following chapters will illustrate the working methods studied to find an effective way how to fulfil the requirements and the work being performed by the SARP team.

C EURSAFE methodology and results

The objectives of the EURSAFE thematic network (Ref. [1]) were to establish a large consensus on the Severe Accident issues where large uncertainties still subsist, and to propose a structure to address these uncertainties by appropriate R&D programmes making the best use of the European resources. It incorporated issues related to existing plants (PWR, BWR and VVER), lifetime extension of these plants, evolutionary concepts (higher burn-up and MOX fuels), and safety and efficiency of future systems.

20 partners representing R&D governmental institutions, regulatory bodies, nuclear industry, utilities and universities from 9 European countries (Finland, France, Germany, Spain, Sweden, United Kingdom, Czech Republic, Hungary, Switzerland) and the USA were brought to work together in a network structure, which was supposed to be the embryo of SARNET.

To achieve the objectives, sufficient convergence on issues and phenomena and on their importance in terms of safety and knowledge was required among all the major European actors in Nuclear Safety. The final objective was a consensual approach to resolve the remaining uncertainties. Establishing Phenomena Identification and Ranking Tables (PIRT) has been proved in other areas (e.g. Loss-of-coolant accidents, LOCA) to be an efficient and unbiased way to reach such a consensus (Ref. [2]).

In EURSAFE the first PIRT was realised for severe accidents as an initial step towards the objectives. It integrated all the severe accident issues from core degradation up to release of fission products in the containment, taking into account any possible counter-measures and the evolution of fuel management.

As a basis for the PIRT, a comprehensive list of 916 severe accident phenomena was established. The phenomena were classified in five groups:

– In-vessel (162 phenomena),
– Ex-vessel (149 phenomena),
– Dynamic loading (461 phenomena),
– Long term loading (116 phenomena),
– Fission products (128 phenomena).

Three safety-oriented groups of experts scrutinized these phenomena of the five lists and ranked them in accordance to their safety importance for

– primary circuit,
– containment and
– source term.

The rationale for voting on safety importance was as follows:

– **Vote level 3:** High priority; the phenomenon (or the aspect) is highly important for safety and the probability of occurrence is high, medium or unknown. The uncertainties on this phenomenon should be reduced to the minimum possible.
– **Vote level 3L:** High priority but low probability; the phenomenon (or the aspect) has important consequences and the probability of occurrence is low.
– **Vote level 2:** Medium priority; the phenomenon (or the aspect) is important for safety and the probability of occurrence is medium or unknown.
– **Vote level 1:** Low priority; the phenomenon (or the aspect) has low importance for safety, or has medium importance for safety and its probability of occurrence is low.
– **Vote NO:** No Opinion.

– **Vote NA:** Not Applicable; phenomenon not relevant for the considered safety oriented situation.

– **"-":** No participation.

According to the number of High, Medium and Low priority votes assigned to a phenomenon, an Importance Ratio (IR) was deduced from:

$$IR = \frac{(3n_H + 2n_M + n_L)}{(n_H + n_M + n_L)} \qquad IR \in [1,3]$$

A classification based on vote averages was established as follows:

– $IR \geq 2.33$ means HIGH Importance ranking

– $1.66 < IR < 2.33$ means MEDIUM Importance ranking

– $IR \leq 1.66$ means LOW Importance ranking

Any phenomena for which the number of votes was less than five, whatever was the average value of the votes, was disregarded. On the other hand, phenomena having more than five votes “3” were selected as highly important anyway. A few bi-modal cases (phenomena having an equal number of votes 1 and 3) could not be resolved and remained in the list.

After this evaluation a reduced list of 229 severe accident phenomena with high importance for reactor safety was established:

– 44 phenomena for In-vessel,

– 48 phenomena for Ex-vessel,

– 71 phenomena for Dynamic loading,

– 36 phenomena for Long term loading,

– 30 phenomena for Fission products.

Then, the five previously mentioned phenomena-oriented groups ranked the phenomena selected as important for safety in terms of knowledge. Rationale for voting on phenomena knowledge was as follows:

– **Vote level 3:** The phenomenon/aspect is only partly understood. The models are rudimentary. The model verification is insufficient due to a significant lack of experimental data. Needs significant R&D effort.

– **Vote level 2:** The phenomenon/aspect is on the whole understood, uncertainties remain for unexplored parameter ranges or extrapolation to reactor scale. The main processes are described by adequate models but the verification is not complete due to a limited understanding and to limited number of data.

– **Vote level 1:** The phenomenon/aspect is well understood. The processes are adequately modelled and well verified in general on an extended experimental basis. Needs little or no R&D.

– **Vote NF:** None of the suggested votes fits; provide explanation in the comments.

– **Vote NE:** Problem unknown (no expertise)

– **"–"**: no participation

The vote averaging for the Knowledge Ratio (KR) was performed as described above for the Importance Ratio (IR). The classification based on vote averages was established as follows:

– $KR \geq 2.3$: selected as most significant lack of knowledge; put into List 1.

– $2.1 < KR < 2.3$ and bi-modals: To be re-discussed on the basis of the rationales summarised by the chairpersons of the various groups and either not considered or put into List 2 as still lacking knowledge for some aspects.

After completion of the two ranking phases, this procedure clearly emphasized the phenomena being simultaneously highly important for safety and significantly lacking of knowledge. The remaining 106 phenomena are obviously candidates for further R&D work, which will be specified in the PIRT's implications work package. The allocation of these phenomena to the specified domains was the following:

– 24 phenomena for In-vessel,

– 28 phenomena for Ex-vessel,

– 26 phenomena for Dynamic loading,

– 10 phenomena for Long term loading,

– 18 phenomena for Fission products.

Starting with 916 identified phenomena, the list was reduced to 229 important for safety, of which 106 were found with significant lack of knowledge. The list was in turn divided into two categories: phenomena with most significant lack of knowledge (57 phenomena) and those with a significant lack of knowledge for some aspects (49 phenomena).

After that the PIRT implications were deduced taking into account existing and planned European facilities, codes and programmes. The work package included:

– Defining R&D needs in terms of objectives and priorities;

– Identifying the required R&D tasks in terms of experimental programmes and codes;

– Reviewing the European facilities and codes which could be used for these tasks, taking into account the existing and planned programmes.

Table 1: EURSAFE items for needed research and rationale for selection

No	Items for needed Research	Rationale for selection
1,1	Hydrogen generation during reflood or melt relocation into water	Rapid generation of hydrogen which may not be accommodated by re-combiners and the risk of early containment failure. Improve knowledge about the magnitude of hydrogen generation.
1,2	Core coolability during reflood and thermal-hydraulics within particulate debris	Termination of the accident by re-flooding of the core while maintaining RCS integrity. Increase predictability of core cooling during re-flood.
1,3	Corium coolability in lower head and external corium catcher device	Improve predictability of the thermal loading on RPV lower head or corium catcher devices to maintain their integrity.
1,4	Integrity of RPV due to external vessel cooling	Improve data base for critical heat flux and external cooling conditions to evaluate and design AM strategies of external vessel cooling for in-vessel melt retention.
1,5	Integrity of RCS	Improve predictability of heat distribution in the RCS to quantify the risk of RCS failure and possible containment bypass.
1,6	Corium release following vessel failure	Improve predictability of mode and location of RPV failure to characterise the corium release into the containment.
2,1	MCCI: molten pool configuration and concrete ablation	Improve predictability of axial versus radial ablation up to late phase MCCI to determine basemat failure time and loss of containment integrity.
2,2	Ex-Vessel corium coolability, top flooding	Increase the knowledge of cooling mechanisms by top flooding the corium pool to demonstrate termination of accident progression and maintenance of containment integrity.
2,3	Ex-Vessel corium catcher: corium ceramics interaction and properties	Demonstrate the efficiency of specific corium catcher designs by improving the predictability of the corium interaction with corium catcher materials.
2,4	Ex-Vessel corium catcher: coolability and water bottom injection	Demonstrate the efficiency of water bottom injection to cool corium pool and its impact on containment pressurisation.
3,1	Melt relocation into water and particulate formation	Determine characteristics of jet fragmentation, debris bed formation and debris coolability towards maintenance of vessel and respectively containment integrity.
3,2	FCI incl. steam explosion: melt into water, in-vessel and ex-vessel	Increase the knowledge of parameters affecting steam explosion energetics during corium relocation into water and determine the risk of vessel or containment failure.
3,3	FCI incl. steam explosion in stratified situation	Investigate the risk of weakened vessel failure during reflooding of a molten pool in the lower head.
3,4	Containment atmosphere mixing and hydrogen combustion / detonation	Identify the risk of early containment failure due to hydrogen accumulation leading to deflagration / detonation and to identify counter-measures.
3,5	Dynamic and static behaviour of containment, crack formation and leakage at penetrations	Estimate the leakage of fission products to the environment.
4,1	Direct containment heating	Increase the knowledge of parameters affecting the pressure build-up due to DCH and determine the risk of containment failure.
5,1	Oxidising environment impact on source term	Quantify the source term, in particular for Ru, under oxidation conditions / air ingress for HBU and MOX.
5,2	RCS high temperature chemistry impact on source term	Improve predictability of iodine species exiting RCS to provide the best estimate of the source into the containment.
5,3	Aerosol behaviour impact on source term	Quantify the source term for aerosol retention in the secondary side of steam generator and leakage through cracks in the containment wall as well as the source into the containment due to revolatilasation in RCS.
5,4	Containment chemistry impact on source term	Improve the predictability of iodine chemistry in the containment to reduce the uncertainty in iodine source term.
5,5	Core re-flooding impact on source term	Characterise and quantify the FP release during core re-flooding.

As a further step, the research needs to address each selected phenomena of the PIRT list were identified. First, the objectives of research and the description of programmes and codes needed (including existing capabilities) to address each selected phenomena of the PIRT list were reviewed. A list was established assigning to each selected phenomena the relative research needs and programmes. In the column "Objectives of needed research" (See Table I of Ref. [3]), the key is as follows:

- A: perform experimental work to produce the missing information,
- B: perform analytical work to integrate the existing data in best estimate codes,
- C: develop a conservative approach,
- D: perform R&D work for the development of new accident management procedures,
- 1, 2, 3… indicate a chronological order for performing the research.

Next, the phenomena were regrouped into a limited number of research items according to their similarities in terms of research needs/physical processes, with the scope of being able to set up a limited number of coherent R&D programmes. A rationale for these research needs was established based on safety relevance and lack of knowledge. The outcome of this process is summarised in Table 1, which gives the 21 items of needed research and relative rationales drawn from the 106 phenomena selected in the PIRT.

D Summary of results of the work package SARP

The methodology applied in EURSAFE to establish an internationally agreed list of needed research items has been proven as adequate. It started with a comprehensive list of phenomena and finished by using a bottom-up approach with 21 items of needed research areas. Investigations have shown that a well balanced top-down approach gives very similar results. Therefore the EURSAFE methodology will be applied in SARNET to.

By comparing the research performed in SARNET with the needed research areas indicated by EURSAFE, three out of 21 items have been recognized as not being covered at all:

- Integrity of RCS, distribution of decay heat, containment bypass (ERI 1.5.).
- Dynamic and static behaviour of containment, crack formation (ERI 3.5.).
- Characterisation and quantification of fission product release during core reflooding. There are virtually no data available on real irradiated fuel (ERI 5.5.).

And three more items are not appropriately covered:

- Coolability of particulate debris bed in case of reflooding. The validation of existing models remains insufficient do to the lack of multi-D experimental data (ERI 1.2).
- Ex vessel corium coolability. The size of existing experiments does not adequately address scale effects (ERI 2.2 & 2.4).

Up to know three possible new research items have been identified. The assessment of these items is underway. In the following a preliminary evaluation will be given.

The objective of WP15 (Aerosol Behaviour Impact on Source Term AEROB) is to quantify the effect of uncertain key aerosol phenomena on the source term. The main emphasis is placed on aerosol retention in the secondary side of the steam generator during steam generator tube rupture sequences and in cracks of containment walls. Attention is also being paid to the late in-containment source term from re-volatilisation of previously deposited aerosols in the RCS. The re-volatilisation is caused by re-evaporation due to changes in temperature and partial pressure or mechanical re-suspension due to higher velocities. In EURSAFE the maximum value of safety oriented votes for the mechanical re-suspension was 2.20 (= 3x1 + 6x2 + 6x3) and thus below the cut off value of 2.33. Therefore the phenomenon oriented votes have not been elected. On the other hand, the code models to predict mechanical re-suspension are weak and must be improved to adequately determine deposition accompanied by this process and to allow a well balanced estimation of re-volatilisation due to thermal/chemical and mechanical/physical effects. It will be assessed whether mechanical re-suspension will be investigated in SARNET.

Also the re-volatilisation of iodides is located in the responsibility of WP15. One important source could be the volatilisation and decomposition of airborne iodides due to violent heat-up induced by hydrogen burning or by recombiner. This phenomenon was rated with medium priority regarding the safety relevance (Safety oriented vote 2.08 = 4x1 + 3x2 + 5x3) and therefore not further evaluated. On the other hand the voting has two extreme values. One for low safety relevance (4 voices) and one for high safety relevance (5 voices) and is with this “bimodal”. Such cases should be investigated carefully and re-evaluated in case of more detailed information of the consequences of the process or phenomenon. This will be done by a new evaluation in the SARP with special attention of iodine volatilisation due to heat-up induced by hydrogen recombiner.

The objective of WP16 (Containment Chemistry Impact on Source Term CONTCHEM) is to improve the predictability of the iodine chemistry in the containment, to reduce the uncertainty in the iodine source term. In other words the objectives are restricted to Iodine only. The containment chemistry is determined by the source from the reactor cooling system (RCS) with lies in the responsibility of WP14 (Fission Product Release and Transport FPRT), sub-group 1 (OXIDEN). The objectives of WP 14-1 are the quantification of the source term, in particular for Ruthenium, under oxidizing conditions/air ingress for HBU and MOX fuel. This phenomenon was rated with high priority (Safety oriented vote 2.36) und significant lack of knowledge (Phenomenon oriented vote 2.69). It was recognized, that there are some inconsistencies regarding the role of Ruthenium in the RCS and the containment. To clarify this, it should be assessed whether Ruthenium should be considered in the containment chemistry or not.

The discussed three cases should be re-evaluated within the work package SARP. The procedure to be applied for the re-evaluation is described in the following chapter.

D Strategy followed through in the work package SARP

The strategy planned to be applied in the work package SARP is outlined in the following and should be discussed during ERMSAR and the next weeks to develop an agreed procedure. It should be mentioned, that this work requires a strong cooperation between SARP team, technical leaders of the work package, topical coordinators and the Management Team.

One requirement is that all steps of the decision process must be documented to allow a well funded judgment for the SARNET community and for the end users of SARNET products. For this reason a template (see Table 2) has been constructed, which will be described in the following. The structure of the template reflects the strategy of the decision process.

The template is used for the three possible “Decisions”:

1. The issue is closed by sufficiently improved knowledge (To be closed).
2. The work should be reoriented to fulfil the objectives (Reorientation).
3. A new research item should be set up (New Item).

The corresponding indication is the first entry in the head line. The head line is repeated on the top of a new page. It includes with the “Topical Research Area”, the “Work Package Number” as well as the corresponding “EURSAFE Research Item” and “EURSAFE Reference Number” the main indicators. The following line is a “Short description of the action” given by the technical leader who requested the decision.

After this descriptive part, the template includes 10 “Actions” named “A” to “J” with a clear indication of responsibility and the time of execution “Date”.

The first action “A” is to reflect the situation described by EURSAFE. It is filled in by the technical leaders of the work package and the SARP. It comprises

- the description of the corresponding “Items for needed Research”, “Rationale for selection” and the “Description of phenomena”
- the Safety oriented Votes (SoV) regarding the Primary Circuit (PC), Containment (Cont) and Source Term (ST) as well as the Phenomenon oriented Vote (PoV) and the selection of priority list (1 = highest, 2 = second, 0 = not selected)
- the “Objectives of needed research” and “Description of experimental program and code development”.

The second action “B” is a comprehensive description of the “Rationale for the decision to be taken, written by the technical leader of the work package”. If the decision process is launched by the SARP, its technical leader takes this action.

The following step “C” is the “Evaluation of rationale by the topical coordinator”. With this the rationale written by the technical leader is revised and the state of knowledge, the corresponding test facilities and computer programmes, modules or models are described and listed.

After this the SARP team has to asses in step “D” the rationale and justifications of the leaders of the work package. Furthermore it has, in accordance to the methodology developed in EURSAFE, to vote regarding the safety relevance and risk potential (SoV \ PC, Cont, ST) as well as to estimate the state of knowledge (PoV).

Table 2: Template for decision process

Ac-tion	Decision New Item	Topical Research Area Source Term	Work Package Number WP16	EURSAFE Research Item ERI 5,1 & 5,4	EURSAFE Ref. Number ERN 5,1,026 & 5,5,000	YY/MM/DD Date
	Short description of the action: Investigate the volatility and behaviour of Ruthenium in the containment.					05/06/23
A	Items for needed Research ERI 5,1 Oxidising environment impact on source term.		Rationale for selection ERI 5,1 Quantify the source term, in particular for Ru, under oxidation conditions / air ingress for HBU and MOX.			05/10/23
	Items for needed Research ERI 5,4 Containment chemistry impact on source term.		Rationale for selection ERI 5,4 Improve the predictability of iodine chemistry in the containment to reduce the uncertainty in iodine source term.			
	Description of phenomena: Fission Products \ Invessel Release \ Release mechanisms for FPs and actinides from solid fuel \ ERN 5,1,026: Important increase of the volatility of certain elements due to a high state of oxidation, e.g. in the situation of air ingress in the core. Containment filtered pressure relief is a likely measure to achieve severe accident final safe state. The issue is important for assessing containment by-pass scenarios. Knowledge base during refuelling outages, when the reactor vessel is open, should be increased. Chemistry in the containment is an important issue for long-term accident management.					
	SoV \ PC: 1.67 2x1 + 0x2 + 1x3	SoV \ Cont: 1.00 3x1 + 0x2 + 0x3	SoV \ ST: 2.36 3x1 + 3x2 + 8x3	PoV: 2.69 1x1 + 2x2 + 10x3	Selected List: 1	
	Objectives of needed research: B1: Review of existing data		Description of Experimental Program / Codes:			
	B2: analysis of reactor scenarios to define the test conditions		ATHLET-CD, ASTEC			
	A3: Small scale exp. to examine the speciation and aerosol behaviour of Ru under different oxidising environments, temperatures etc. with simulants and real FPs and other materials		Transport (thermal gradient tube etc.) and speciation (mass spectrometry, UV/vis spectroscopy etc.) experiments would be conducted under a range of conditions relevant to severe reactor accidents with involve identification of the dominant vapour-phase and condensed-phase (aerosol) species of ruthenium and simulant FPs. RUSET, (AEKI): separate effect tests on the oxidation and release of Ru and other simulant FPs (1 rod segment) VERDON, MADRAGUE, real FP materials CODEX-RU bundle (7-9 rods) tests with fission product simulant materials.			
	B4: modelling improvement for FP release induced by fuel oxidation		ICARE/ELSA, DIVA/ELSA (ASTEC)			
	B5: modelling effort for Ru transport including necessary kinetic effects		SOPHAEROS (ASTEC)			
	A6: integral exp. to complement existing data from separate effect tests - coupling between fuel degradation and FP release		PHEBUS 2K planned mid 2007			
	Description of phenomena: Fission Products \ Iodine Chemistry \ ERN 5,5,000: There is no specific element besides Iodine included in this chapter.					
B	Rationale for the decision to be taken, written by technical leader of the work package: (to be completed)					

Ac-tion	Decision New Item	Topical Research Area Source Term	Work Package Number WP16	EURSAFE Research Item ERI 5,1 & 5,4	EURSAFE Ref. Number ERN 5,1,026 & 5,5,000	YY/MM/DD Date
C	Evaluation of rationale by the topical coordinator (State of knowledge, test facility, model development): (to be completed)					
D	Assessment of rationale by the SARP team (Safety and risk significance, review evaluation by TC): (to be completed)					
	SoV \ PC: 0.00 0x1 + 0x2 + 0x3	SoV \ Cont: 0.00 0x1 + 0x2 + 0x3	SoV \ ST: 0.00 0x1 + 0x2 + 0x3	PoV: 0.00 0x1 + 0x2 + 0x3	Selected List: 0	
E	Review of SARP evaluation by MT: (to be completed)					
F	Statement of decision to be published on the ACT and to be given to end users for comment: (to be completed)					
G	Comments from the SARNET community and end user: (to be completed)					
H	Summary of comments from the end user compiled by SARP team: (to be completed)					
I	Revised statement of decision to be published on the ACT: (to be completed)					
J	Objectives of needed research for the new item: (to be completed)		Description of Experimental Program / Codes: (to be completed)			

In the next step “E” the management team (MT) reviews the evaluation of the SARP and informs all previous actors about its assessment to allow them to clarify or to improve the arguments documented in the template.

After this, in step “F” the preliminary decision is published in the ACT and distributed to the end users by the MT with reference to the template and a clear dead line for comments (usually 4 weeks, in vacation time 8 weeks).

Under step “G” all comments of the SARNET community and the end users are collected.

After crossing the dead line for comments, the SARP team compiles in step “H” the comments collected in the previous step and briefly summarize them.

In cooperation of SARP and MT the summary of the comments (step “H”) is used to assess the decision published in step “F”. In step “I” the revised (or original) decision is published as final decision in the ACT.

In case of new or new oriented research item, the “Objectives of needed research for the new item” and the “Description of experimental program or code development” are documented in step “J” by applying the same methodology as utilised in EURSAFE. In case of the decision to close the issue, this article is not applicable.

This strategy is an attempt to come in a reasonable time under consideration of all useful co-determination to an agreed decision considering all aspects of innovation and economic efficiency. The next weeks should allow an assessment of this procedure.

References

[1] FISA 2003: EU research in reactor safety, Luxembourg, 10-13 Nov. 2003, EUR 21026.

[2] Phenomena Identification and Ranking Tables (PIRT's) for Loss-of-Coolant Accidents in Pressurized and Boiling Water Reactors Containing High Burnup Fuel, NUREG/CR-6744, LA-UR-00-5079.

[3] Final synthesis report of EURSAFE or
D. Magallon et al, European expert network for the reduction of uncertainties in severe accident safety issues (EURSAFE), NED 235 (2005) 309-346