REDUCTION OF RADIOLOGICAL ACCIDENT CONSEQUENCES

Title	**Recommendations for methodologies harmonization**
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Affiliation:	Bel V
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Acronyms

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BWR : Boiling Water Reactor

CVCS : Chemical and Volumetric Control System

DBA : Design Basis Accident

FW : Feedwater

LOCA : Loss of Coolant Accident

NPP : Nuclear Power Plant

PWR : Pressurized Water Reactor

SAR : Safety Analysis Report

SGTR : Steam Generator Tube Rupture

Introduction

REDUCTION OF RADIOLOGICAL CONSEQUENCES OF DESIGN BASIS & DESIGN EXTENSION ACCIDENTS

Initial ambitions of the R2CA project :

GA part B §1.4 :

To provide knowledge and numerical tools that will allow a less conservative evaluation of the safety margins and provide recommendations for a reduction of radiological consequences of DBA and DEC-A situations.

Some former projects of the EC dedicated to similar subject → …

1992 EC project related to LOCA

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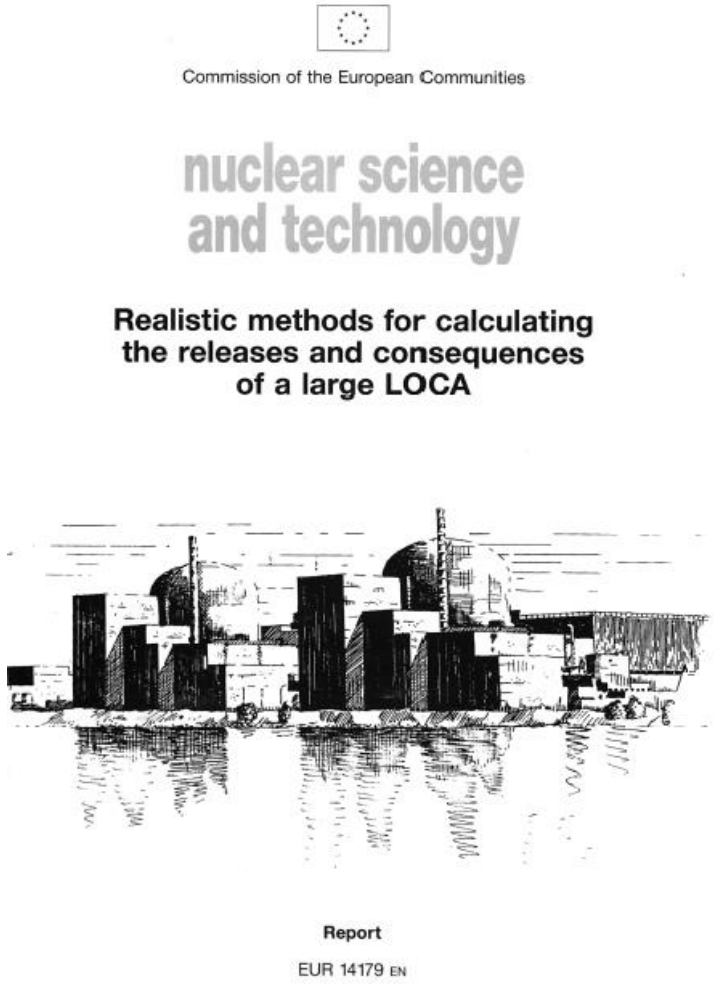

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2001 EC project related to LOCA

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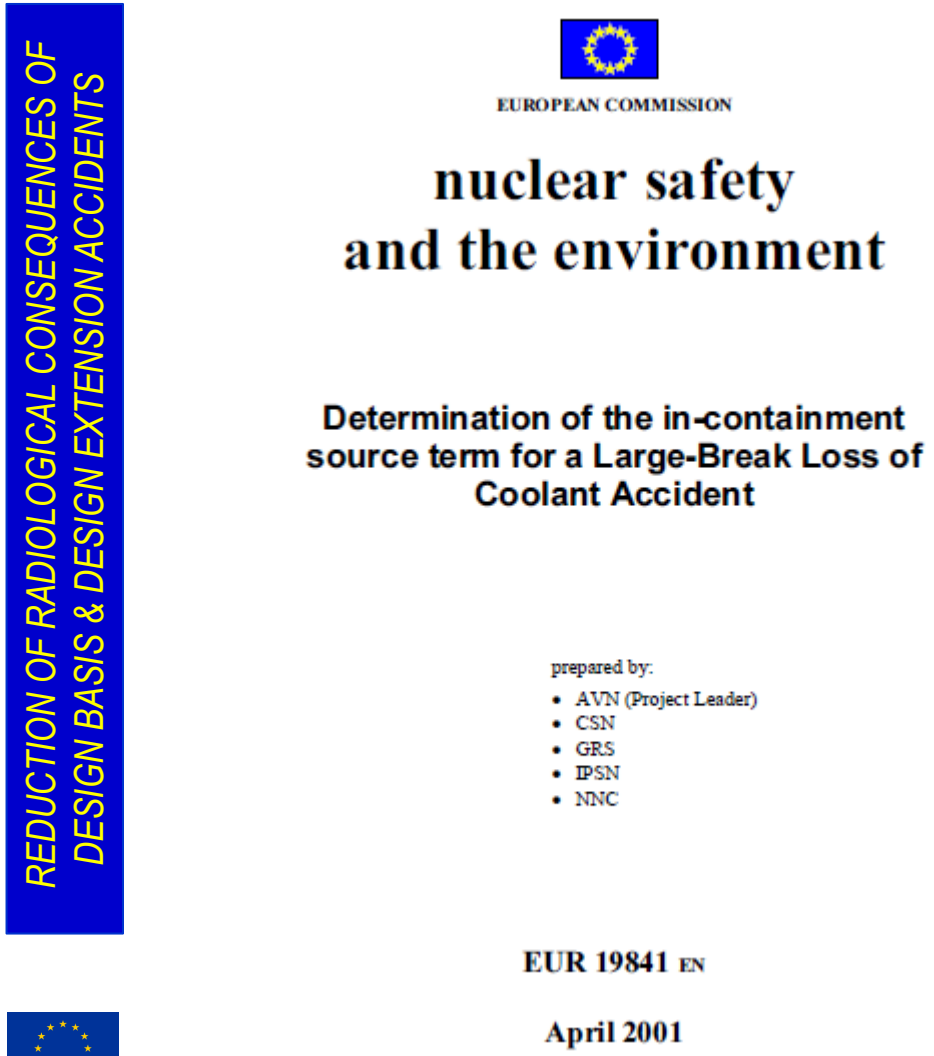

EUROPEAN COMMISSION

nuclear safety
and the environment

Determination of the in-containment source term for a Large-Break Loss of Coolant Accident

prepared by:

- AVN (Project Leader)
- CSN
- GRS
- IPSN
- NNC

EUR 19841 EN

April 2001

https://inis.iaea.org/search/search.aspx?orig_q=RN:36090315

1997 EC project related to SGTR

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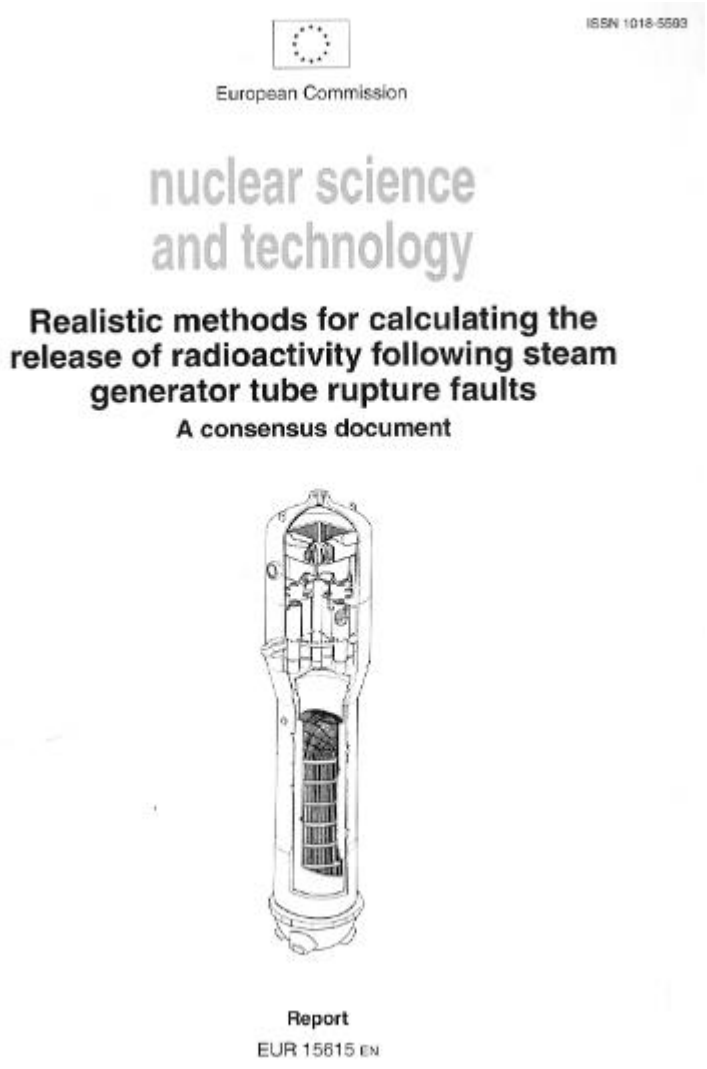

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Former projects compared to R2CA

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Former projects :

- Limited number of participants in former project (17 in R2CA)
- Limited number of used calculation codes like RELAP or CATHARE (early versions), other codes not yet existing or not same level of development, other simplified codes that are not existing/used anymore
- Rough source term for SGTR : spiking with simplified expression
- Notion of DEC-A was not existing
- Up to the dose calculation for the LOCA report

R2CA compared to RG1.195 : Belgian example

Each country/company has its own experience/history.

Belgium = 7 NPP's either at their end of life or recently definitely stopped (2)

RG1.195 gives conservative source terms for LOCA and SGTR. Decoupled approach → opposite aim compared to R2CA….

Belgian SAR's of NPP's are today composed of :

- One single SGTR support study : TH and RC calculations in the same study (→ "in the spirit" of R2CA project, not in the RG1.195 spirit). Such studies were matter of intense debates during decades in Belgium
- 2 LOCA's (decoupled) : one TH calculation §15 verifying LOCA fuel criteria and another LOCA study for RC calculations respecting RG1.195 (→ "not in the spirit" of R2CA project)

Timeline of main deliverables up to final recommendations

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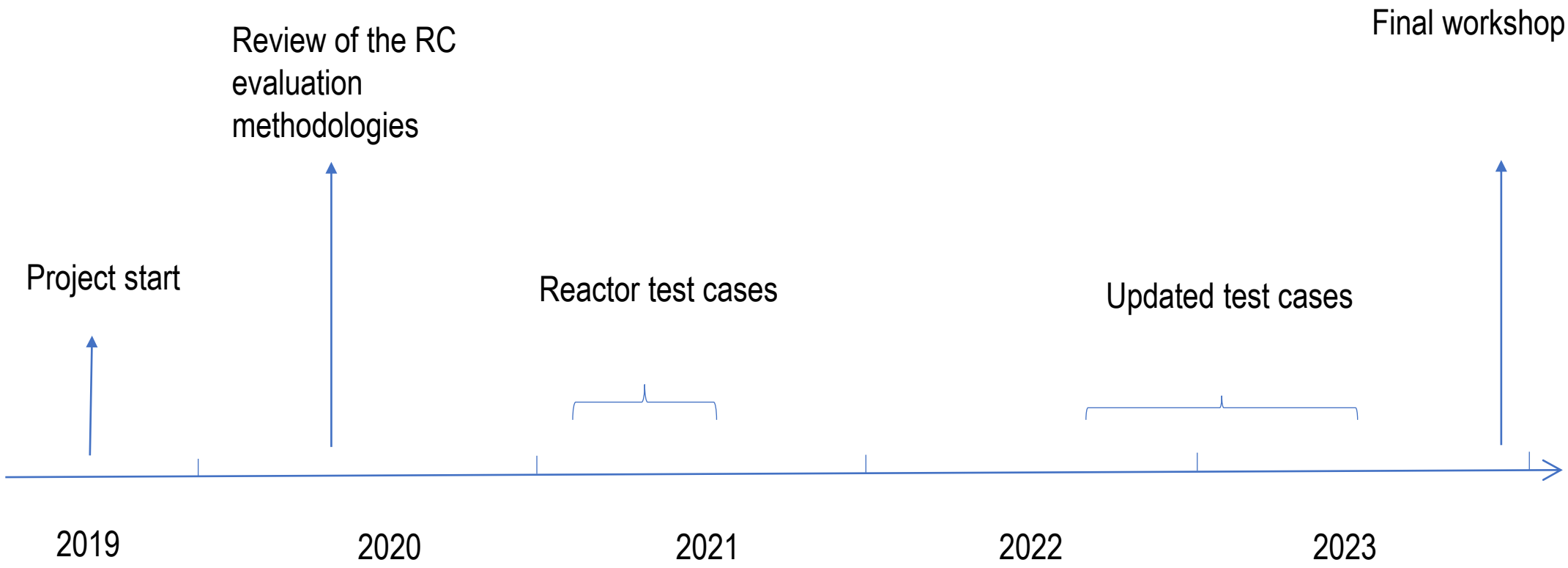

Parameters selected in R2CA exercise

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Difficulty : wide range of parameters were selected for the present project :

- 2 accidents studied : LOCA and SGTR
- 2 “categories” of accidents (→ various initiators and adopted initial and boundary conditions) : DBC and DEC-A
- Several designs : PWR (EPR in particular), VVER, BWR

Boundaries of recommendations given by R2CA (1)

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The following points clearly affect the calculations of RC's but are considered to be not discussed/judged/treated by the R2CA project, and therefore not included as recommendations (ref to GA §1.3) :

1. Releases (in Bq) are used as final result of the calculations, not the dose → site specificities, atmospheric dilution factors, Bq → Sv effect
2. Mandatory rules (inside the regulation or not) are attached to accident calculations (like SGTR and LOCA) in support of the licensing of NPP's. Such rules can be strongly country dependent (as example : single failure definition). This concerns DBA's and not DEC-A scenarios
3. Hardware characteristics. Past and future hardware improvements regarding design of new NPP's, existing NPP's, and fuel fabrication. This includes EOP's.

Boundaries of recommendations given by R2CA (2)

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Other considerations :

- Expressed recommendations ≠ exhaustive list of all factors influencing the calculations.
- Recommendations voluntary enhance the importance of some points compared to others → arbitrary judgement.

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Fuel release model of LOCA

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Recommendations :

- Better characterization of the gap inventory/source term
- Coupling between TH and thermo-mechanic, using 3D core model, appear crucial to predict damaged fuel rods during LOCA (asymmetric transient) → Results are sensitive to refined core model (ex : DRACCAR)
- Expressing specific rod initial conditions (burnup, internal pressure, power) provides less conservative results (compared to uniformed initial state)
- New criteria of “cladding burst Temperature and strain” were developed and used with success by different partners in updated calculations. Cliff-edge ! → recommend to apply such advanced criteria to obtain more realistic results

Fuel release model of SGTR

Fuel release is independent of the TH transient for the SGTR.

Release of FP's present in the gap occur through cracks (pre-existing defaults) and spiking phenomenon.

Recommendations :

- (illustrated by several partners) Using best-fitted spiking correlations based on experience is clearly valuable for the RC calculations of SGTR. Some of them were developed during the project (ex : RING)
- Spiking can be directly modelled by a code (ex : ASTEC) → improving models of spiking remains a valuable future subject of development
- Dilution and filtration in the primary system are identified as improvements

Recom. for transfer from primary to SG (for SGTR) (1)

Remark : VVER and PWR presents some similarities but also significant difference regarding SGTR event (ex : nature and size of breaks)

Recommendations :

- Initial and boundary conditions + their uncertainties are fundamental because of the existing threshold “flooded break” versus “uncovered break”. Recommended to investigate these and provide beneficial change when possible
- Flashing of iodine at the break depends on the chemical species having own volatility → speciation of iodine is necessary to evaluate this (Ex : with Sophaeros/ASTEC). This contribution appears specific to the scenario.

Recom. for transfer from primary to SG (for SGTR) (2)

- Part of the break transformed into aerosols (also named “Carry-over/ atomization”, attention to vocabulary) is usually not modelled → constant value fixed by partners and has large impact on the result. Retention of aerosols inside SG and steam line is subject to high uncertainties. It is recommended to chose reasonably conservative values based on results from test facilities (ref. ARTIST or recent KAERI experiments). Some codes are able to model this (ex : DROPLET)
- Regarding evolution of activities in the secondary system, valuable to have separated models of liquid phase and gas phase in the affected SG (ex : SAFARI)

For transfer to atmosphere, TH model of SG relief valve (safety valve) and associated correlations was identified as attention point.

Recom. for transfer from containment to env. (for LOCA)

Containment barrier is crucial for LOCA, here are the R2CA recommendations :

- Distinguishing “groups” of FP with similar behaviors : noble gases, aerosols, iodine (with individual volatility for each species). Speciation of iodine in containment is complex, and time dependent, impossible to simulate without dedicated calculation code
- Considering retention of FP on the surfaces, significantly different values are observed between partners + evolution notified in updates calculations (ex : painted surface for VVER) → useful to refine estimation of this contributor

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Conclusions

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- R2CA calculations = huge database of results that still remains to consider after the R2CA project
- Several orders of magnitude of differences in term of RC's in these results → R2CA = kind of measurement of the distance between a refined best-estimate calculation and a rough conservative calculation
- Long way remains to converge to harmonization of methodologies. Depends also on the purpose : NPP licensing ? R&D ?
- R2CA recommendations are leading to further useful subjects of development

Thank you!

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