Joint ICTP-IAEA Essential Knowledge Workshop on Deterministic Safety Assessment and Engineering Aspects Important to Safety

Safety Documentation and Format and Content of SAR

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Content

- Plant documentation
  - Basic features and rules
  - Operator side
  - Regulator side

- SAR
  - Purpose
  - Format and content (IAEA SS GS-G-4.1)
  - Regulatory review

- IAEA GRSR service
The process of regulating a nuclear facility entails the preparation of a large amount of documentation, both by the operator of the facility and by the regulatory body.

- **Operator**
  - Demonstration of nuclear facility safety
  - Description of the actual status of the facility
  - Records of facility history

- **Regulator**
  - List of the required documentation to be prepared
  - Structure and content
  - Review and verification
The operating organization, in accordance with the regulatory requirements, shall submit or make available to the regulatory body all necessary documents and information.

The operating organization shall provide the regulatory body with all necessary assistance to enable it to perform its duties, including enabling unhindered access to the plant and providing documentation.
The operating organization shall establish and implement a system for plant configuration management to ensure consistency between design requirements, physical configuration and plant documentation.

- Changes to the plant and its safety related systems are properly identified, screened, designed, evaluated, implemented and recorded.
- Documentation shall be issued under controlled conditions, and shall be subject to approval and periodically reviewed and revised as necessary to ensure its adequacy.
Documents to be produced by regulator

- Regulations – common safety requirements
- Licence conditions – specific safety requirements
- Industrial standards – supplement requirements issued/developed by other organizations
- Guides – non-mandatory documents with specific details how to comply with regulations
- Internal documents – instructions and guidance on authorization/review processes (consistency)
- Review reports and other technical documents
Documents to be produced by operator

- Documents required to be submitted to the regulatory body for formal approval at the various stages of the authorization process
- Reports which should be submitted to the regulatory body periodically or, for events, incidents or accidents (rules specified in the regulations)
- Documents which should be prepared for the conduct of activities relating to the facility and which should be made available to the regulatory body upon request
Documents to be submitted for authorization

- Operator should provide all relevant information describing the approach to safety in order to demonstrate that the facility will not present undue radiological risks to workers, the public and the environment.

- The aim should be to present the relevant information in such a way that the regulatory body can conduct the review and assessment process without needing to seek further information or clarification.
Basic information for the authorization process

- Description of the site in terms of geography, demography, topography, meteorology, hydrology, geology and seismology
- Description of the facility, including the layout of buildings and equipment
- Applicable safety regulations, guides and industrial standards;
- Safety concepts and criteria used in the design of the facility
  - Classification of equipment, systems and components
  - Application of the defence in depth principle, the use of multiple barriers to prevent radioactive releases
  - Approach to issues relating to the human–machine interface;
- Description of the facility’s systems and components, including their design criteria, the processes involved in their design, and the modes of operation and testing
- Demonstration of safety
Documentation at plant stages

- Various types and/or updates of documentation needed during different plant stages, such as:
  - Siting
  - Construction
  - Commissioning/Operation
  - Decommissioning
  - Closure/removal

- Only part of this documentation has to be submitted and reviewed/approved by the regulator
Documentation through plant stages - example

- Permission for sitting of nuclear facility
  - Safety report of reference
  - Report of reference on the decommissioning method
  - Project intention for physical and technical solution of nuclear installation – design development project level
  - Report of reference on the method of management of radioactive wastes and spent nuclear fuel
  - Requirements on the quality of the nuclear installation
  - Proposed boundaries of the nuclear installation
  - Proposed size of the emergency planning zone
  - Environmental impact assessment of the nuclear installation
Documentation through plant stages - example

- Permission for construction of nuclear facility
  - Preliminary safety analysis report
  - Project documentation needed for building permission proceedings
  - Preliminary plan of management of radioactive waste and spent fuel
  - Preliminary decommissioning plan concept
  - Classification of classified equipment into the safety classes
  - Preliminary plan of physical protection
  - Quality system documentation
  - Preliminary on-site emergency plan
  - Preliminary limits and conditions of safe operation
  - Pre-operation preliminary inspection programme of nuclear installation
  - Preliminary outline of the boundaries of the nuclear installation
  - Preliminary definition of the size of the emergency planning
Documentation through plant stages - example

- Permission for commissioning/operation of nuclear facility
  - Limits and conditions of safe operation
  - List of classified equipment as classified into safety classes
  - Testing programmes of classified equipment
  - Nuclear installation commissioning programme
  - Operational control programme of classified equipment
  - Quality system documentation
  - On-site emergency plan
  - Pre-operation safety report
  - Physical protection plan
  - Radioactive waste and spent fuel management plan
  - Plan concept of decommissioning of the nuclear installation
  - Document providing evidence for financial coverage of liability for nuclear damage
  - Training programmes
  - Documents providing evidence for the preparedness of nuclear installation to be commissioned
  - Off-site emergency plan for regions within the emergency planning zone
  - Definition of boundaries of nuclear installation
  - Definition of the size of the emergency planning zone of nuclear installation
Documentation through plant stages - example

- Permission for decommissioning of nuclear facility
  - Limits and conditions of safe decommissioning
  - Documentation of quality system and requirements on the quality of nuclear installation
  - On-site emergency plan
  - Decommissioning stage plan
  - Decommissioning concept
  - Physical protection plan
  - Radioactive waste management and shipment plan
  - Document providing evidence for financial coverage of liability for nuclear damage
  - Test programme of classified equipment
  - Operating regulations
  - Training programmes
  - Off-site emergency plan for regions within the emergency planning zone
  - Modifications of boundaries of nuclear installation
  - Modifications of the size of the emergency planning zone of nuclear installation
  - Classification of classified equipment into safety classes
Reporting by the operator

- Periodic and progress reporting
  - Typically specified in regulations or licence conditions
  - Keeps regulator informed about the status of the facility and the progress of the project
- Notification and reporting of events, incidents and accidents
- Reporting of changes and modifications
Review by the regulator

- Report on decision of the authorization process containing covering the following issues:
  - Reference to the documentation submitted by the operator
  - The basis for the evaluation
  - The evaluations performed
  - Conformance with regulatory requirements and guides
  - Comparison with similar (reference) facilities
  - Independent analysis and inspections performed by the staff of the regulatory body or by consultants on its behalf
  - Conclusions with respect to nuclear safety
  - Reasons for the decisions made
  - Any additional conditions to be fulfilled by the operator
SAR - purpose and role

- Reference material demonstrating the safety of the plant
- Important part of the licensing basis
- It is essential that both the regulator and the licensee should consider the SAR as the basic reference material of the plant
- The SAR should present sufficient information for the purposes of nuclear and radiation safety assessment
- Information should be accurate and up-to-date
- The SAR may refer to more detailed supplementary information
Formats of SAR

IAEA
SAFETY STANDARDS SERIES

Format and Content of the Safety Analysis Report for Nuclear Power Plants

SAFETY GUIDE
No. GS-G-4.1

IAEA International Atomic Energy Agency

STANDARD FORMAT AND CONTENT OF SAFETY ANALYSIS REPORTS FOR NUCLEAR POWER PLANTS
LWR EDITION

NOVEMBER 1978

OFFICE OF STANDARDS DEVELOPMENT
U. S. NUCLEAR REGULATORY COMMISSION
Formats of SAR

  - The most widely accepted and applied format and most detailed description of the contents (cca. 400 pages)

  - This guide represents the minimum requirements about the SAR, as accepted by all IAEA member states (79 pages).

- **The NRC guide is more detailed and more demanding, while the IAEA guide is more up-to-date**
  - Note: most countries’ legislation require some up-dated variation of the RG-1.70 requirements
Statement of the main purpose of the SAR

Identification of the designer, vendor, constructor and operating organization of the NPP

The main information on the preparation of the SAR

It also describes the structure of the report with the objectives and scopes of the sections
General description of the plant, including a consideration of current safety concepts and a general comparison with appropriate international practices

Applicable (applied) standards and regulations along with deviations with proper justification

Basic technical characteristics

Plant layout

Operating modes
GS-G-4.1: Chapter 3 – Management of safety

- Operating organization’s management structure and the procedures and processes
- All safety specific aspects of the management
- Operating organization’s strategy to encourage the development, maintenance and enhancement of a strong safety culture
- QA system
- Safety performance – monitoring and review
Information on the geological, seismological, volcanic, hydrological and meteorological characteristics of the site

From safety standpoint, the focus is on the “external hazards”:
  - Natural hazards (earthquake, flooding, extreme weather, etc.)
  - Man-made hazards (traffic – roads, air, waterways; nearby industry; security related issues)

Clear definition for the design basis for the external hazards

The re-occurrence probability of natural events plays a key role

One further aspect: the population distribution in the area with special attention to sensitive establishments, e. g.: schools, hospitals etc.
GS-G-4.1: Chapter 5 – General design aspects

- Approach adopted to meet the fundamental safety objectives
  - Defense in depth (DiD)
  - Fundamental safety functions
  - Establishing the deterministic design criteria
  - Single failure criterion
  - Probabilistic design criteria
  - Radiation protection (ALARA and limitation)

- Safety classification of SSCs – principles

- Civil engineering works and structures – including containment

- Equipment qualification

- Human factors engineering
  - All operational states, all plant locations
GS-G-4.1: Chapter 6 – Description and conformance to the design of plant systems

- Systematic and detailed specification and description of all safety relevant plant systems
  - System requirements and description
  - Engineering evaluation – reference to applicable standards, regulatory requirements, assessment of single failure and common cause failure sensitivity, reliability, environmental qualification etc.
  - Safety assessment: summary of statements and relevant information about the sufficient capacities, fault tolerances, separation etc. of SSCs.

- For complex SSCs (e.g., reactor) the description should be subdivided
GS-G-4.1: Chapter 6 – Description and conformance to the design of plant systems

- List of obligatory SSCs:
  - Reactor – including the fuel
  - Primary circuit and related systems
  - Engineered safety features (for handling DBAs)
  - Instrumentation and control (I&C) – reactor trip system
  - Electrical systems
  - Auxiliary systems
  - Power conversion systems; Fire protection; Fuel handling and storage; Radioactive waste treatment and storing; other …
Description of the results of the safety analyses performed to assess the safety of a plant in response to PIEs.

Analyses shall include the normal operation, the anticipated operational occurrences, the design basis accidents (the Design Basis).

The analyses may include the level I and level II PSA studies, beyond design basis events, accidents, some selected severe accidents.
GS-G-4.1: Chapter 8 – Commissioning

- Goal: proving that the plant is ready to enter operational phase, i.e. the safety performance of each SSC is corresponding to the design requirements

- In addition to the commissioning program and the detailed results of the tests, the chapter should include evidences about the applicability of the procedures and also about the proper qualification of the operating personnel

*This chapter should be different in preliminary, intermediate, final phases of the SAR*
The key sub-chapters are:

- Organization – administrative procedures
- Operating procedures (incl. EOPs and SAMG)
- Maintenance, surveillance, inspection and testing procedures
- Core management and fuel handling (incl. spent fuel)
- Outage arrangements
- Ageing management
- Modifications control
- Qualification and training of personnel – Human factors
- Operational experience feedback program
- Documents and records
The OLC specifies the “boundaries” of “normal operation” - basis on which the operating organization is authorized to operate the plant.

- Controls, limits, conditions, rules and required actions including numerical values of limiting parameters and operability conditions of systems and components.

It is a result of a special iteration: it comes from the results of the safety analyses, and also the initial and boundary conditions for the analyses are specified here.
Policy, strategy, methods and provisions for radiation protection

Shall cover the normal operational arrangements and equipment for radiation protection (program, organization, equipment, procedures etc.)

Expected occupational radiation exposures during normal operation and anticipated operational occurrences, including measures to avoid and restrict exposure

- Radiation sources
- Radiation monitoring
Emergency preparedness arrangements should cover the full range of accidents (in particular beyond design basis accidents and severe accidents) that would have effects on the environment and the off-site areas where preparations for the implementation of protective measures are warranted.

The description should include information on the objectives and strategies, organization and management, and should provide sufficient information to show how the practical goals of the emergency plan will be met.

- Emergency management
- Emergency response facilities
Description of the measures that will be taken to control discharges to the environment of solid, liquid and gaseous radioactive effluents

Authorized limits

Monitoring

Methods to make, store and retain records of radioactive releases
Arrangements for collecting, handling, storing, conditioning and disposing rad-waste

Description of the main sources of solid, liquid and gaseous waste and estimates of their generation rate

Control of waste

Handling of radioactive waste

Minimizing the accumulation of waste
Proposals anticipated for the eventual decommissioning of the plant

Decommissioning concept

Should be periodically updated to allow for an increasing level of detail and to reflect developments in the strategy for decommissioning
Regulatory review of SAR

- Compliance with national regulations (formal and content)
- Completeness
- Internal consistency
- Compliance with the required depth and details
- Correctness of acceptance criteria for the safety analyses
- Correctness of safety analyses (methodology, assumptions, approximations, enveloping etc.)
Regulatory review

The focus depends on the given SAR phase: preliminary, intermediate, final SAR:

- In the preliminary phase the focus should be on the siting and on the design concepts (design basis envelope).
- In the intermediate phase (typically related to the commissioning period) the focal point of the review should be around the ”as built plant” (its correspondence to the original design) and the commissioning studies.
- In the final phase the highest emphasis should be on the safety analyses.
- The up-dated FSAR should be reviewed at the modified points (typically in periods, e. g. yearly).
Regulatory review

- A proper project plan should be elaborated, describing the project goals, structures, responsibilities, as well as the methodologies.
- The timing of the project phases should also be settled.
- A typical amount of minimum resources can be characterized as the involvement of ~30 experts for a several months to one year period (experienced regulator).
- External experts may be necessary to be involved.
- Important milestones should be defined. It is typical that at some points there are requests for additional information.
- Consultations with the licensee can be scheduled.
### Regulatory review – structure of findings (example)

**Review group:**

**Reviewer:**

<table>
<thead>
<tr>
<th>No.</th>
<th>Place</th>
<th>Finding</th>
<th>Sev.</th>
<th>Comment</th>
<th>Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Chap./page</td>
<td>Detailed description of the found inconsistency or other anomaly</td>
<td>A (code)</td>
<td>Justification (may be filled by the group leader)</td>
<td>Filled in a later phase</td>
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<tr>
<td>2.</td>
<td>…</td>
<td>…</td>
<td></td>
<td></td>
<td></td>
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</table>

**General comments of the reviewer:**
Regulatory use of SAR

- Reference in any case of a safety issue
- Educational material for the inspectors and any other technical people at the Regulator
- Initial source to find more detailed technical documents in relation to some issue
  - Event investigation
  - Modification review, approval
  - Safety evaluation of plant performance
  - Inspection planning etc.
AP1000 SAR Example

- SAR
  
  http://pbadupws.nrc.gov/docs/ML1117/ML11171A500.html

- US NRC regulatory review
  
  http://pbadupws.nrc.gov/docs/ML1120/ML112061231.pdf
IAEA GRSR Service

- Review service of IAEA (NSNI-SAS)
- Performed at the request of a Member State organization
- Objective is to evaluate the completeness and comprehensiveness of a reactor's safety documentation by an international team of senior experts
- Review based on
  - IAEA Fundamental Safety Principles (SF-1)
  - Safety Requirements for Safety Assessment for Facilities and Activities (GS-R Part 4)
  - Safety of Nuclear Power Plants: Design (SSR-2/1)
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IAEA GRSR Service

- Aim of the service is
  - To determine whether the safety requirements are being addressed in the design safety case and identify any that have been omitted
  - For those requirements that are addressed, form a view on whether they are being addressed in a way that is consistent with the spirit of the IAEA requirements
  - For the safety requirements that are not being addressed or are partially addressed, form a view on their relative significance and highlight their importance to safety

- Does not replace national regulatory review nor constitute the design certification
## IAEA GRSR Service

<table>
<thead>
<tr>
<th>Reactor type/Requesting organization/Country</th>
<th>Status</th>
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<tbody>
<tr>
<td>ACR1000 (CANDU)/NII-HSC/UK1</td>
<td>Completed March 2008</td>
</tr>
<tr>
<td>AP1000 (Westinghouse)/NII-HSC/UK1</td>
<td>Completed March 2008</td>
</tr>
<tr>
<td>ESBWR (GE/Toshiba)/NII-HSC/UK1</td>
<td>Completed March 2008</td>
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<tr>
<td>EPR (AREVA)/NII-HSC/UK1</td>
<td>Completed March 2008</td>
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<tr>
<td>ATMEA1 (Conceptual)/AREVA-MHI/France2</td>
<td>Completed June 2008</td>
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<tr>
<td>AP1000/Westinghouse/USA</td>
<td>Completed January 2009</td>
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<td>APR1400/KHNP/Korea</td>
<td>Completed August 2009</td>
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<td>APR1000/KEPCO Research Institute/Korea</td>
<td>Completed August 2010</td>
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<td>AES 2006/Rosenergoatom Concern OJSC/Russia3</td>
<td>Completed January 2013</td>
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<td>ACPR 1000+ (Conceptual Design)/China Guangdong Nuclear Power Holding Co., LTD/China</td>
<td>Completed May 2013</td>
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<td>VVER-T01/Rosenergoatom Concern OJSC/Russia</td>
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<td>ACP1000/China National Nuclear Corporation/China</td>
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<td>ACP100/China National Nuclear Corporation/China</td>
<td>Started July 2015</td>
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<tr>
<td>CAP1400/Shanghai Nuclear Engineering Research and Design Institute/China</td>
<td>Started July 2015</td>
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</tbody>
</table>
### GRSR Project for Review of GSR Part 4 Requirement: Requirement 2

The results and findings of the safety assessment shall be presented in a form of a safety report, reflecting the complexity of the facility associated with it. The purpose of the safety report is to demonstrate that the safety principles and the requirements established here and national laws and regulations are satisfied.

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4.63. The quantitative and qualitative outcomes of the safety assessment shall be supplemented by supporting evidence to enhance the reliability of the safety assessment and its assumptions, including the accuracy of the input data and the adequacy of the adopted system components as appropriate.

#### Integrated or supplementary paragraphs from SSR:

<table>
<thead>
<tr>
<th>n/a</th>
<th>Review</th>
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</table>
| **Review Result: Addressed** | Structure of the report follows US NRC RG 1.70 on “For Protection” and is commonly used and accepted worldwide as well as by the International Atomic Energy Agency (IAEA). It simplifies search for relevant information and facilitates the evaluation of the results.

Compliance with applicable law and regulation is summarized in the report. Relevant Chinese regulatory requirements (laws, codes, and regulations) as well as other national and international codes, standards, and guidelines are taken into account in the report. The radiation protection guidelines, radwaste management, air and water quality, design compliance with domestic and international standards, and other related matters are addressed.

Results of the probabilistic and deterministic safety assessments are presented in the report. The methodology used is not clearly described. Quantitative results and findings of individual PIs or acceptance criteria are given without unambiguous comparison to acceptance criterion values. It would also facilitate the review of the safety assessment report by providing relevant information (e.g., in the form of the table) where all calculated and estimated values and relevant acceptance criteria would be provided to simplify the review process.

Robustness and reliability of the safety assessment is not discussed. Methodology (apart of LOCA events where ASSTR methodology is applied and described in PSAR) and initiating events (PIE) are not provided. Therefore, the reliability of the safety assessment cannot be assessed. Additional details on the safety assessment methodology and initiating events would facilitate an enhanced understanding of the results and findings presented in the safety report.