Status of the international review on SFR SDC Phase I report and SDG development in Phase II

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Introduction

- ***Safety Design Criteria (SDC) development for Generation-IV systems was proposed at GIF Policy Group meeting in October 2010***
  - ***SFR system was selected as the initial application since it represents one of the more mature next generation nuclear energy concepts***
    - » ***Several prototypes being pursued by GIF member states***
- ***Task Force (TF) started work in 2011 and completed SDC Phase I report in 2013***
  - ***Establish reference criteria for safety design of structures, systems and components***
  - ***Achieve harmonization of safety approaches among GIF member states***
    - » ***Realization of enhanced safety designs common to Gen-IV SFRs***
    - » ***Preparation for upcoming licensing efforts***

Introduction (continued)

- ***An important incentive and motivation for further technical interpretation and clarification of SDC***
- ***Phase II activity of SDC TF for the development of safety design guidelines (SDG) was started in September 2013***
  – ***To support practical application of SDC***
    » ***Quantification of key aspects***
    » ***Clarification on technical issues for common understandings***

Hierarchy of Safety Standards

Safety Fundamentals

e.g. IAEA SF-1: Fundamental Safety Principles

Safety Requirements

e.g. IAEA SSR 2/1*:
Safety of Nuclear Power Plants: Design

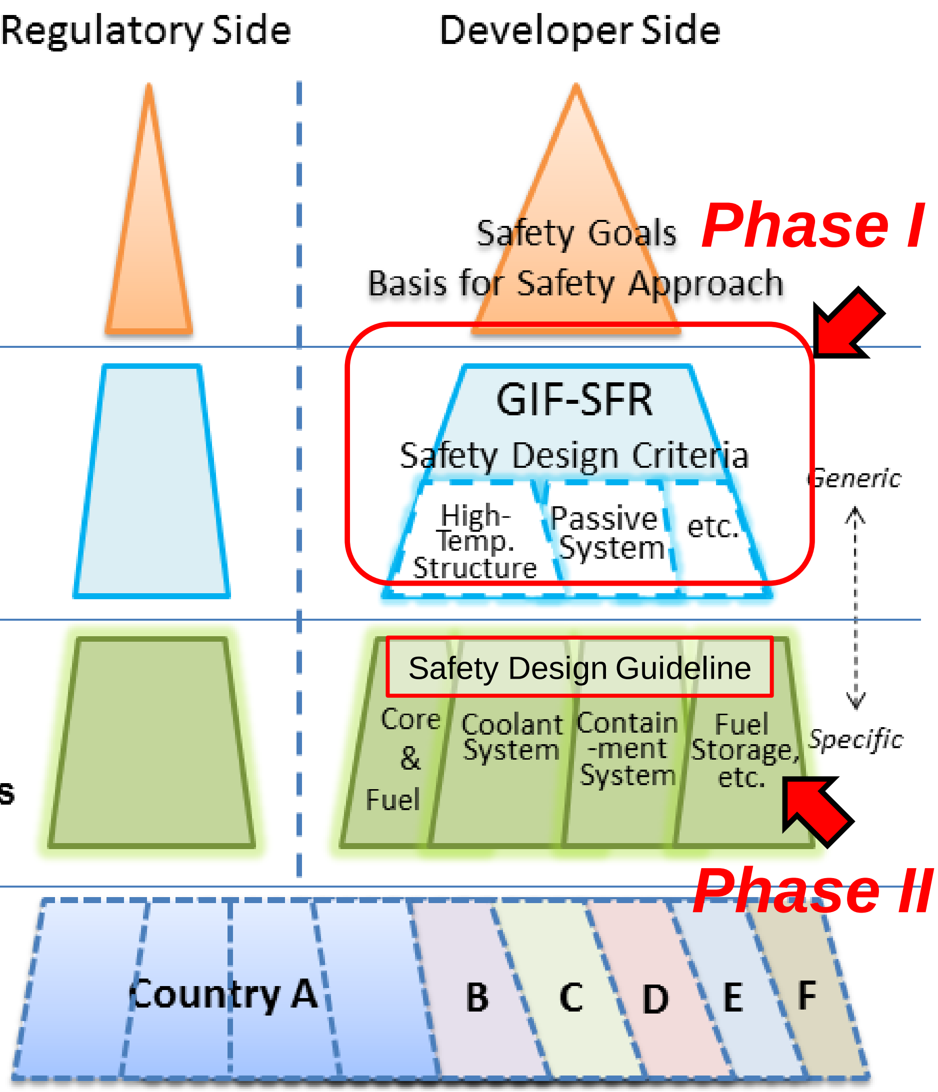
Safety Guides

e.g. IAEA NS-G-1.9*:
Design of the Reactor Coolant System and Associated Systems in Nuclear Power Plants

*These are for Light Water Reactors; but not for Gen-IV reactor systems.

Codes and Standards

Domestic Codes & Standards



Status of International reviews on SDC

- ***GIF SFR "SDC Phase 1 Report"***
  - ***Review requests for the SDC Report***
    - » ***For "Review by external organizations" and***
    - » ***For "Enhancing interaction with regulatory bodies"***
  - ***Sent the report (ca. July 2013) to***
    - » ***International organizations***
      IAEA, MDEP, OECD/NEA/CNRA
    - » ***Regulatory authorities at national level***
      China (NNSA), Euratom (ENSREG), France (ASN), Japan (NRA), Republic of Korea (NSSC), Russia (Rostechnadzor), USA (NRC)

International reviews on “SDC” (1)

- ***IRSN (France)***
  - ***Comments on interim version at 3rd GIF-IAEA Safety Workshop (Feb. 2013), resolutions already included in Phase I report.***
- ***NNSA (China)***
  - ***Review results (Oct. 2013 & Jan. 2014)***
  - ***GIF SDC TF resolution replied (Aug. 2014)***
  - ***Consideration on Sodium Void Worth at SDG report***
- ***NRC (USA)***
  - ***Comprehensive & detailed review, with proposals (Jan. 2014)***
  - ***GIF SDC Task Force prepared the resolutions to incorporate***
- ***IAEA***
  - ***General and technically specific reviews (April 2014)***
  - ***GIF SDC Task Force prepared the resolutions to incorporate***

International reviews on "SDC" (2)

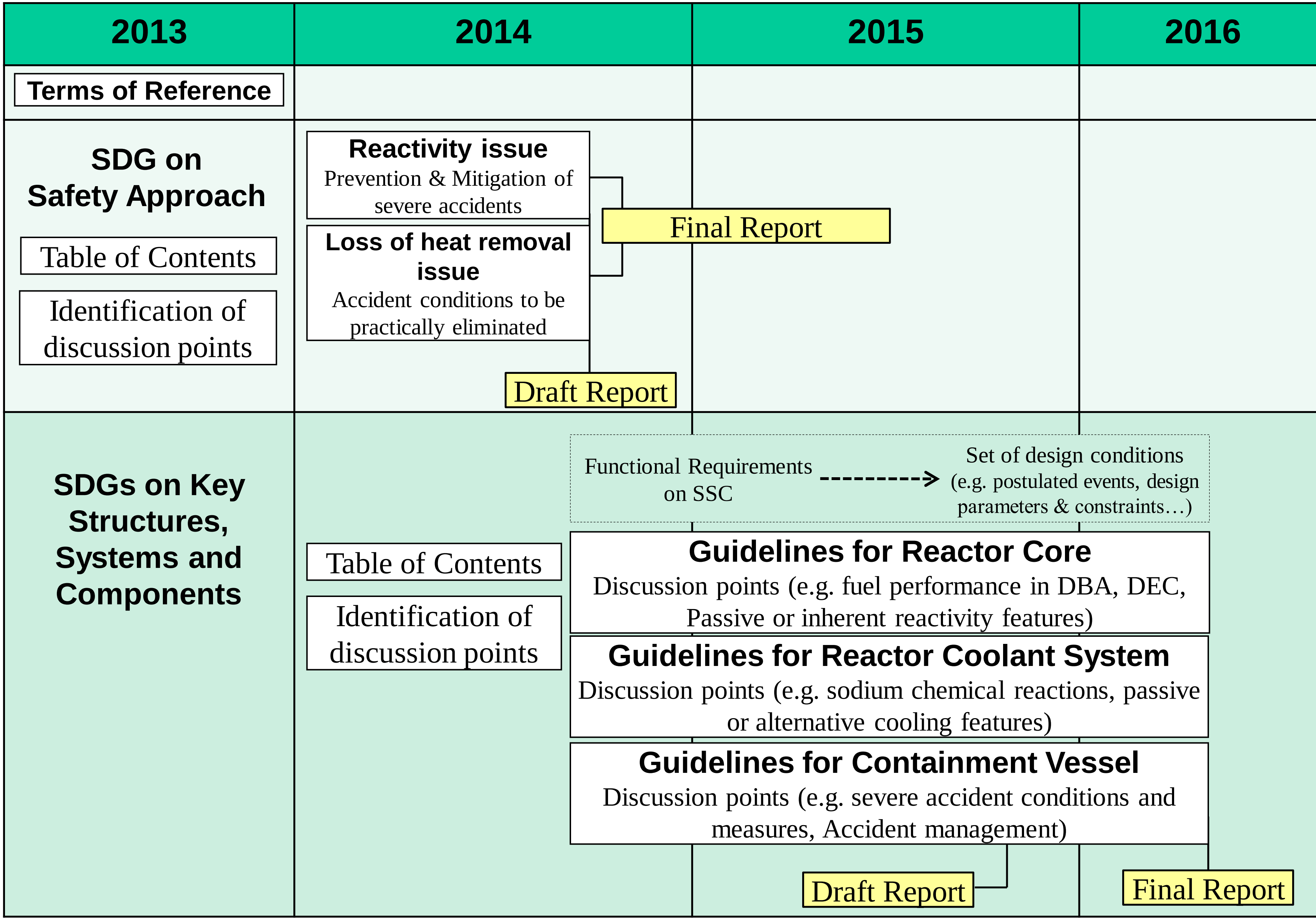
- ***Rostechnadzor (Russia)***
  - ***Comments on SDC report at 4th IAEA-GIF Safety Workshop (June. 2014)***
  - ***Containment function will be discussed in the SDG/SSC development***
- ***IRSN (France)***
  - ***Comments on SDC report (June 2015)***
  - ***To be discussed and consider to incorporate***

External feedbacks have been or are being incorporated

Safety Design Guidelines (SDG) Development

- ***Main objective***
  - ***to support practical application of SDC in design process for improving safety in specific topical areas***
    - » ***including use of inherent/passive safety features***
    - » ***design measures for prevention and mitigation of severe accidents.***
  - ***Initial topical areas are considered:***
    - » ***Particular importance since a fast reactor core is typically not in its most reactive configuration***
    - » ***Quantification of key criteria for safety improvement***

Schematic View of SDG Development Schedule



Exploiting SFR Characteristics to Enhance Safety

- ***<u>Passive/Inherent safety for DEC</u>***
  - ***On reactivity***
    - » ***Inherent reactivity feedback to reduce the power as core temperatures rise or***
    - » ***Passive mechanism are applicable for shutdown systems, such as SASS, HSR, and GEM***
  - ***On decay heat removal***
    - » ***Natural circulation of single phase sodium coolant***
    - » ***can be placed in different locations for enhancing diversity***

Exploiting SFR Characteristics to Enhance Safety

- ***<u>In-Vessel Retention</u>***
  - ***In the course of core degradation during unprotected transients, measures should be provided to prevent prompt criticality***
  - ***Reactor coolant boundary should maintain the boundary function against pressure load including fuel-coolant interaction***
  - ***Measures should be provided for ensuring long term cooling of core materials inside the reactor vessel under sub-critical condition***

Practical Elimination of Accident Situations:

- ***Severe accidents with mechanical energy release higher than the containment capability***
  - *Power excursions for intact core situations*
    - » *Large gas flow through the core*
    - » *Large-scale core compaction*
    - » *Collapse of the core support structures*
- ***Situations leading to the failure of the containment with risk of fuel damage***
  - *Complete loss of decay heat removal function that leads to core damage and failure of primary coolant boundary*
  - *Core uncovering due to sodium inventory loss*
- ***Fuel degradation in fuel storage or during when the containment may not be functional due to maintenance***
  - *Core damage during maintenance*
  - *Spent fuel melting in the storage*

Quantification of requirement on reactivity characteristics

- **For Normal operation, AOO and DBA**
  - » Power reactivity coefficient < 0 (Negative)
  - » Reactor shutdown capability with inherent feedback > Postulated reactivity insertion
- **For Design Extension Condition**
  - » Before core damage: same as the requirement for DBA,
    - – Achieved by passive measures or inherent features
  - » After core damage:
    - – Total reactor core reactivity < 1$ (below prompt criticality)

  - » Sodium void worth can be positive as far as the above conditions are satisfied.

Concluding Remarks

- ***The "Safety Design Criteria Phase 1 Report"***
  - ***Issued by the GIF on May 2013***
  - ***Disseminated for international review to:***
    - » ***International organizations***
    - » ***National Regulatory Bodies***
  - ***Important feedbacks have been or are being incorporated:***
    - » ***e.g. IAEA, IRSN, USNRC, NNSA, Rostechnadzor …***
- ***The "Safety Design Guidelines" development in Phase II***
  - ***Started from Sept. 2013***
  - ***Two Safety Design Guidelines (SDG):***
    - » ***Safety Approach and Design Conditions SDG in final drafting stage***
    - » ***Key Structures, Systems and Components SDG***

Thank you
for your attention !!