Safety Design Criteria (SDC) for Gen-IV Sodium-cooled Fast Reactor

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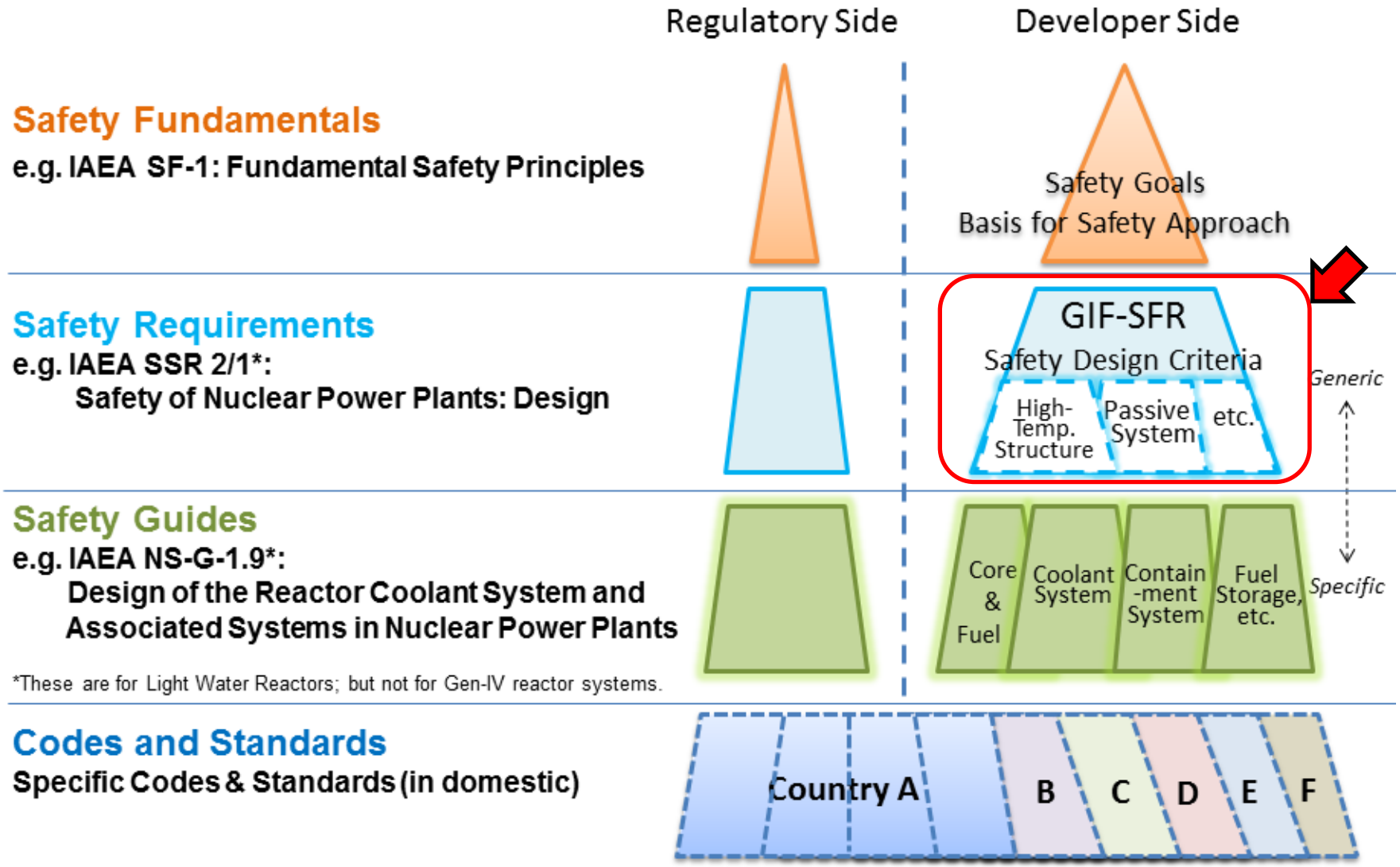
SDC Development Background & Objectives

- *Safety Design Criteria (SDC) Development for Gen-IV SFR*
  - *Proposed at the GIF Policy Group (PG) meeting in October 2010*
  - *SDC "harmonization" is increasingly important for:*
    - *Realization of enhanced safety designs meeting to Gen-IV safety goals and safety approach common to SFR systems,*
    - *Preparation for the forthcoming licensing in the near future*
    - *Because Gen-IV SFR are progressing into conceptual design stage*
- *The SDC is the Reference criteria*
  - *Of the designs of safety-related Structures, Systems & Components that are specific to the SFR system,*
  - *For clarifying the requisites systematically & comprehensively,*
  - *When the technology developers apply the basic safety approach and use the codes & standards for conceptual design of the Gen-IV SFR system*

Hierarchy of Safety Standards



Basic Scheme to outline the SDC

High level safety fundamentals, and safety design goals

- *GIF's Goals for safety & reliability*
- *Basis for safety approach for design & assessment*
- *Requirements in SFR System Research Plan*

1) Particular issues for SFR

- Characteristic of Sodium-cooled Fast Reactor
  - Reactivity (void) …
  - Sodium fire & Sodium-water reaction…
- Consideration on Severe Accident
  - Re-criticality during Core Disruptive Accident
- High Temperature & Low pressure system
  - Creep property, Leak-Before-Break…
  - No LOCA and no need of ECCS…
- Enhanced Safety Approach
  - Passive system for shutdown & cooling

2) Reference of SDC Structure

IAEA SSR 2/1

- Management of safety in design
- Principal technical requirement
- General Plant design
- Design of specific plant system

3) Lessons learned from Fukushima Dai-ichi NPPs accident

- Common cause failure by external event
- Loss of power for longer period
  - Decay heat removal, Fuel pool cooling
- Containment function on spent fuel in the pool
- Preparing multiple AMs, e.t.c.

GIF SFR SDC

GIF's Safety & Reliability Goals

SR-1: Excel in Operational Safety and Reliability

Safety and reliability during normal operation, and likely kinds of operational events that set forced outage

SR-2: Very low likelihood & degree of reactor core damage

Minimizing frequency of initiating events, and design features for controlling & mitigating any initiating events w/o causing core damage

SR-3: Eliminate the need for offsite emergency response

Safety architecture to manage & mitigate severe plant conditions, for making small the possibility of releases of radiation

GIF's Basic Safety Approach

- ***Defence-in-depth***
- ***Risk-informed***
- ***Built-in safety function, and not add-on***
- ***Utilisation of passive safety features***
- ***High level safety meeting to GIF's safety & reliability goals***

Approach based on SFR basic characteristics

- *Core and Fuel Characteristics*
  - *Operated in fast neutron spectrum*
  - *Reactor core is not in the most reactive configuration and it is possible to have a positive void reactivity in core centre*
- *Physical and Chemical Properties Sodium Coolant*
  - *High thermal conductivity & high boiling point,*
  - *Chemically active, Opaque, & Freeze at room temperature*
- *Material usage environment*
  - *High temperature & high fast neutron fluence conditions,*
  - *Possibility of Thermal striping*
- *Operation under low pressure condition*
  - *Coolant leakage NOT lead to LOCA*
  - *Need to maintenance sodium coolant level above the core*

L. L. from Fukushima Dai-ichi NPP Accident

- *Key Viewpoints*
  - *Robustness in power supplies, cooling functions, heat transportation system including final heat sink*
  - *Instrumentation to identify status of reactor core and containment vessel*
  - *Independency and diversity of safety systems*

- *General aspect against extreme external hazards*
  - *Sufficient margins*
  - *Protection measures*
  - *Enhancing passive safety functions*

SDC : Table of contents

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Example of Criterion in SDC Report

Criterion #20: Design Extension Conditions, para.5.31

- ***IAEA SSR 2/1***

5.31 The design shall be such that design extension conditions that could lead to significant radioactive releases are practically eliminated. If not, for design extension conditions that cannot be practically eliminated...

- ***GIF SFR SDC***

5.31 The design shall be such that design extension conditions that could lead to significant radioactive releases are practically eliminated.
Since a fast reactor core is not in its most reactive configuration under normal operating conditions, the following design features for prevention and mitigation of severe accidents in postulated design extension conditions shall be considered:

(a) Additional reactor shutdown measures against failure of active reactor shutdown systems,

(b) Mitigation provision to avoid recriticality leading large mechanical energy release during a core degradation progression,

(c) Means for decay heat removal of a degraded core, and

(d) Containment capability of enduring thermal and mechanical loads under severe accident conditions.

Concluding Remarks

- ***The Interim Report on GIF SFR Safety Design Criteria (SDC)***
  - *Summarized as the set of safety design reference of the Gen-IV SFR system,*
  - *To meet the Gen-IV goals and safety approaches.*
  - *Provided to IAEA and discussed at Joint GIF-IAEA workshop on SDC*
  - *The SDC will be updated with the times as necessary by including constructive feedbacks from all international technical entities.*

- ***Provision on future SDC-related Activity***
  - *The SDC will be disseminated and utilized for SFR design at international level in interaction with IAEA and MDEP.*
  - *The guidelines of the SDC will be elaborated for further detailed technical specification of the SDC.*