IAEA 60 Years
Atoms for Peace and Development

From Strategies to Guidelines – Creation of SAMG

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Strategies → Guidelines

- The strategies and measures discussed in the previous presentations should be converted into guidelines for the mitigatory domain, i.e. to the **S**evere **A**ccident **M**anagement **G**uidelines (SAMG)
- As we must give the TSC and the MCR clear guidance *what* to do and *when* to do this
  - i.e. which are the parameters to which we must respond, and what should that response be?
- Next 2 slides: structured process of development of SAMG (follows SRS-32, NS-G-2.15)

What is needed to develop a set of SAM guidelines? (1v2)

Adequate information to *understand the* ***vulnerabilities***, ***capabilities*** *and potential* ***limitations*** *of the plant*, including both equipment and personnel

Vulnerabilities are threats to fission product boundaries (e.g. from PSA), *capabilities* are all strong elements of a plant (e.g. strong containment, much cooling water, extensive AC power), *limitations* concern availability of resources, including manpower

1. A clearly identified set of ***accident management strategies*** that will effectively prevent or mitigate undesirable accident consequences

   (e.g. to be derived from so-called Candidate High Level Actions, see EPRI Technical Basis Report, excerpts later in the course)

2. ***Procedures and guidelines*** implemented at all appropriate levels in the organisation for executing the strategies

   Not only MCR, but *everybody* with a function in A/M (TSC, other)

What is needed to develop a set of SAM guidelines? (2v2)

4. ***Engineered methods*** (necessary systems and equipment) identified for the proper implementation of strategies.
5. Indication that ***adequate plant status information*** is available to monitor all plant safety functions, and is available to select and to assess the effectiveness of all strategies.
6. ***Verification*** *of the SAMG and* ***validation*** of the performance of the implemented accident management plan.
7. Clear lines of decision making ***authority*** *and* ***responsibility****.*

   Various solutions, but they must be defined and described!
8. ***Adequate training*** of all personnel involved in AM.
9. A formal mechanism in place to identify and ***incorporate new information*** into the implemented accident management plan as it becomes available.
   - Experience with other plants
   - Progress in research

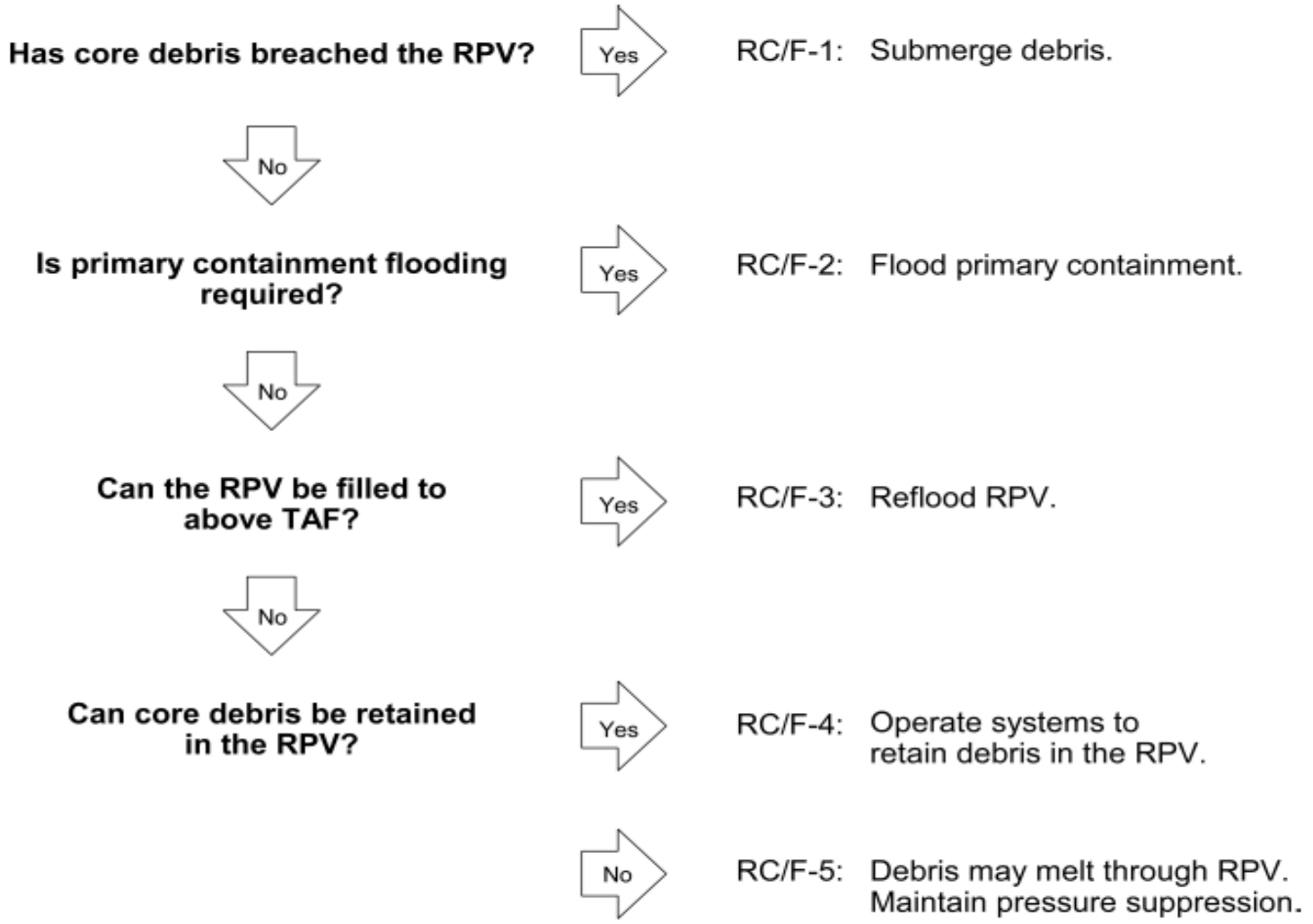
Create a logic diagram

- Not all *can* be done at the same time
- Not all *needs* to be done at the same time
- Hence: priorities must be indicated
- Useful tool: a logic diagram
  - Is based on a sequence of questions to be asked
  - CAUTION: logic diagram may change during the evolution of the accident!
    - Example: Whether we must depressurise RPV is obsolete once at low pressure or if core has molten through the bottom – that question can then be left out from the logic diagram
  - Contains exit – if all SAMG criteria have been satisfied
    - Accident management is not over, but transfers to a long term phase
- Next seven slides: examples of logic diagrams
  - BWR Owners Group, Westinghouse Owners Group, PWR Owners Group (is new)

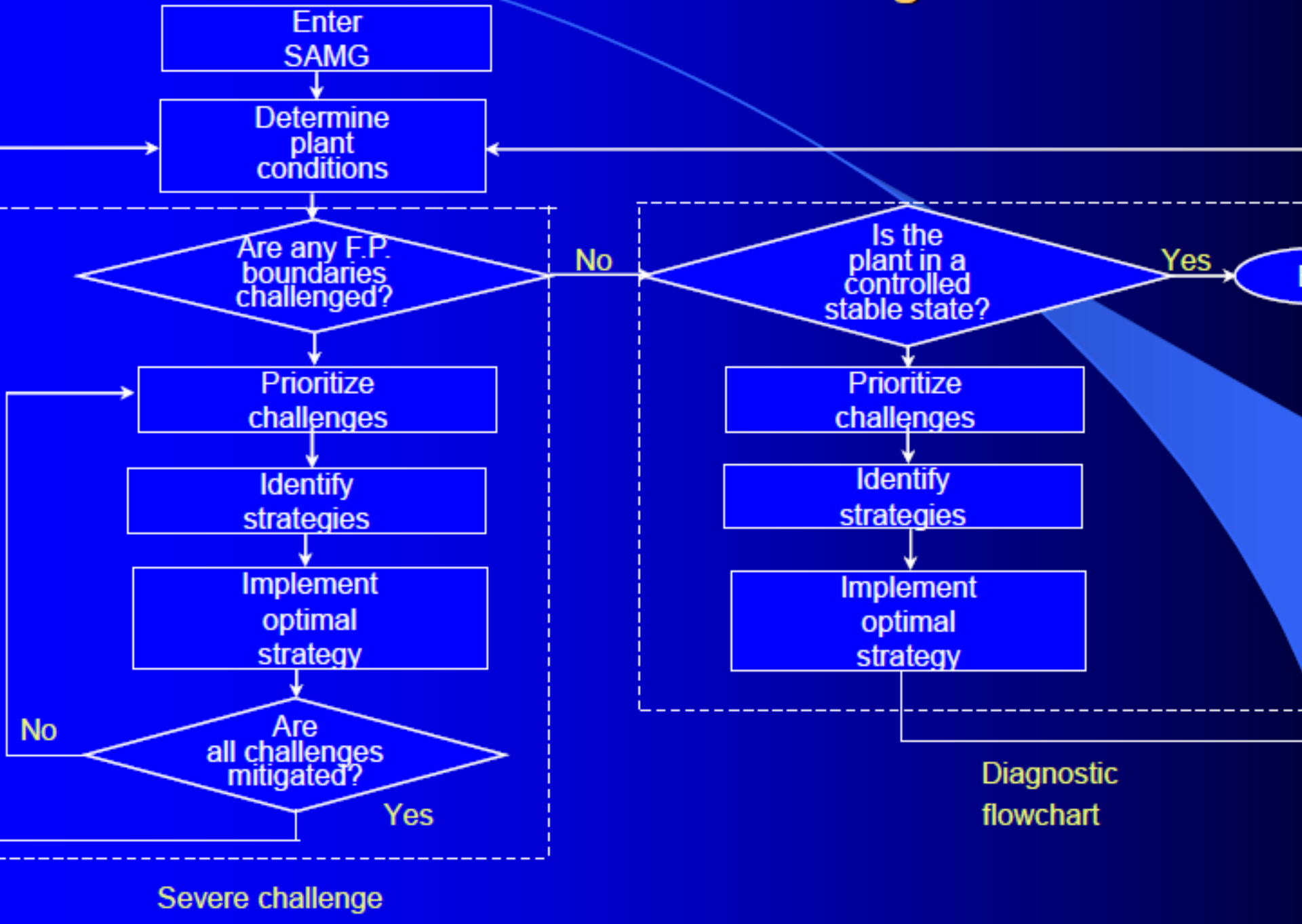
Use of logic diagram

- Each question has an answer: yes / no
- Each answer leads to an action (i.e. a guideline) or to another question
- **Walk** through the logic diagram repeatedly
  - Things may have changed in the mean time (this is usually done in exercises)
- **Check** the logic diagram repeatedly
  - Priorities may have changed (this is usually *not* done in exercises)

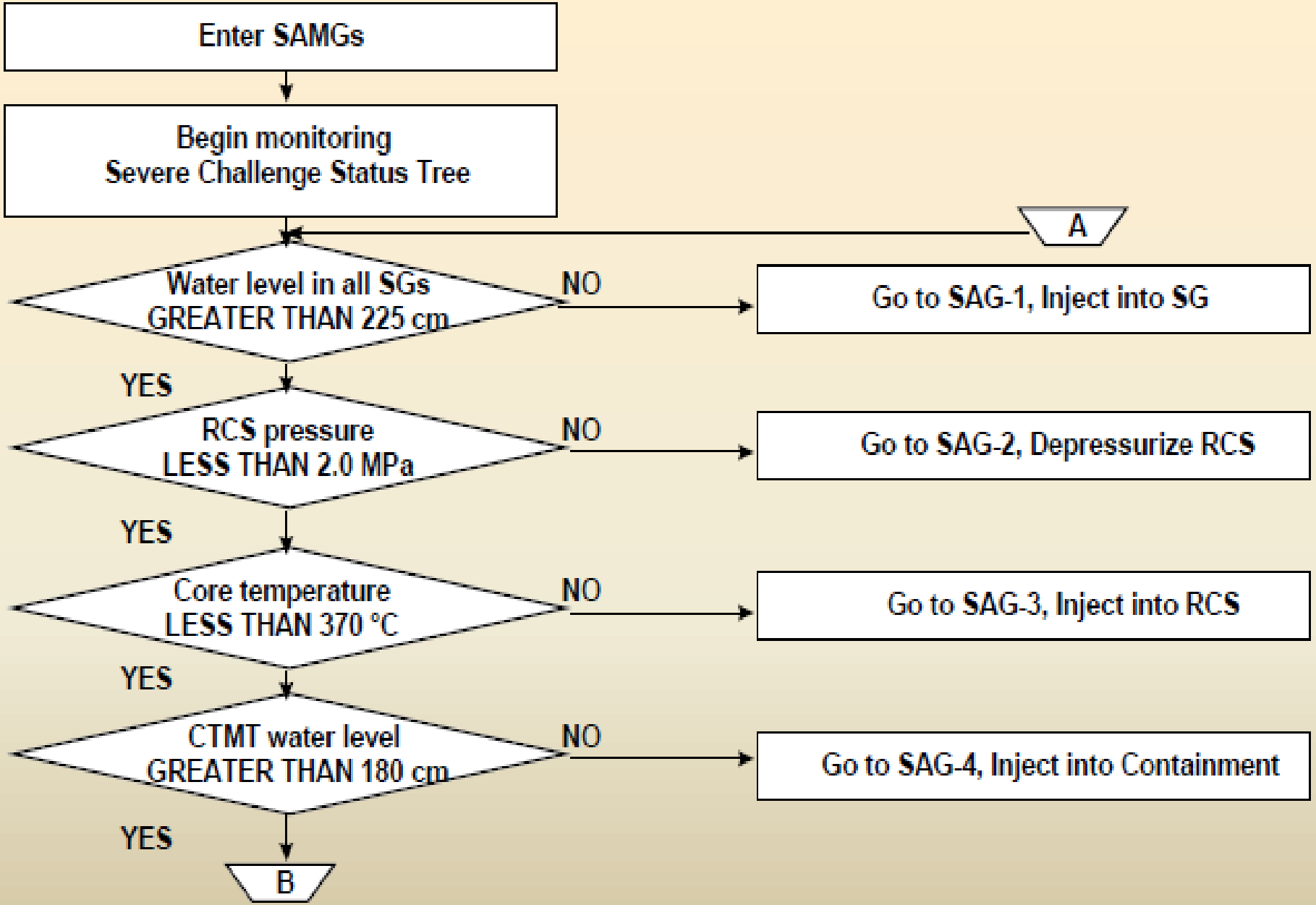
After transition to SAMG: logic diagram (example: BWROG)

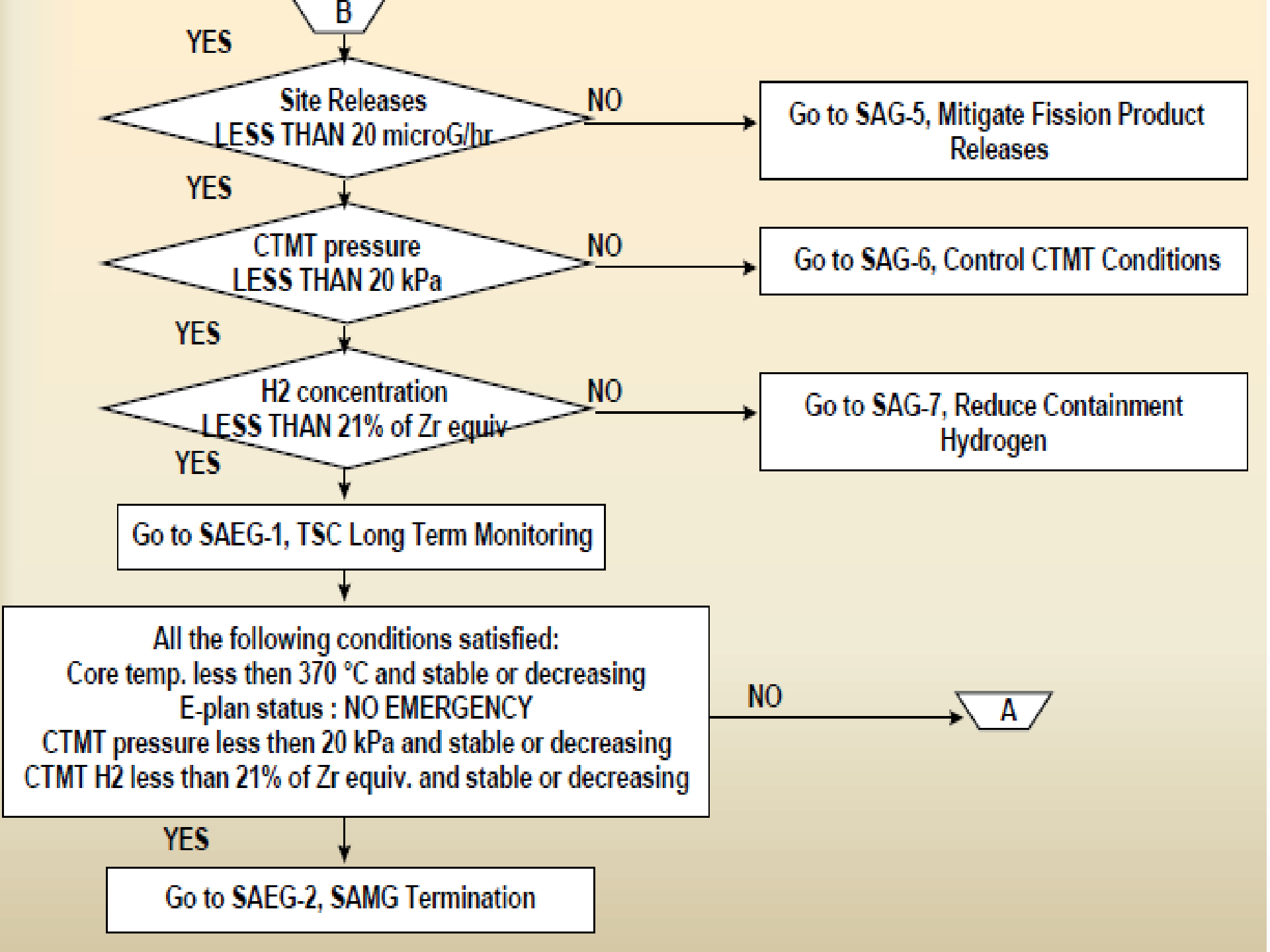


Reference Decision Making Process

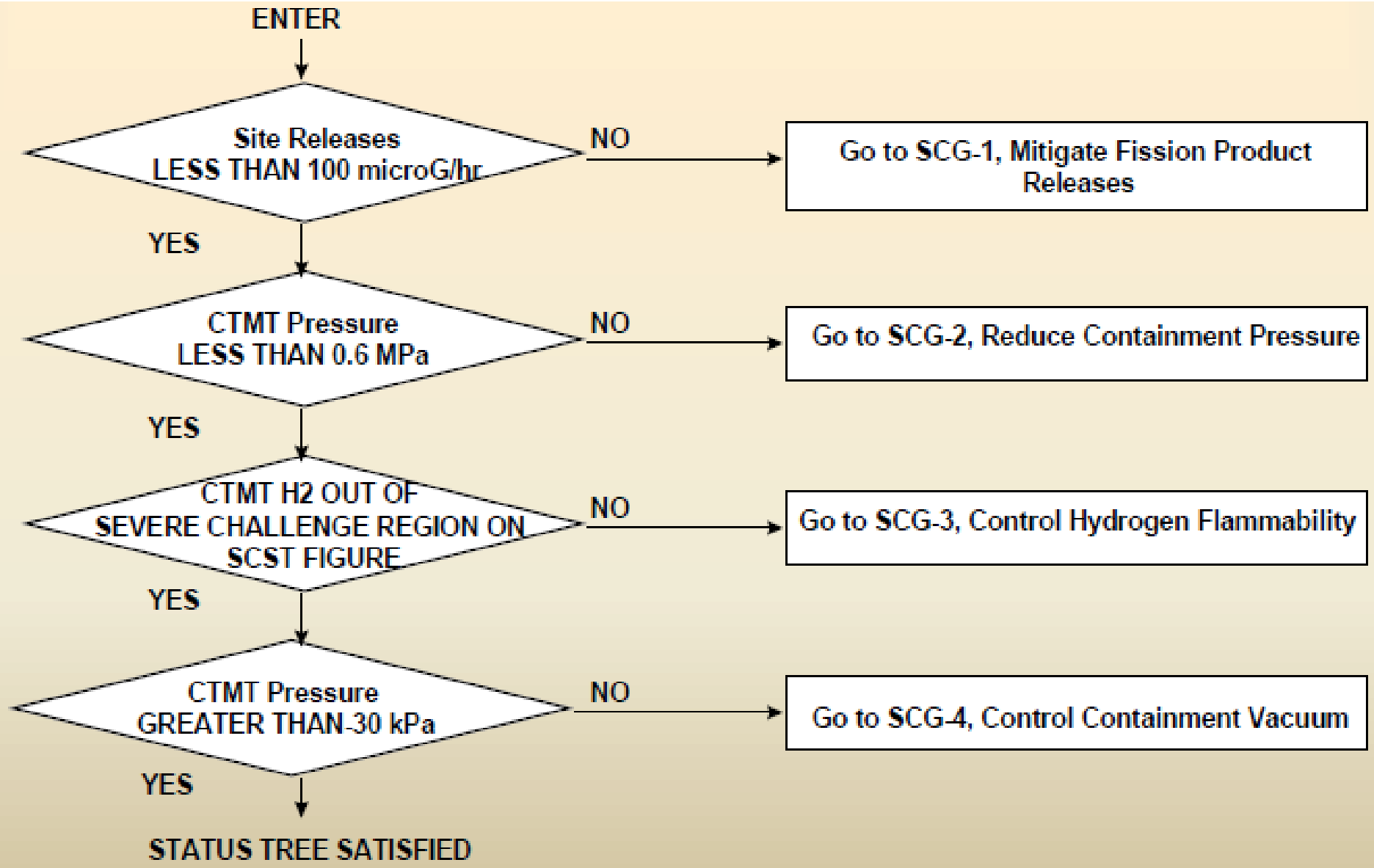


Example of Diagnostic Flow Chart (DFC)




B
YES
Site Releases
LESS THAN 20 microG/hr
NO
Go to SAG-5, Mitigate Fission Product Releases
YES
CTMT pressure
LESS THAN 20 kPa
NO
Go to SAG-6, Control CTMT Conditions
YES
H2 concentration
LESS THAN 21% of Zr equiv
NO
Go to SAG-7, Reduce Containment Hydrogen
YES
Go to SAEG-1, TSC Long Term Monitoring
All the following conditions satisfied:
Core temp. less then 370 °C and stable or decreasing
E-plan status : NO EMERGENCY
CTMT pressure less then 20 kPa and stable or decreasing
CTMT H2 less than 21% of Zr equiv. and stable or decreasing
NO
A
YES
Go to SAEG-2, SAMG Termination

Example of Severe Challenge Status Tree (SCST)



Decision Making Authority

- For many SAMG, the authority for decision making transfers to another (~ higher) level than the Main Control Room (MCR); it includes the support by a ´Technical Support Centre` - TSC - for evaluation and preparation of the decision making
  - Countries have various options; a MUST is that all functions are well defined and allocated
- The MCR focuses on actions which are uniquely safety beneficial, until the TSC is ready, upon which they execute the SAMG

Control Room

Severe Accident Control Room Guideline (SACRG-1) Initial Response

Severe Accident Control Room Guideline (SACRG-2) for Transients after the TSC is Functional

Technical Support Center

Diagnostic Flow Chart (DFC)

Severe Challenge Status Tree (SCST)

Severe Accident Guidelines
- SAG-1
- SAG-2
- SAG-3
- SAG-4
- SAG-5
- SAG-6
- SAG-7
- SAG-8

Severe Challenge Guidelines
- SCG-1
- SCG-2
- SCG-3
- SCG-4

Graphical Computation Aids

SAEG-1 TSC Long Term Monitoring Activities

SAEG-2 SAMG Termination

Highest Priority

DATE:_____ TIME:_____		RED	ORANGE	YELLOW	GREEN	TREND (Circle One)
SG Level	Setpoint		LESS THAN L01		GREATER THAN L01	↑ STABLE ↓
Go to SAG-1	Actual					
RCS Pressure	Setpoint		GREATER THAN P02		LESS THAN P02	↑ STABLE ↓
Go to SAG-2	Actual					
Core Temperature	Setpoint		GREATER THAN T01		LESS THAN T01	↑ STABLE ↓
Go to SAG-3	Actual					
Containment Water Level	Setpoint		LESS THAN L02	BETWEEN L02 and L04	GREATER THAN L04	↑ STABLE ↓
Go to SAG-4	Actual					
Containment Pressure	Setpoint	GREATER THAN P01	BETWEEN P01 and P03	LESS THAN P04	BETWEEN P03 and P04	↑ STABLE ↓
Go to SAG-5	Actual					
Containment Hydrogen Concentration	Setpoint	GREATER THAN H01		BETWEEN H01 and H02	LESS THAN H02	↑ STABLE ↓
Go to SAG-6	Actual					
Site Release Level	Setpoint	GREATER THAN R01	BETWEEN R01 and R02		LESS THAN R02	↑ STABLE ↓
Go to SAG-7	Actual					
SFP Water Level	Setpoint		LESS THAN L03	BETWEEN L03 and L05	GREATER THAN L05	↑ STABLE ↓
Go to SAG-8	Actual					

Lowest Priority

Contents of the guidelines - 1

- Document briefly the main objectives of the guideline and the strategies which are to be executed
- Define initiation criteria
  - Parameters
    - Pressure, temperature, hydrogen concentration, etc.
    - Be aware that instrument readings may deviate due to their harsh environment – try to quantify!
      - E.g. SG level measurement depends on pressure in containment
- Specify the time window available for actions
  - Maybe no time available – immediate action!
  - If time available then consider
    - When to start
    - When to throttle (if needed)
    - When to stop – consider the duration of the accident

Contents of the guidelines - 2

- Define equipment and resources required
  - AC, DC, pumps, valves, water, pneumatic
- Define actions to be executed
  - E.g. open SRVs, start pump X, open valve Y
- Include cautions, for example:
  - Do not open valve X if the temperature in the suppression pool > Y
  - Observe cooldown limits
  - While spraying the containment be aware of potential de-inerting the containment atmosphere
    - May result in explosions and loss of containment

Contents of the guidelines - 3

- List of potential negative consequences of proposed actions
  - Try to quantify those in advance
    - Do not try to do that on the fly during the accident!
  - Try to mitigate any relevant negative consequences
    - If not possible, consider NOT to take the action

Contents of the guidelines - last

- Monitor plant response
  - Action effective?
  - Action not effective?
    - Find cause, remove cause
    - E.g. pump did not start, repair pump or find portable pump and hook it on
- Work sheets, diagrams
- Return to the logic diagram

Writing the Guidelines

- Use a ´Writer´s Guide`for consistent formulation throughout the guideline, irrespective of the individual author
  - e.g. INPO has developed ´Writer´s Guides`
    - For EOPs INPO 82-017 (old)
    - For BWR EOPs, see next slide
    - For generic procedure writing see e.g. Wisconsin GNP 3.2.1
      - links in Module 3 of the Toolkit

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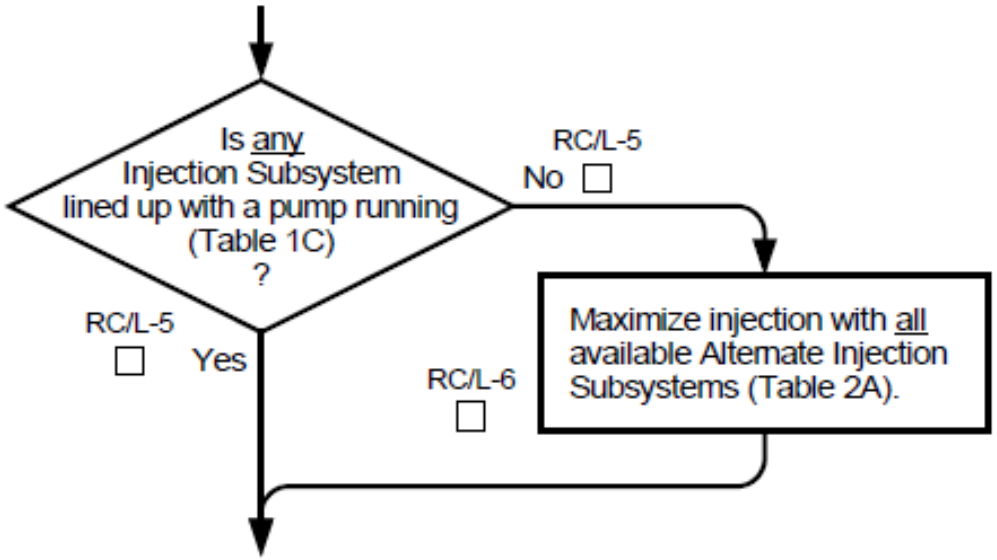
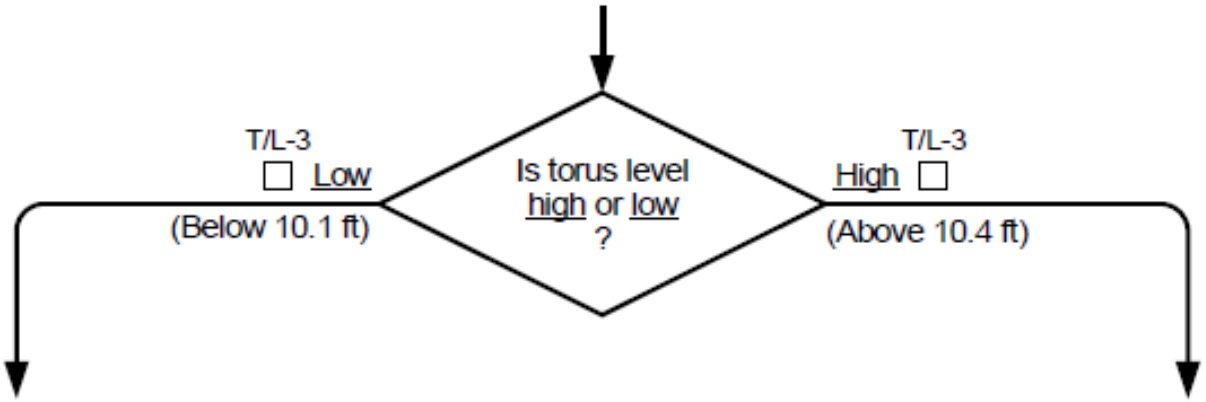
Examples of BWR EOP-part

Example of a decision point with "Yes" and "No" responses:



Example of a decision point with parameter responses:



Westinghouse Owners Group SAMG

- Example of guideline: SAG-3 (injection into the RCS) from US PWR

(proprietary information)

Transition EOP - SAMG

- Define exits from EOPs, for example:
  - RPV flooding not successful
  - CET > a certain pre-defined value *and all preventive actions associated with this CET failed* (WOG)
    - CET = Core Exit Thermocouple
  - Superheat on the CET
  - Decision by high level management
    - E.g. the Site Emergency Director (SED)
- Include the exits in the EOPs!

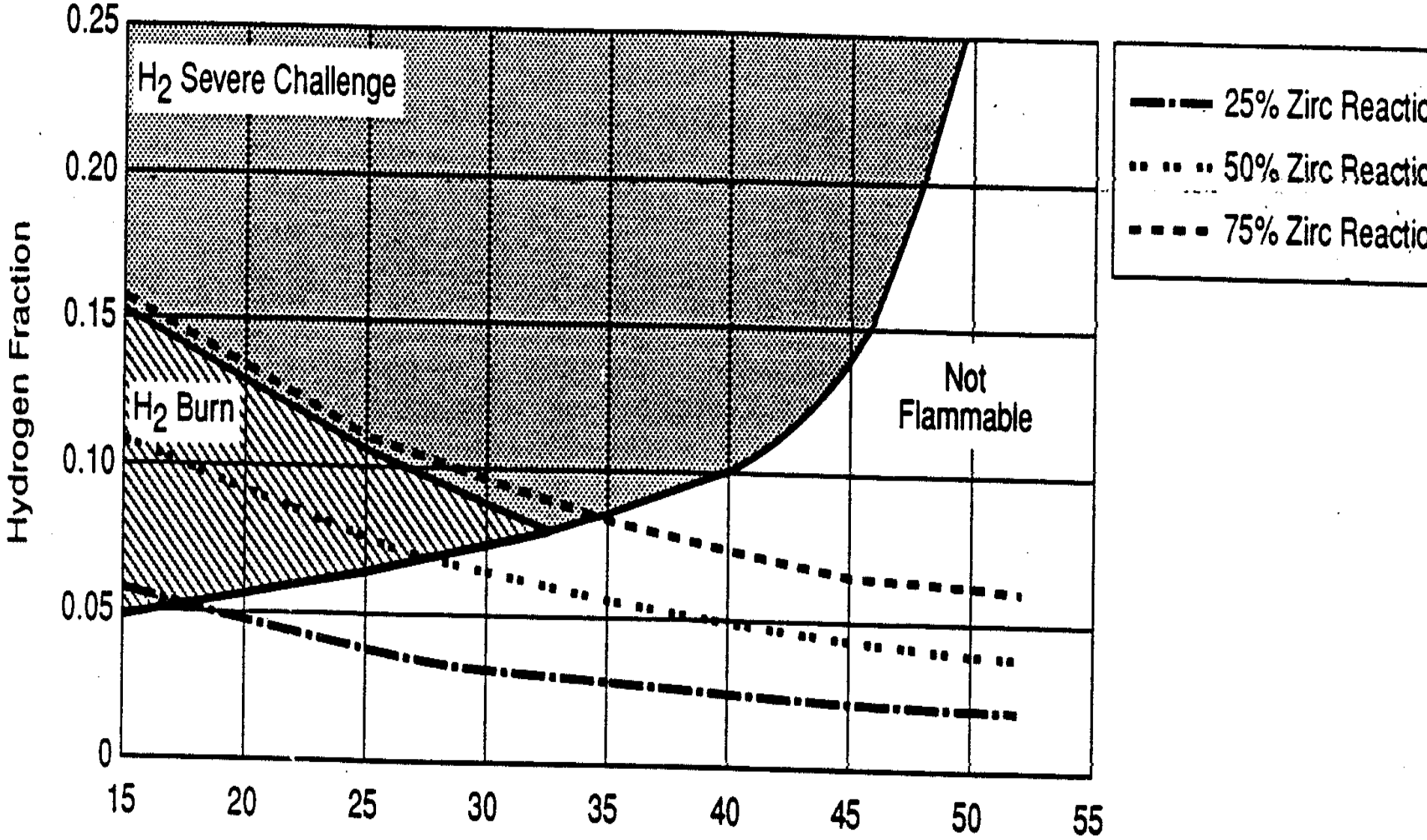
Computational Aids

- Graphical aids to support analysis and decision making
- Mostly in the form of graphs and tables
- Insights, e.g.:
  - the amount of water needed to cool debris
- flow through safety valves to obtain RPV depressurization
- Note: they serve actions, no information needs (e.g. amount of core damage)
- Some are not for analysis but to supply missing information
  - because detector not in existence or defect
    - e.g. hydrogen monitor absent or defect

Computational Aids in the Westinghouse Owners Group SAMG

- CA-1 RCS injection to recover the core
- CA-2 Injection rate for long term decay heat removal
- CA-3 Flammability in the containment, with/without venting, and with/without Core Concrete Interaction – next slide
- CA-4 Volumetric release rate from vent
- CA-5 Containment water level and volume: correlation between injected water and containment water level to determine the flooding level.
- CA-6 Gravity drain: to estimate the flow rate into the containment by gravity drain from the Reactor Water Storage Tank.
- CA-7 Containment challenge; to determine whether depressurizing the containment may induce a (future) hydrogen challenge or burn.

NO VENTING, NO CORE / CONCRETE INTERACTION



Graphic No. SB914

Rules of Usage – 1

(more info in separate lecture)

- SAMG is often executed by the TSC, not by the MCR
  - Guidance is NOT directed to save the core, but to protect fission product boundaries
  - Guidance requires balancing pluses and minuses
  - Deviations of Guidelines may be possible
    - Decision may be NOT to execute the Guideline if negative consequence too big
  - Evaluation and decision making are separate
- This opposes the ordinary training of the MCR
- Special guidance developed for the TSC

Rules of Usage - 2

Examples:

- If an EOP is in execution but the point of entry to SAMG is reached, should actions in the EOP then be interrupted, continued if not in conflict with the applicable SAMG, or continued in any case?
- Should actions that have (been) started in EOP-domain be continued in SAMG-domain?
- If a SAM Guideline is in execution, but the point of entry for another SAMG is also reached, should that other SAMG then be executed in parallel?
- Should the consideration to initiate another SAMG be delayed while parameters that called upon the former one are changing value?

BWROG – Extensive TSC Guidelines (TSGs - more info in separate lecture)

- Control Parameter Assessment (CPA)
  - Check instruments (deviations, limitations), use alternate methods (e.g. Comp. Aids)
- Plant Status Assessment (PSA)
  - Forecast SAG control parameters (extrapolation, calculation), optimise EPG/SAG limit curves
- Function Status Assessment (FSA)
  - Determine RPV breach, impairment of containment, availability of systems (primary and support) – if available: how long? if not available: how long to repair?
- EPG/SAG Action Assessment (EAA)
  - What is needed for EPG/SAG? When to start and how long? What happened, what will happen?
    - Example in next slide
- Note: comparable extensive guidelines are now also applied by the PWR Owners Group in its revised SAMG
  - was already done by Borssele NPP, Netherlands

Example of TSG: Core damage monitoring, TSG 3.8 (BWR)

- Prolonged existence of RPV injection flow rate below the MDRIR (Minimum Debris Retention Injection Rate, i.e. the flow rate required to make up for steam generated by the core W_{vap} defined in EPRI TBR)
- SRV tailpipe temperatures above the temperature indicating superheated steam is exiting the core
  - E.g. highest observed is 217 °C, so take 232 °C (450 °F)
- Indications of hydrogen concentration increasing above the minimum detectable concentration
- Indications of primary containment radiation above the maximum normal primary containment radiation rate and increasing

SAMG for Spent Fuel Pool (SFP) and Shutdown States

- Emphasized after Fukushima
  - Some plants already had
- Topic of a next presentation

What if TSC not (yet) available?

- TSC is usually already called to the site during EOP-phase
- Either accident may be very *fast* (e.g. from ATWS), or TSC may be very *slow* (e.g. because they cannot or not easily reach the site)
- Then special SAMG is available, calling for actions that make anyhow sense during the early phase of a severe accident
  - Sometimes called ´Severe Accident Management Control Room Guides, SACRGs – have same format as EOPs

Example of SACRGs (WOG)

- SACRG 1: initial response
- SACRG 2: after TSC has arrived AND is functional
  - i.e. is *ready to give ist first recommendation*

What if no instruments are available?

- Use Computational Aids
  - Some are designed to estimate parameters that otherwise would be available from instruments
  - Example: pressure rise in containment due to CCI or flooding debris, pressure rise from hydrogen burn
- Use ´Black SAMG`
  - Is recent development in the US-based Owners Groups
  - Example: early venting of the containment BEFORE there is significant radiation in the containment
    - buys margin to venting later in the evolution of the accident

Conclusions

- Development of SAMG is a structured process, once strategies are selected
- Use a logic diagram to execute the various SAMG in proper order
- Develop Computational Aids to support SAMG
- Develop guidance for the TSC how to handle the SAMG, often called TSGs (Tech. Support. Gls)
  - more in separate presentation
- Develop guidance for the MCR if the TSC is not readily available
  - E.g., for fast developing accidents