RISK-INFORMED 50.44

PUBLIC MEETING

MAY 17, 2000

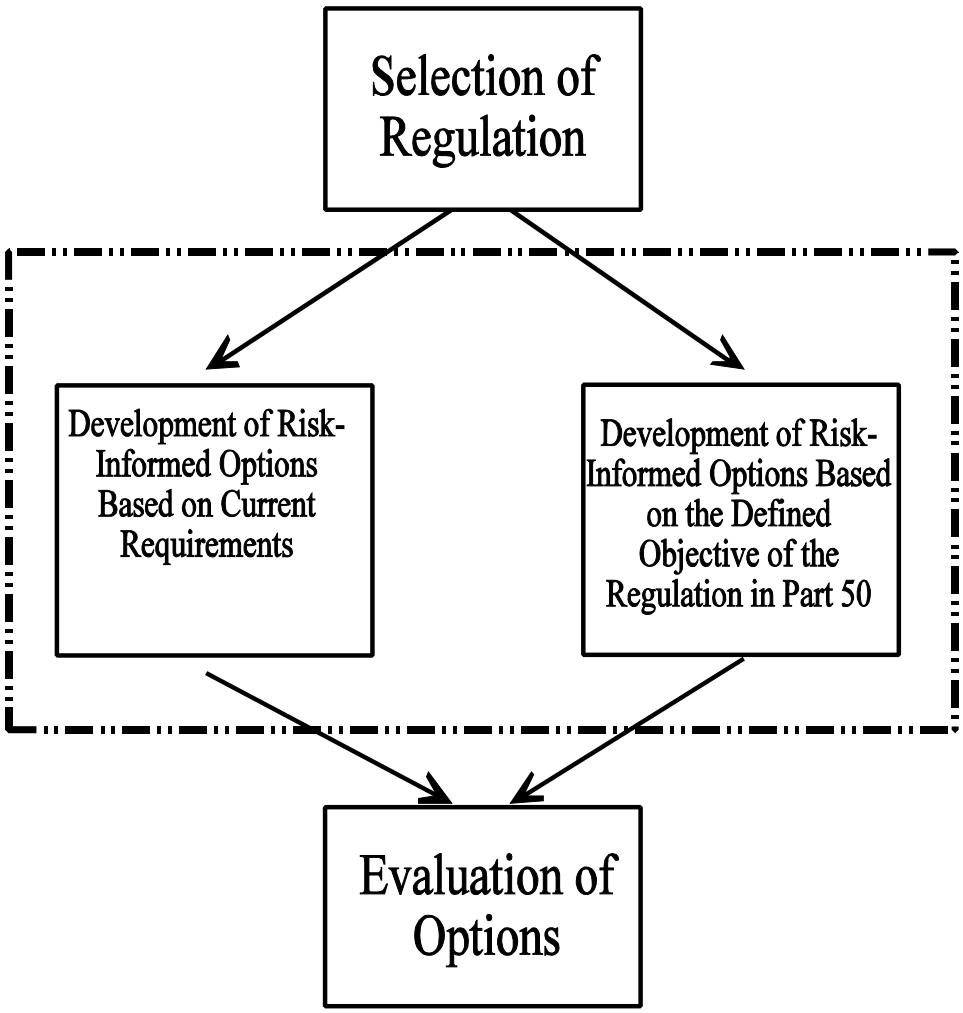
AGENDA

8:00-8:15	Introduction
8:15-8:45	Overview of risk-informing Part 50, as related to 50.44
8:45-10:00	NRC current status on 50.44
10:00-10:15	Break
10:15-10:45	Presentation by Bob Christie (Performance Tech)
10:45-11:30	Open discussion
11:30-12:00	Wrap-up/future activities

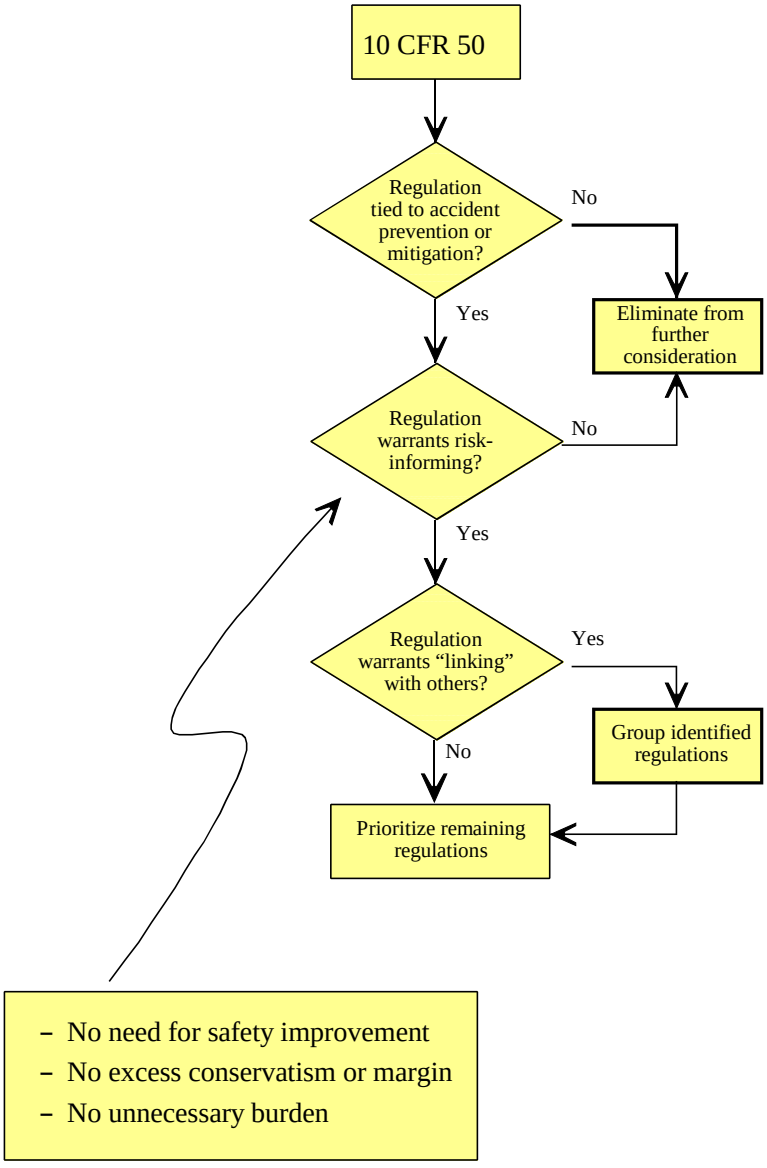
NRC PRESENTATION -- OUTLINE

- Approach
- Current Status
- Schedule

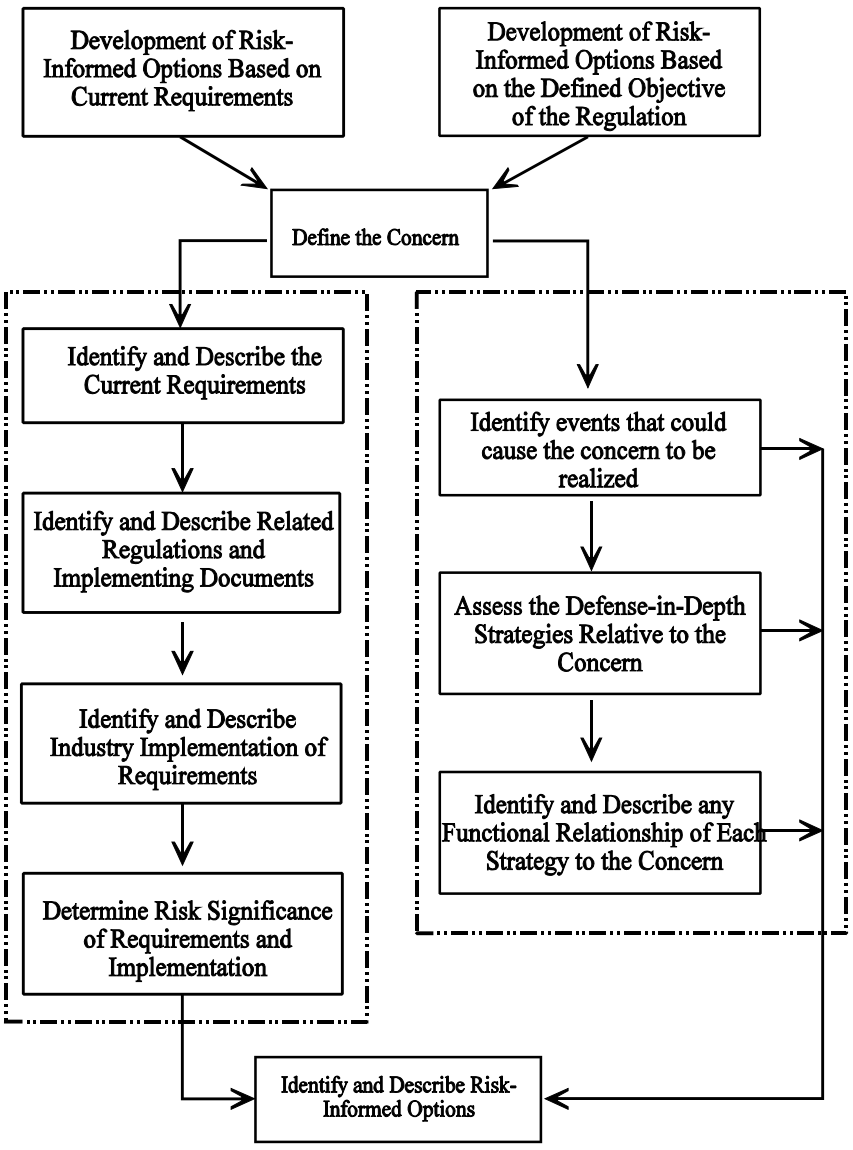
GENERAL APPROACH -- THREE STEPS



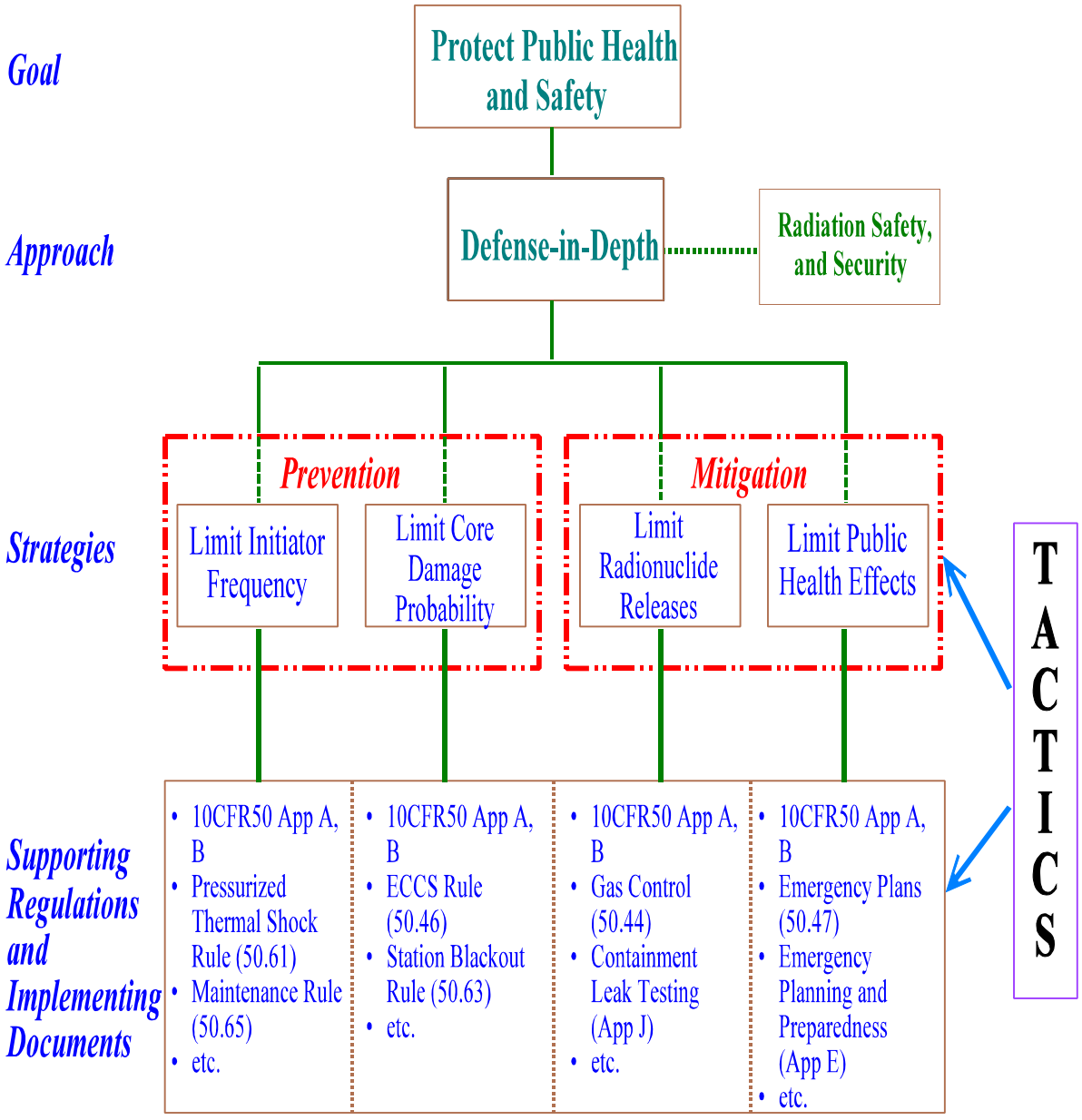
APPROACH:
SELECTION OF REGULATION



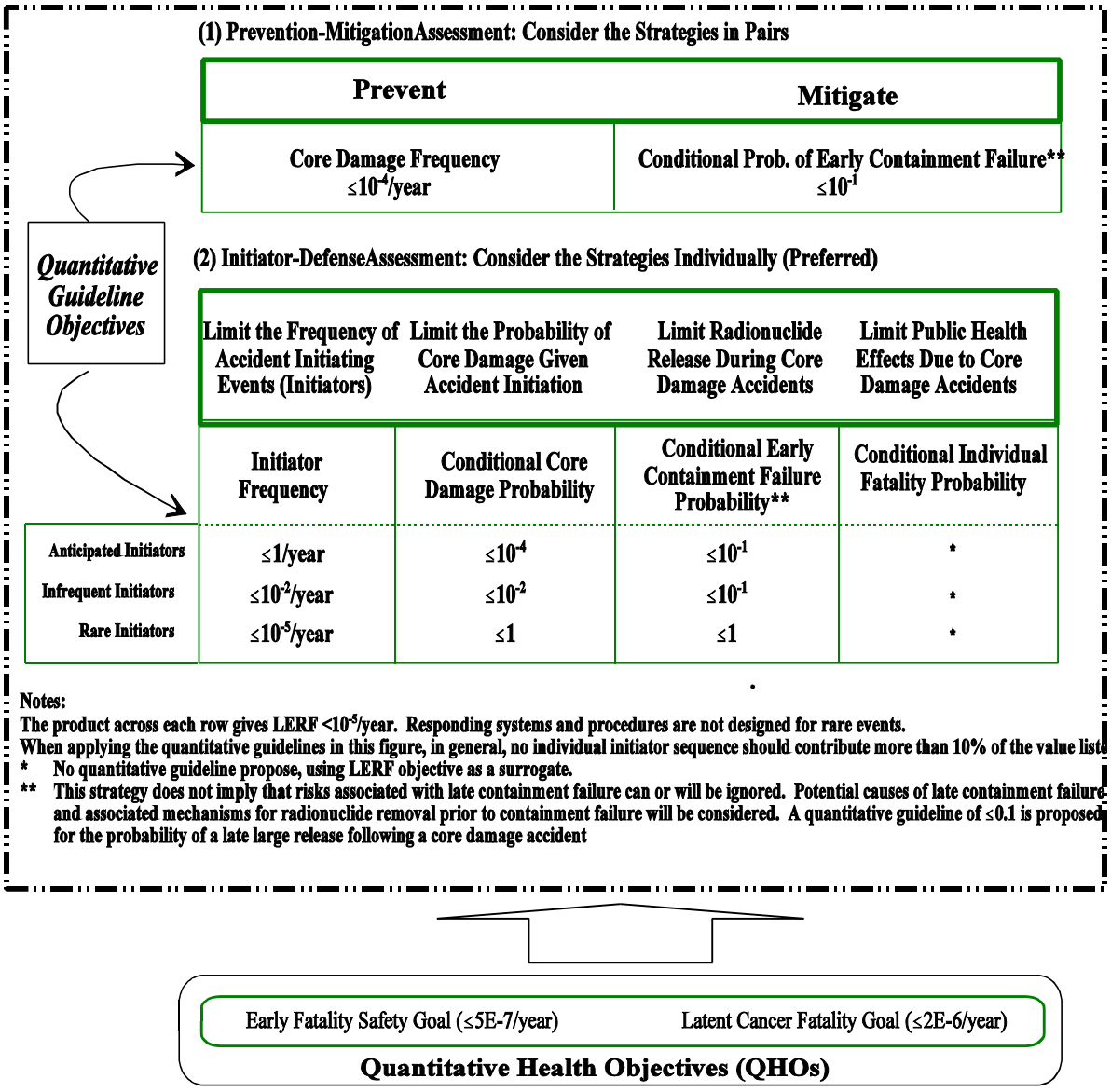
APPROACH:
DEVELOPMENT OF OPTIONS



APPROACH: FRAMEWORK



APPROACH:
QUANTITATIVE GUIDELINES



DEVELOPMENT OF OPTIONS: REVISING CURRENT REQUIREMENTS

(1) Identify and describe the current requirements

(2) Identify and describe related regulations and implementing documents

(3) Identify and describe industry implementation of the requirements

(4) Determine risk significance of requirements and implementation
- Assess against the four strategies and the quantitative guidelines
- Assess for possible elimination
- Consider other cornerstones

(5) Identify and describe risk informed options:
- Deletion of the current requirement
- Keeping the current requirement as is
- Revision and/or enhancement of the current requirement
  - risk insights from plant specific PRAs
  - industry experience
  - consistency with the quantitative guidelines
  - reasonable cost/burden
  - proven technology
  - suitability for performance-based compliance monitoring

DEVELOPMENT OF OPTIONS: DEVELOPING ALTERNATIVE REQUIREMENTS

1. Identify events capable of causing the concern to be realized

2. Assess the defense-in-depth strategies relative to the concern

3. Identify the functional relationship of each strategy to the concern

4. Identify risk-informed options

APPROACH:
EVALUATION OF OPTIONS

- Eliminate options not meeting the CDF and LERF quantitative guidelines

- Comparable risk implications
  - Preferable option imposing least burden

- Differing risk implications
  - Preferable option offering most safety benefit per unit cost

- Safety benefit – assessed in terms of incremental risk relative to the quantitative guidelines

- Cost – both licensee and NRC, considers both implementation and maintenance (e.g., additional or savings)

RISK EVALUATION OF 50.44

- Concern related to combustible gases
- Risk from combustible gases
- Current challenge to containments

CONCERN RELATED TO COMBUSTIBLE GASES

- Combustion events (deflagrations and detonations) can cause structural failure of containment
- Containment failure early during accident can lead to release of large quantities of radionuclides
- Combustible gases (hydrogen) released during TMI, ignited and burned
- Pressure pulse did not fail containment, but could have failed smaller containments

RISK FROM COMBUSTIBLE GASES

TIME	EVENT	REGULATORY RESPONSE
Early 1970s	• core melt accidents not considered credible	• no regulations imposed
1975	• WASH-1400 • large quantities of H2 predicted but containment failure dominated by other modes	• no regulations imposed
late 1970s	• H2 generation predicted from LLOCA DBA	• original version of 50.44 – measure concentration – mixed atmosphere – control concentration
1979	• Severe accident at TMI-2 • Large quantity of H2 generated • H2 combustion event in containment	• 1981 amendment – inert Mark I and II – recombiners – high point vents • 1985 amendment – H2 control system
1980s/ 1990s	• SARP • Confirmed ignition limits for variety of H2:air:steam mixtures • Evaluated effectiveness of H2 mitigative systems; example, – igniters work at low H2 concentrations • Established basis for detonability of H2; examples, – possibility of detonation given composition – not a concern for ***large*** volume containments • Studied H2 transport and mixing • NUREG-1150 • H2 combustion significant contributor to early containment failure for Mark III and ice condensers during SBO • H2 combustion not a challenge to integrity of large volume containments • NUREG-1560 • Per IPEs, H2 combustion – not a contributor at ice condensers because of small SBO contribution – contributor at Mark III because of the high SBO contribution	• no regulations imposed

CURRENT CHALLENGE TO CONTAINMENTS

BWR Mark I and Mark II Containments

- inert during plant operation
- H2 combustion cannot occur
- without inert atmosphere H2 would pose severe challenge to containment integrity

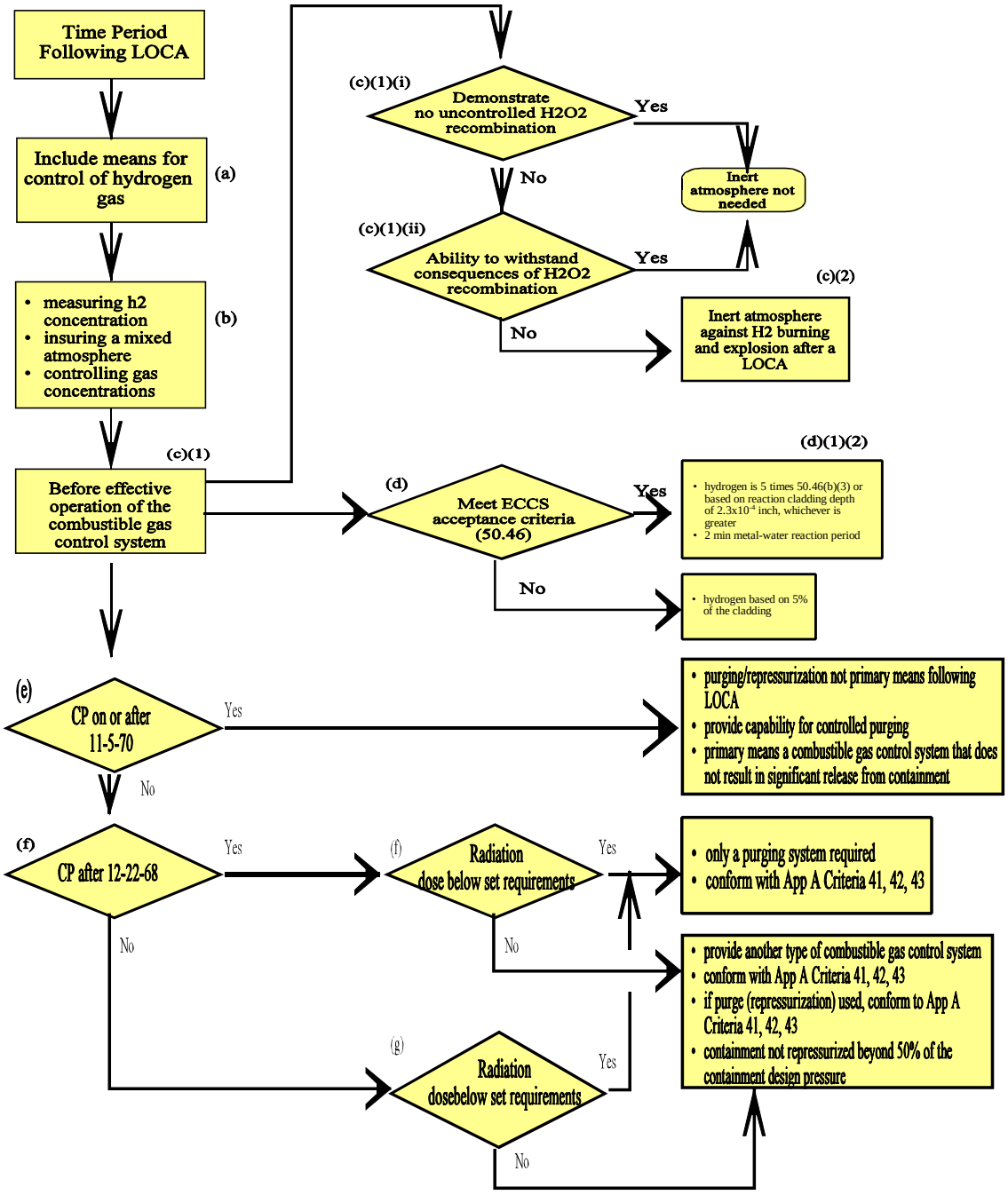
BWR Mark III and PWR ice condenser Containments

- igniter system installed
- H2 problem for accidents where igniters are not operating (i.e., SBO)

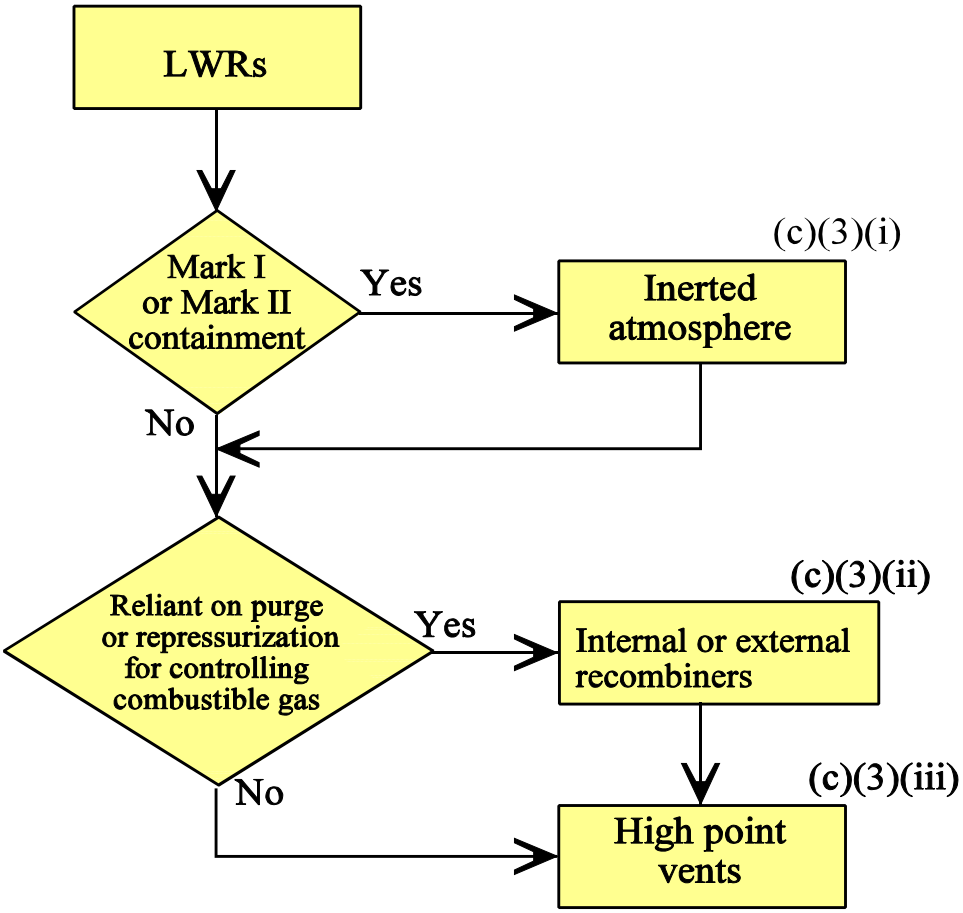
PWR Large Volume and Subatmospheric Containments

- H2 combustion not a challenge to early containment failure

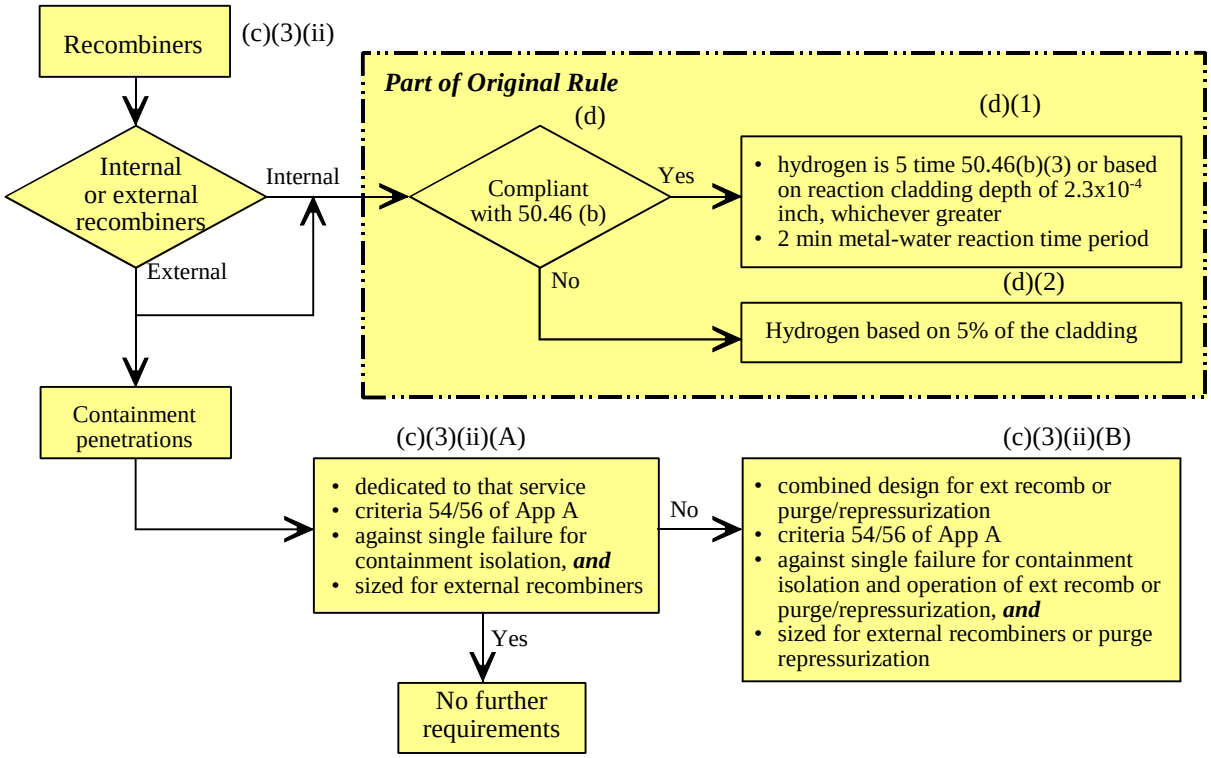
OVERVIEW OF 50.44: ORIGINAL RULE



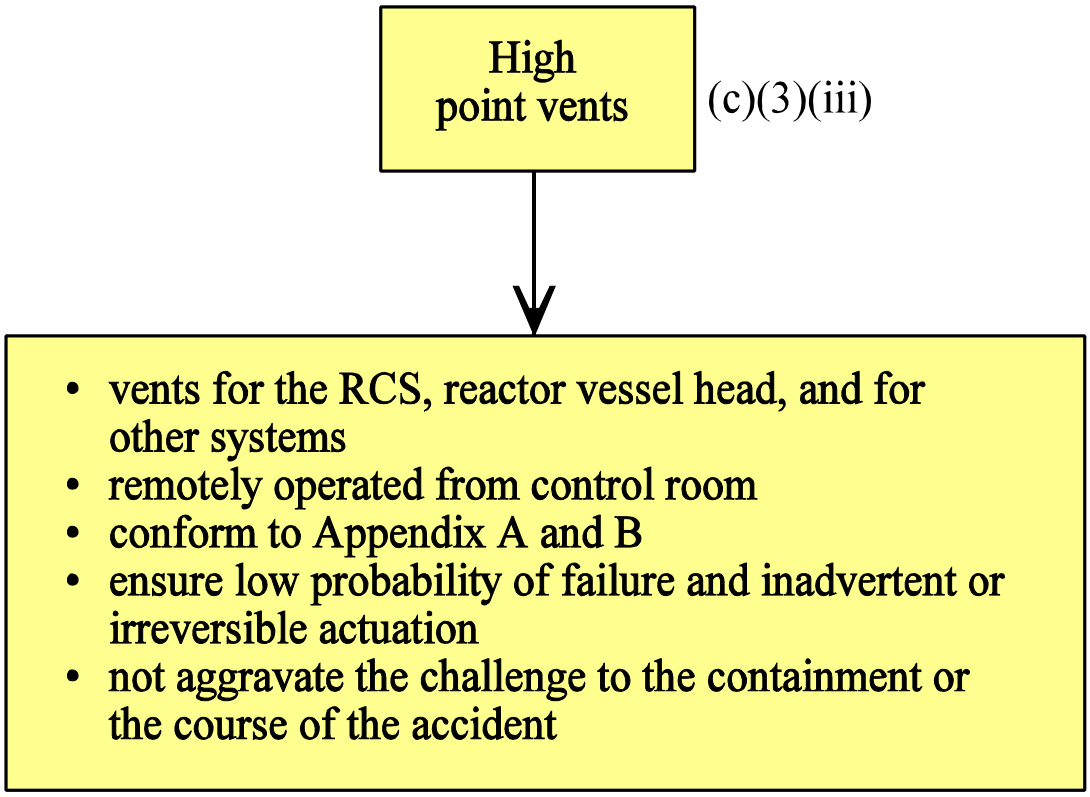
OVERVIEW OF 50.44: 1981 AMENDMENT



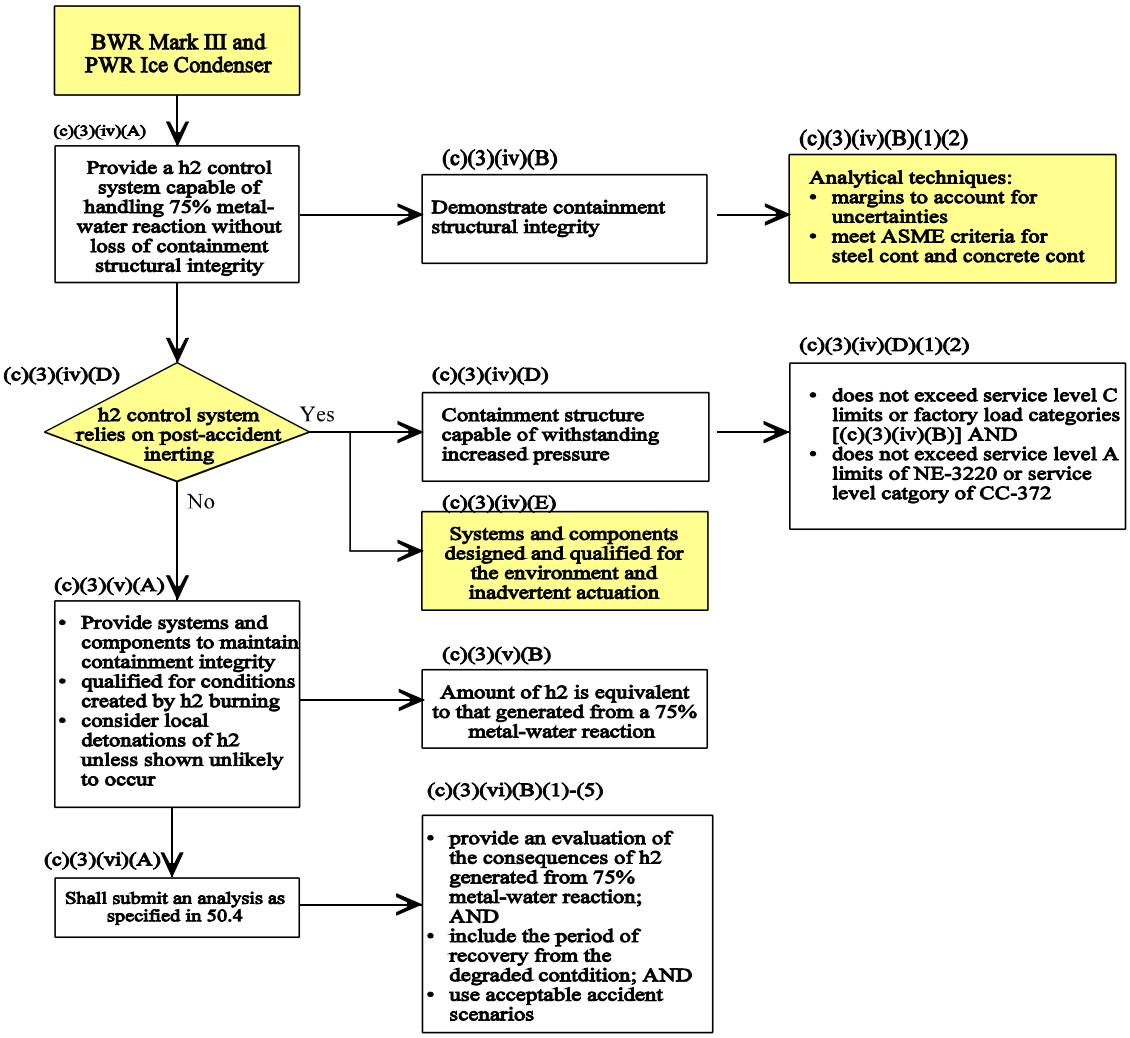
OVERVIEW OF 50.44:
1981 AMENDMENT – RECOMBINERS



OVERVIEW OF 50.44:
1981 AMENDMENT – HIGH POINT VENTS



OVERVIEW OF 50.44: 1985 AMENDMENT



SUMMARY OF RELATED REGULATIONS TO 50.44 (DRAFT)

Referenced Regulation	***Description of Requirement***
50.82(a)(1)	Excludes nuclear power reactor facilities that have certified permanent cessation of operation from purview of 50.44
Criteria 54 & 56 of Appendix A	Applies to containment penetrations for external recombiners 54: provides requirements on piping systems penetrating containment 56: provides requirements on primary containment isolation
Appendix A and B	Design of high point vents and associated controls, instruments, and power sources
50.55a	ASME Codes for steel containments required to demonstrate structural integrity for Mark III and ice condenser plants
50.4	Specifies requirements for written communications from licensees operating Mark III and ice condenser plants that are required to submit accident analyses
100.11(a)(2) Criteria 41,42,43 of Appendix A	Pertains to facilities licensed prior to 5/11/1970 and applies dose based criteria, with doses calculated in accordance with the siting regulation in Part 100 used to develop exclusion area and LPZ boundary distances, to determine if both purging and repressurization systems are needed to comply with GDC 41
50.47, Appendix E	Specifies requirements for hydrogen monitoring as part of the Emergency Response Data System that overlap requirements in 50.44
50.34 (f)	50.34 (f) "Additional TMI-related requirements" establishes requirements for combustible gas control for future plants whose applications for a construction permit or manufacturing license were pending as of 2/16/1982
50.46(b)	Establishes the amount and rate of H2 generated in a postulated LOCA and used in original version of 50.44 for purpose of design of the H2 control system

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(NUREG-0737)

SUMMARY OF IMPLEMENTING DOCUMENTS ASSOCIATED WITH 50.44 (DRAFT)

Referenced Document	***Description of Guideline***
RG 1.7	Provides guidance on implementation of the original version of 50.44, i.e. H2 generation following a LOCA, limited to a maximum metal-water reaction of 5 times the amount calculated to meet the ECCS acceptance criteria, post-accident radiolysis of water, and corrosion.
RG 1.70, Section 6.2.5	Provides guidance on design bases, system designs, and design evaluation of systems to mix the containment atmosphere, monitor combustible gas concentrations within containment regions, and reduce combustible gas concentrations in containment
RG 1.97	Provides guidance on instrumentation to assess plant conditions during an accident, establishes H2 concentration in containment/drywell as a Type C variable, recommends H2 monitors as safety-grade
SRP, Section 6.2.5	
BTP, 6-2 and 6-4	
GL 84-09	Applies to BWR Mark I plants whose notices of hearing on applications for a construction permit were published prior to 11/5/70 and which do not rely on purge or repressurization systems as a primary means of H2 control; removes requirements for recombiners from these plants subject to meeting tech specs on inerting
NUREG-0654	via rg 1.101 rev 2
NUMARC NESP-007, Rev 2	via rg 1.101 rev 3

RISK-INFORMED OPTIONS ***(preliminary)***: *MEASURING HYDROGEN CONCENTRATION*

Supporting Requirements
NONE
Related Regulatory Requirements
• H2 monitors (50.47, Part 50 App E) • Instruments to monitor variables for accident conditions (GDC 13 Part 50 App A) • Technical Specifications on monitor operability and surveillance testing (50.36) • Monitor testing reqmts (GDC 43) • Monitor (safety-grade) procurement and QA reqmts (10 CFR 21, App B)
Supporting Guidance
• Guidance on H2 monitoring, system design bases, evaluation, and classification (RG 1.70, RG 1.97, RG 1.89, SRP 6.2.5, NUREG-0737, NUREG-0718, NUREG-0660, ANSI-ANS 4.5) • Guidance on testing requirements (RG 1.118)

Preliminary options (draft):

- revise to include measuring long term H2 concentration
- remove from 50.44, covered in Appendix E
- modify RG 1.7 to allow commercial grade

RISK-INFORMED OPTIONS ***(preliminary)***: *MIXED CONTAINMENT ATMOSPHERE*

Supporting Requirements
NONE
Related Regulatory Requirements
• Systems to control conc. of H2 & O2 to insure containment integrity (GDC 41) • Tech Specs on mixing systems (50.36)
Supporting Guidance
• Guidance on design bases and evaluation of mixing systems (RG 1.70, SRP 6.2.5)

Preliminary options (draft):

- no change to 50.44
- revise to be consistent with 50.34
- consider possible revision to RG or SRP to address SBO concerns for ice condensers

RISK-INFORMED OPTIONS *(preliminary)*: *CONTROL POST LOCA COMBUSTIBLE GASES*

Supporting Requirements

- Following LOCA show: no uncontrolled H2-O2 recombination or plant could withstand consequences; if not, inert containment (c)(1)(i),(c)(1)(ii),(c)(2)
- If purge/repress. systems are *primary* means of control, provide recombiners; assume H2 equal to 5% metal-water reaction or 5x that needed to comply with 50.46 (c)(3)(ii),(d)(1),(d)(2)
- Containment penetrations for ext. recombiners and purge/repressurization systems (c)(3)(ii)(A),(c)(3)(ii)(B)
- If NOHC received
  - > 11/5/70 require systems other than purge-repress. as primary means of comb gas control (e)
  - < 11/5/70 require only purging systems if certain dose based requirements calculated on basis of 100.11 are met (f,g)

Related Regulatory Requirements

- Amount and rate of H2 generated in LOCA (50.46)
- Reqmts. on containment penetrations for ext. recombiners and purge-repress. systems (GDC 54, 56)
- Quality standards for comb gas control systems (App B)
- Dose calculation methods for 50.44(f,g) compliance (100.11)
- Sharing of external recombiners between units at one site (GDC 5)
- Tech Spec requirements and surveillance testing of recombiners (50.36)
- ISI check valve tests (50.55a)
- Testing of containment penetrations (App J)

Supporting Guidance

- Guidance on H2 generated in metal-water reaction, radiolysis, corrosion (RG 1.7)
- Design and evaluation of systems to reduce comb gas concentrations (RG 1.70, SRP 6.2.5)
- Dedicated penetrations for ext. recombiners or purge systems (NUREG-0737, NUREG-0578, GL 83-02, SECY 80-399)
- Penetration piping leakage surveillance (ASME section XI)
- Quality standards for design, fabrication, erection, and testing (RG 1.26, SRP 6.2.5)
- Designed for SSE (RG 1.29, SRP 6.2.5)
- For inerted Mark I containments with NOHC<11/5/70 that do not rely on purge-repress systems as primary means of H2 control, recombiners not required provided certain TS are met (GL 84-09)
- Containment atmosphere dilution systems considered to be purge systems (NUREG-0737)
- Surveillance reqmts for HEPA filters and charcoal adsorbers in TS on ESF cleanup systems (RG 1.52, GL 83-13)

Preliminary options (draft):

- remove post LOCA hydrogen control from 50.44

RISK-INFORMED OPTIONS *(preliminary)*: *RCS HIGH POINT VENTS*

Supporting Requirements
• vents for the RCS, reactor vessel head and for other systems • remotely operated from control room • conform to Appendix A and B • ensure low probability of failure and inadvertent or irreversible actuation • not aggravate the challenge to the containment or the course of the accident
Related Regulatory Requirements
• Requirements for design of vents and associated systems (App A, App B) • Vent size smaller than LOCA definition (App A)
Supporting Guidance
• Seismic qualification and EQ of vent systems (IEEE 344-1975, RG 1.100, RG 1.92, CLI-80-21) • Guidance on vent system (NUREG-0737, NUREG-0660)

Preliminary options (draft):

- no change to 50.44
- move from 50.44 to ECCS related regulation

RISK-INFORMED OPTIONS ***(preliminary)***: *INERT MARK I & II CONTAINMENTS*

Supporting Requirements
NONE
Related Regulatory Requirements
• Inerting system lines that penetrate containment must meet redundancy and single-failure criteria (GDC 54, 56) • Testing of containment penetrations (App J) • Tech specs on inerting systems (50.36)
Supporting Guidance
• Penetration piping leakage surveillance (ASME section XI)

Preliminary options (draft):

- no change

RISK-INFORMED OPTIONS ***(preliminary)***: *HYDROGEN CONTROL SYSTEM*

Supporting Requirements
• Demonstrate containment structural integrity based on actual material properties or ASME B&PV code (c)(3)(iv)(B) • For H2 control system using post-accident inerting show containment can withstand increased pressure during the accident or following inadvertent full inerting in normal operation (c)(3)(iv)(D) • Reqmts. on systems and components for plants with post-accident inerting control systems (c)(3)(iv)(E) • Reqmts. on systems and components for plants that do not rely on inerting for H2 control (c)(3)(v)(A) • For plants with CP issued <3/28/79 provide evaluation of consequences of H2 using accident scenarios acceptable to NRC that support design of control system (c)(3)(vi)(A), (c)(3)(vi)(B)
Related Regulatory Requirements
• Reference to ASME B&PV code reqmts. for steel containments (50.55) • Written communications on accident analyses (50.4)
Supporting Guidance
• ASME B&PV code sections for steel containment (Section III, Subsubarticle NE-3220, Service Level C limits) • ASME B&PV Code sections for concrete containments (Section III, Subsubarticle CC-3720, Factored Load Category)

Preliminary options (draft):

- no change
- provide H2 control during SBO
  - — igniters operable during SBO
  - — limited set of igniters operable during SBO
- demonstrate frequency of core damage accident without H2 control less than 1E-6
- for all plants, demonstrate that containment will withstand in both short and long term a specified source term (e.g., keep H2 concentration below 10%)

ALTERNATIVE RISK-INFORMED OPTIONS: ***(preliminary)***

Eliminate the problem

- demonstrate that large amounts of combustible gas can not be generated at high temperatures (e.g., selection of reactor core material)

Lower the frequency of the problem

- demonstrate the frequency of core damage accidents that result in hydrogen generation is very low

⇨ *unlikely due to cost-benefit*

ALTERNATIVE RISK-INFORMED OPTIONS: ***(preliminary)***

- demonstrate the probability of containment failure from combustible gases to be less than 0.1 for each core melt accident type

if not,

- demonstrate the conditional probability of early containment failure from combustible gases to be less than 0.1 for each core melt accident type

AND

- demonstrate the conditional probability of large late release from combustible gases to be less than 0.1 for each core melt accident type

if not,

- demonstrate the large early release frequency from combustible gases to be less than 10^{-6} for each core melt accident type

AND

- demonstrate the large late release frequency from combustible gases to be less than 10^{-6} for each core melt accident type

- for each option, guidance to be specified on H2 source term and compliance methods

if not,

- demonstrate adequate emergency preparedness for core melt accident types for which the above criteria are not met

- compliance guidance to be specified

SCHEDULE

May 17	public meeting on 50.44
June 29	ACRS sub-committee on 50.44 and framework
July 12-14	ACRS full committee on 50.44 and framework
July ??	Public meeting ???
Aug 30	Recommendations due to Commission