Pillars of Emergency Preparedness

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Objective of Radiological Emergency Preparedness

- The objective of emergency preparedness (EP) is to provide dose savings for a spectrum of accidents that could produce doses in excess of the Environment Protection Agency (EPA) protective action guides (PAG)
- NRC EP regulations provide reasonable assurance that adequate protective measures can and will be taken in the event of a radiological emergency
  - Reasonable assurance finding is made before a nuclear facility is licensed
  - Inspected over the lifetime of that facility

What's changed over 40 years?

Technology is Advancing

- Advanced light water reactors, non-light water reactors, and small modular reactors (SMR) with passive safety features, microreactors, accident tolerant fuels, and other new technologies (ONT)
- Technology important to Emergency Preparedness (e.g., IPAWS, artificial intelligence)

Knowledge is Increasing

- Better understanding of actual effects of radiation
- Research to inform protective action decision-making
- Lessons learned from real world events

Regulations and Guidance are Evolving

- NRC has a vision to become a modern risk-informed regulator
- Nuclear Energy Innovation and Modernization Act (NEIMA)
- EP rulemaking for SMR & ONT and decommissioning power reactors

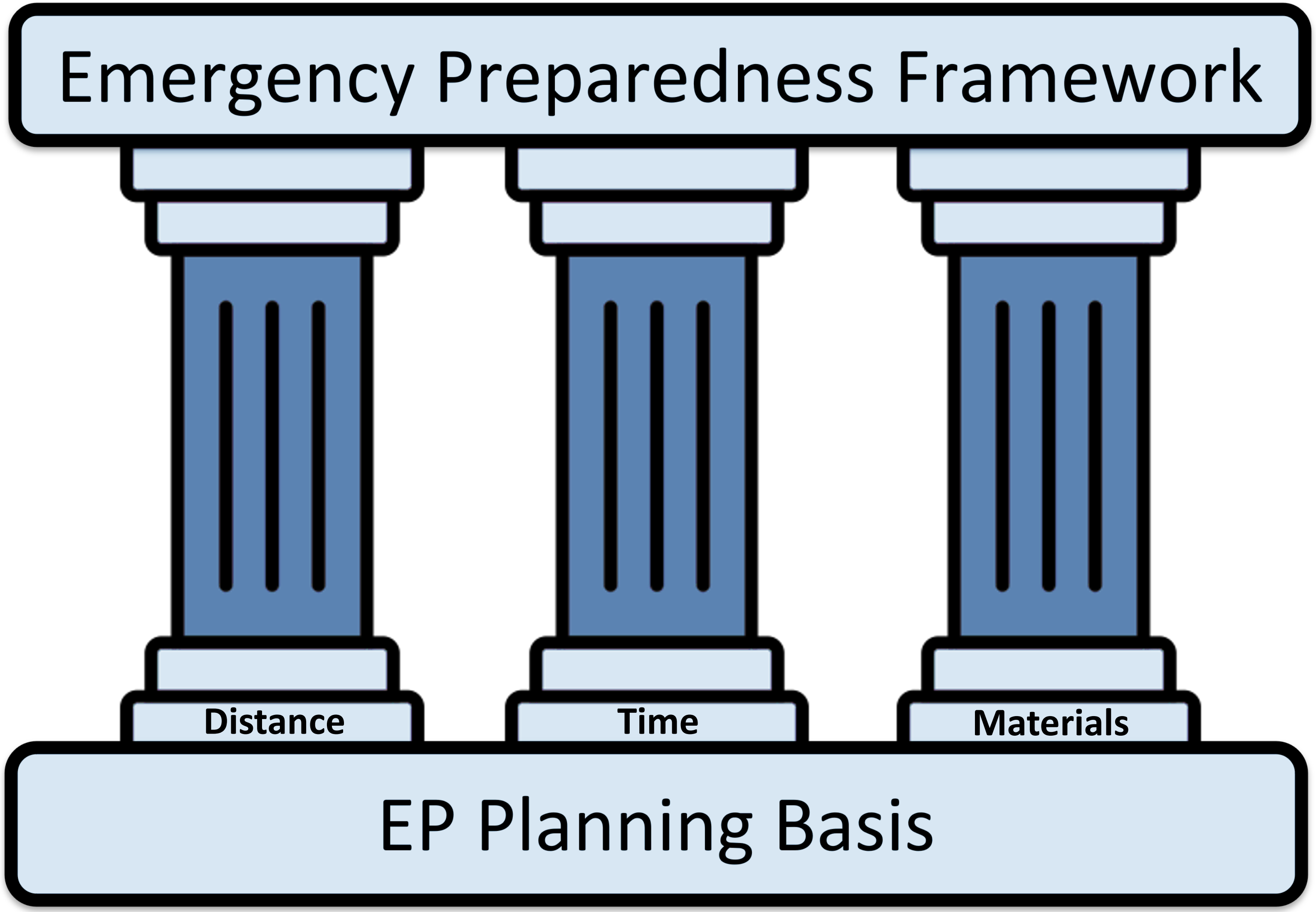
What about…?

A robust defense-in-depth strategy includes EP

- Defense-in-depth is an approach to designing and operating nuclear facilities that prevents and mitigates accidents that release radiation or hazardous materials.
- Provides multiple independent and redundant layers of defense to compensate for potential human and mechanical failures so that no single layer, no matter how robust, is exclusively relied upon.
- EP is required as a final, independent layer of defense-in-depth

The NRC employs a graded approach to EP

- A graded approach is a risk-informed process in which the safety requirements and criteria are set commensurate to the risk of the facility
- EP regulations employ a graded approach to provide the same level of protection
  - Power reactors (low-power testing, power operations, decommissioning)
  - Research and test reactors
  - Fuel Fabrication Facilities
  - Independent Spent Fuel Storage Installations
  - Monitored Retrievable Storage


Emergency Preparedness Framework
Distance
Time
Materials
EP Planning Basis

NUREG-0396 Planning Basis for EP

Pillars of EP:

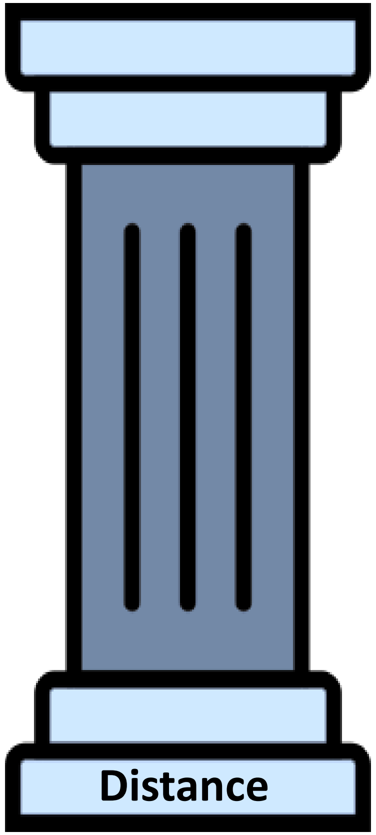
The consequences from a spectrum of accidents, tempered by probability considerations, should be considered to scope the planning efforts for:

- *The **distance** to which planning for predetermined protective actions is warranted*
- *The **time** dependent characteristics of a potential release*
- *The type of radioactive **materials***

NUREG-0396, "Planning Basis for the Development of State and Local Government Radiological Emergency Response Plans in Support of Light Water Nuclear Power Plants," November 1978

Planning Distance

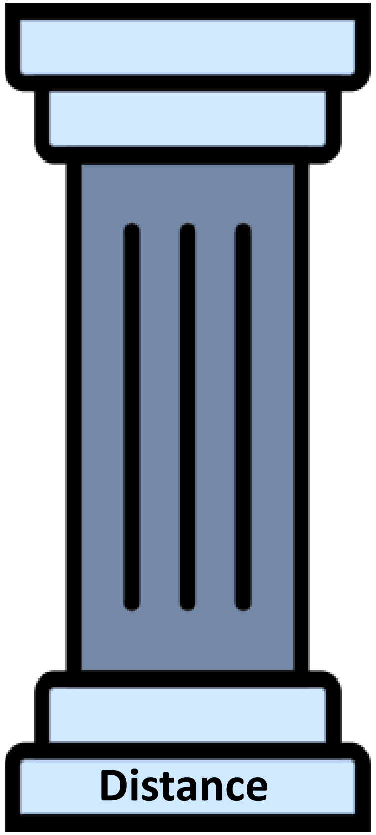
*The **distance** to which planning for predetermined protective actions is warranted*



- EPZ size is based on the consequences from a spectrum of accidents, tempered by probability considerations.
- NRC regulations provide for scalable EPZs
  - Reactors have been approved for a 5-mile EPZ in the past
- Depending on facility type, the EPZ may be at the site-boundary or no EPZ
- Considerable number of studies since the 1980s on sizing EPZs for passive and advanced reactor designs all based on NUREG-0396 methodology

EP ≠ EPZ

The EPZ is a planning tool



Pillars of EP:

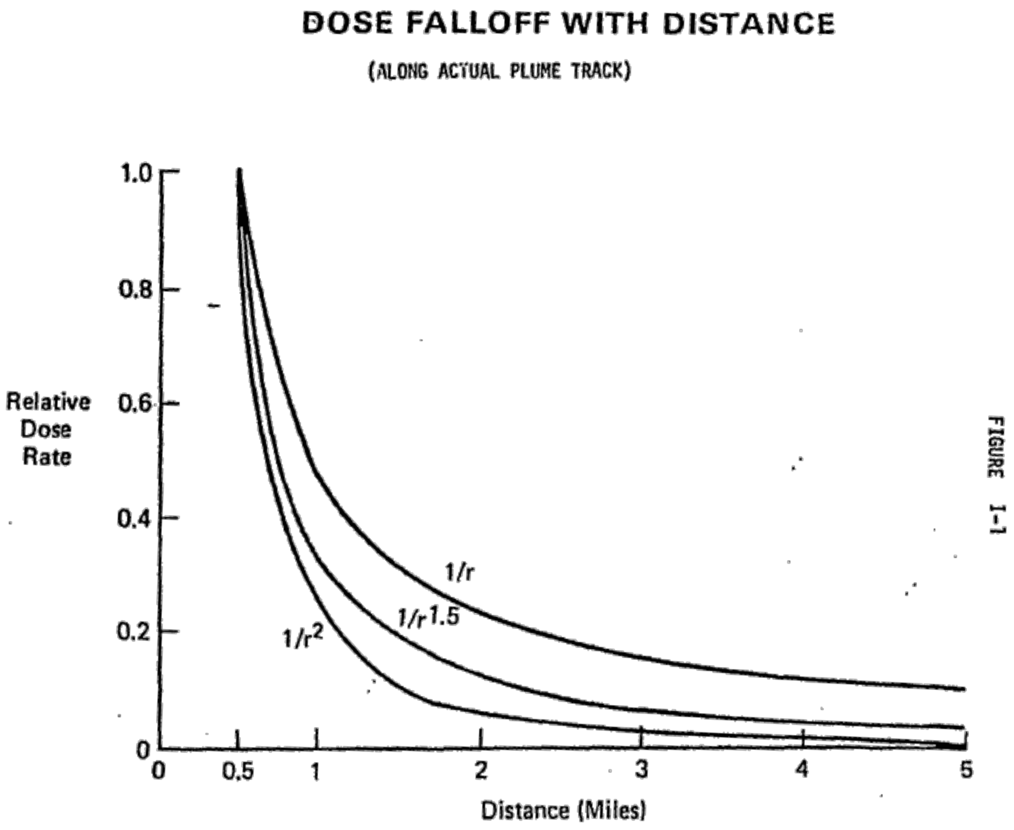
"…it was the consensus of the Task Force that emergency plans could be based upon a generic distance out to which predetermined actions would provide dose savings…"

"The EPZ guidance does not change the requirements for emergency planning, it only sets bounds on the planning problem."

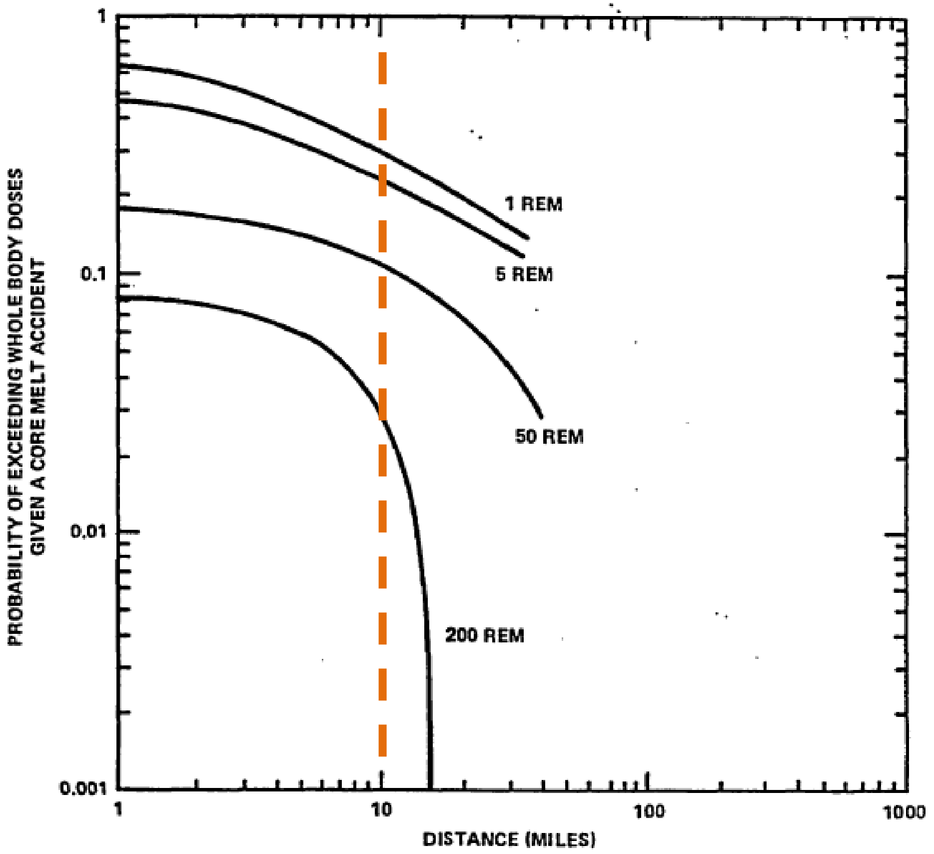
"…beyond the generic distance it was concluded that actions could be taken on an ad hoc basis…"

NUREG-0396, "Planning Basis for the Development of State and Local Government Radiological Emergency Response Plans in Support of Light Water Nuclear Power Plants," November 1978

The EPZ size is risk-informed



Design Basis Accidents



Beyond Design Basis

NUREG-0396, “Planning Basis for the Development of State and Local Government Radiological Emergency Response Plans in Support of Light Water Nuclear Power Plants,” November 1978

What's the likelihood of events considered?

TABLE V 2-1 SUMMARY OF ACCIDENTS INVOLVING CORE

RELEASE CATEGORY	PROBABILITY per Reactor-Yr	TIME OF RELEASE (Hr)	DURATION OF RELEASE (Hr)	WARNING TIME FOR EVACUATION (Hr)	ELEVATION OF RELEASE (Meters)	CONTAINMENT ENERGY RELEASE (10^6 Btu/Hr)	FRACTION OF CORE INVENTORY RELEASED[a]							
							Xe-Kr	Org. I	I	Cs-Rb	Te-Sb	Ba-Sr	Ru[b]	La[c]
PWR 1	$9x10^{-7}$	2.5	0.5	1.0	25	520[d]	0.9	$6x10^{-3}$	0.7	0.4	0.4	0.05	0.4	$3x10^{-3}$
PWR 2	$8x10^{-6}$	2.5	0.5	1.0	0	170	0.9	$7x10^{-3}$	0.7	0.5	0.3	0.06	0.02	$4x10^{-3}$
PWR 3	$4x10^{-6}$	5.0	1.5	2.0	0	6	0.8	$6x10^{-3}$	0.2	0.2	0.3	0.02	0.03	$3x10^{-3}$
PWR 4	$5x10^{-7}$	2.0	3.0	2.0	0	1	0.6	$2x10^{-3}$	0.09	0.04	0.03	$5x10^{-3}$	$3x10^{-3}$	$4x10^{-4}$
PWR 5	$7x10^{-7}$	2.0	4.0	1.0	0	0.3	0.3	$2x10^{-3}$	0.03	$9x10^{-3}$	$5x10^{-3}$	$1x10^{-3}$	$6x10^{-4}$	$7x10^{-5}$
PWR 6	$6x10^{-6}$	12.0	10.0	1.0	0	N/A	0.3	$2x10^{-3}$	$8x10^{-4}$	$8x10^{-4}$	$1x10^{-3}$	$9x10^{-5}$	$7x10^{-5}$	$1x10^{-5}$
PWR 7	$4x10^{-5}$	10.0	10.0	1.0	0	N/A	$6x10^{-3}$	$2x10^{-5}$	$2x10^{-5}$	$1x10^{-5}$	$2x10^{-5}$	$1x10^{-6}$	$1x10^{-6}$	$2x10^{-7}$
PWR 8	$4x10^{-5}$	0.5	0.5	N/A	0	N/A	$2x10^{-3}$	$5x10^{-6}$	$1x10^{-4}$	$5x10^{-4}$	$1x10^{-6}$	$1x10^{-8}$	0	0
PWR 9	$4x10^{-4}$	0.5	0.5	N/A	0	N/A	$3x10^{-6}$	$7x10^{-9}$	$1x10^{-7}$	$6x10^{-7}$	$1x10^{-9}$	$1x10^{-11}$	0	0
BWR 1	$1x10^{-6}$	2.0	2.0	1.5	25	130	1.0	$7x10^{-3}$	0.40	0.40	0.70	0.05	0.5	$5x10^{-3}$
BWR 2	$6x10^{-6}$	30.0	3.0	2.0	0	30	1.0	$7x10^{-3}$	0.90	0.50	0.30	0.10	0.03	$4x10^{-3}$
BWR 3	$2x10^{-5}$	30.0	3.0	2.0	25	20	1.0	$7x10^{-3}$	0.10	0.10	0.30	0.01	0.02	$3x10^{-3}$
BWR 4	$2x10^{-6}$	5.0	2.0	2.0	25	N/A	0.6	$7x10^{-4}$	$8x10^{-4}$	$5x10^{-3}$	$4x10^{-3}$	$6x10^{-4}$	$6x10^{-4}$	$1x10^{-4}$
BWR 5	$1x10^{-4}$	3.5	5.0	N/A	150	N/A	$5x10^{-4}$	$2x10^{-9}$	$6x10^{-11}$	$4x10^{-9}$	$8x10^{-12}$	$8x10^{-14}$	0	0

NUREG-075/014 (WASH-1400), "Reactor Safety Study: An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants," October 1975

...down to 1 chance in 10 lifetimes of the universe

TABLE V 3-4 PWR LARGE LOCA ACCIDENT SEQUENCES vs. RELEASE CATEGORIES

Core melt | No core melt

Release Categories									
	1	2	3	4	5	6	7	8	9
Dominant Large LOCA Accident Sequences With Point Estimates	AB-α $1x10^{-11}$ AF-α $1x10^{-10}$ ACD-α $5x10^{-11}$ AG-α $9x10^{-11}$	AB-γ $1x10^{-10}$ AHF-γ $2x10^{-11}$ AB-δ $4x 10^{-11}$	AD-α $2x10^{-8}$ AH-α $1x10^{-8}$ AF-δ $1x10^{-8}$ AG-δ $9x10^{-9}$	ACD-β $1x10^{-11}$	AD-β $4x10^{-9}$ AH-β $3x10^{-9}$	AB-ε $1x10^{9}$ ADF-ε $2x10^{-10}$ AHF-ε $1x10^{-10}$	AD-ε $2x10^{-6}$ AH-ε $1x10^{-6}$	A-β $2x10^{-7}$	A $1x10^{-4}$
Other Large LOCA Accident Sequences	ACDGI-α AHFI-α ACHF-α ACDI-α ACDG-α AGI-α AFI-α ACG-α ACGI-α ACF-α ACDF-α ACEI-α ACEG-α ACEGI-α ACEF-α ACE-α AHF-α	ADF-β AHFI-δ ACHF-δ ACHF-γ ACDF-γ ACEF-γ AHFI-β ADFI-β ACHF-β ACDF-β AHF-δ AHFI-γ AEF-β AEFI-β ACEF-β AEF-δ AEFI-δ ACEF-δ AB-β AHF-β	AHG-α AHGI-α ADF-α ADFI-α ACH-α ACHI-α ACHG-α ACHGI-α AGI-δ AFI-δ ACG-δ ACGI-δ ACF-δ AHI-α ADGI-α ADI-α ADG-α AE-α AEI-α AEF-α AEFI-α AEG-α AEGI-α	ACDGI-β ADG- β ACDI-β ACDG-β ADGI- β ACE- β ACEI- β ACEG- β ACEGI-β AEG-β AEGI-β	AHI- β AHG- β AHGI-β ADI-β ACH-β ACHI-β ACHG-β AE- β AEI-β	ACHGI- ε AHFI- ε ADFI- ε ACDF- ε ACDGI-ε ACHF- ε AEF- ε AEFI-ε ACEF-ε ACEGI-ε	AHG-δ AHGI- δ AHGI- ε ACH-ε ACHI- ε ACHG- δ ACHG- ε ACHGI- ε ACDI- ε ACDG- δ ACDG- ε ADG- δ ADGI-δ AHG- ε ADI- ε ADG- ε ACD-ε ADGI-ε AHI-ε AE-ε AEI-ε ACE-ε ACEI-ε ACEG-ε ACEG-δ ACEGI-δ ACHGI-δ AEG-δ AEGI-δ AEG-ε AEGI-ε	AI-β AC-β ACI-β	AI AC ACI
$A\Sigma_P^{(a)}$	$3 x 10^{-10}$	$2 x 10^{-10}$	$5 x 10^{-8}$	$1 x 10^{-11}$	$7 x 10^{-9}$	$1 x 10^{-9}$	$3 x 10^{-6}$	$2 x 10^{-7}$	$1 x 10^{-4}$

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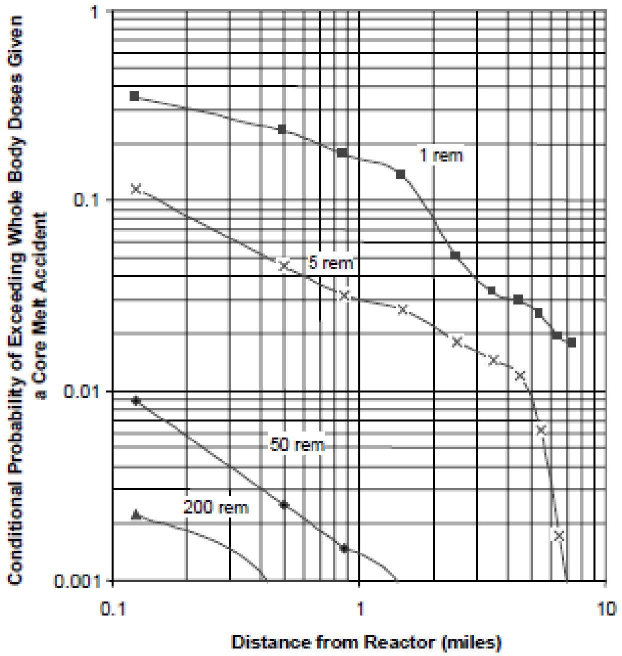
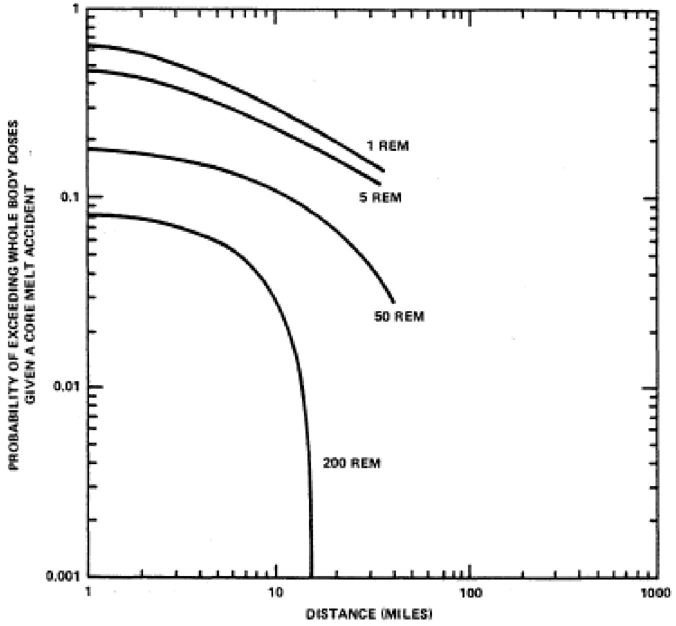
Other Large LOCA Accident Sequences	ACDGI-α AHFI-α ACHF-α ACDI-α ACDG-α AGI-α AFI-α ACG-α ACGI-α ACF-α ACDF-α ACEI-α ACEG-α ACEGI-α ACEF-α ACE-α AHF-α	ADF-β AHFI-δ ACHF-δ ACHF-γ ACDF-γ ACEF-γ AHFI-β ADFI-β ACHF-β ACDF-β AHF-δ AHFI-γ AEF-β AEFI-β ACEF-β AEF-δ AEFI-δ ACEF-δ AB-β AHF-β	AHG-α AHGI-α ADF-α ADFI-α ACH-α ACHI-α ACHG-α ACHGI-α AGI-δ AFI-δ ACG-δ ACGI-δ ACF-δ AHI-α ADGI-α ADI-α ADG-α AE-α AEI-α AEF-α AEFI-α AEG-α AEGI-α	ACDGI-β ADG- β ACDI-β ACDG-β ADGI- β ACE- β ACEI- β ACEG- β ACEGI-β AEG-β AEGI-β	AHI- β AHG- β AHGI-β ADI-β ACH-β ACHI-β ACHG-β AE- β AEI-β	ACHGI- ε AHFI- ε ADFI- ε ACDF- ε ACDGI-ε ACHF- ε AEF- ε AEFI-ε ACEF-ε ACEGI-ε	AHG-δ AHGI- δ AHGI- ε ACH-ε ACHI- ε ACHG- δ ACHG- ε ACHGI- ε ACDI- ε ACDG- δ ACDG- ε ADG- δ ADGI-δ AHG- ε ADI- ε ADG- ε ACD-ε ADGI-ε AHI-ε AE-ε AEI-ε ACE-ε ACEI-ε ACEG-ε ACEG-δ ACEGI-δ ACHGI-δ AEG-δ AEGI-δ AEG-ε AEGI-ε	AI-β AC-β ACI-β	AI AC ACI
$A\Sigma_P^{(a)}$	$3 x 10^{-10}$	$2 x 10^{-10}$	$5 x 10^{-8}$	$1 x 10^{-11}$	$7 x 10^{-9}$	$1 x 10^{-9}$	$3 x 10^{-6}$	$2 x 10^{-7}$	$1 x 10^{-4}$

NUREG-075/014 (WASH-1400), “Reactor Safety Study: An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants,” October 1975

EPZ size methodology can be applied to any facility





	ALWR (0.5 mile)	NUREG-0396, Fig I-11 (10 miles)
Cond. prob. of exceeding 1 rem	0.25	0.3
Cond. prob. of exceeding 5 rem	0.06	0.25
Cond. prob. of exceeding 50 rem	0.006	0.1
Cond. prob. of exceeding 200 rem	<0.001	0.01 – 0.001

EPRI TR-113509, “Technical Aspects of ALWR Emergency Planning,” Final Report, September 1999

Uncertainty can be quantified and bounded

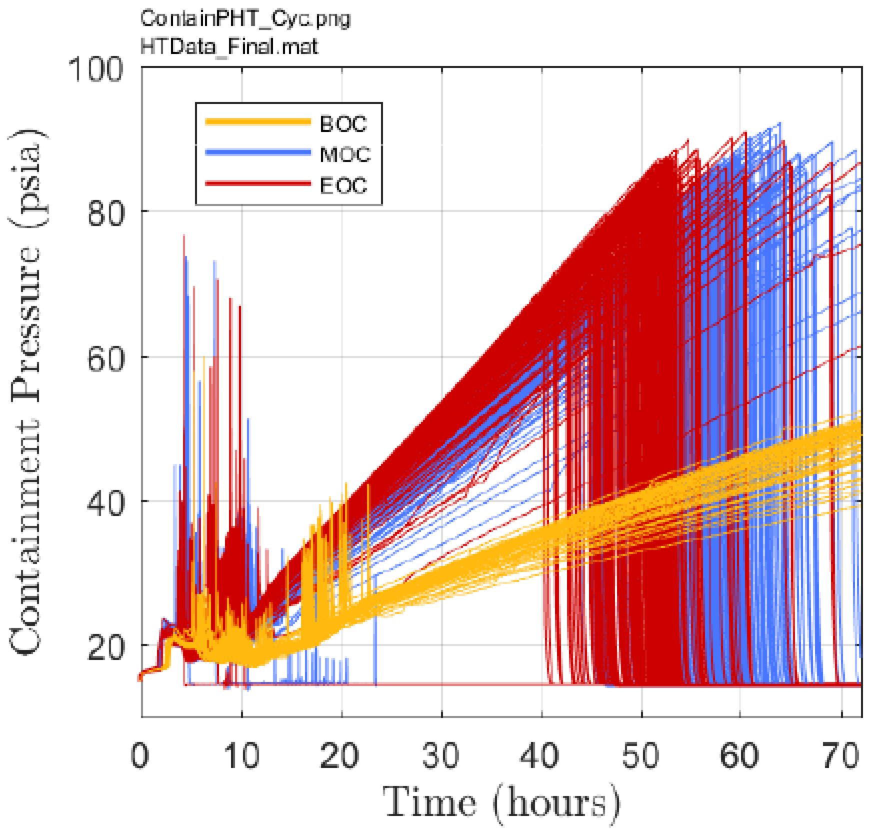


Figure ES-2 Containment pressure response for the STSBO UA realizations.

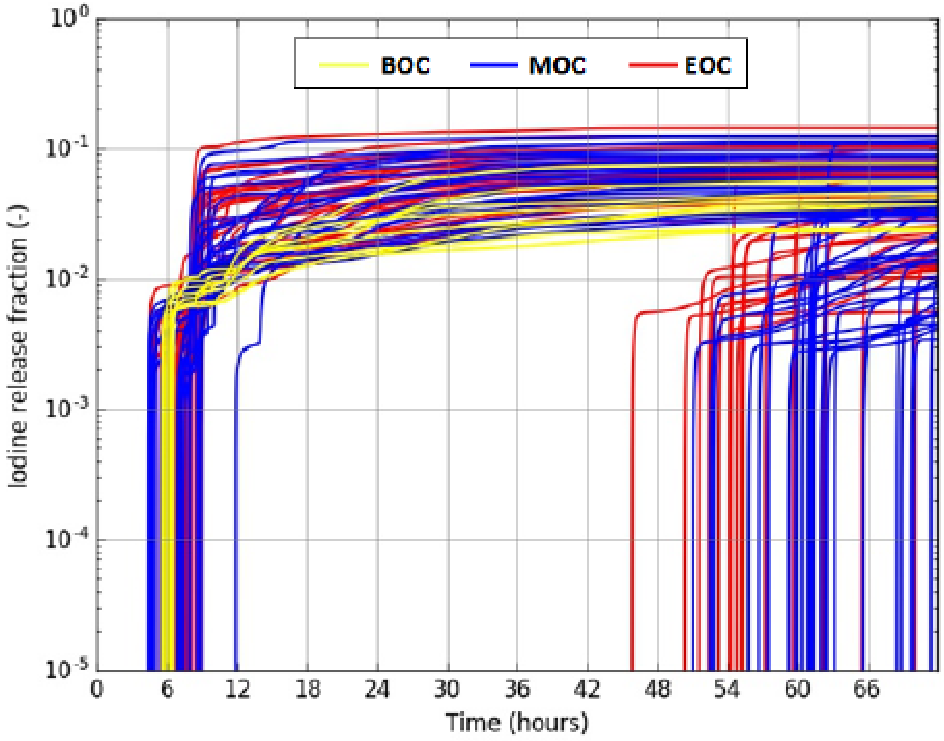


Figure I-15 Iodine release fraction versus time.

NUREG/CR-7245, "State-of-the-Art Reactor Consequence Analyses (SOARCA) Project: Sequoyah Integrated Deterministic and Uncertainty Analyses," October 2019

Planning Time

*The **time** dependent characteristics of a potential release*

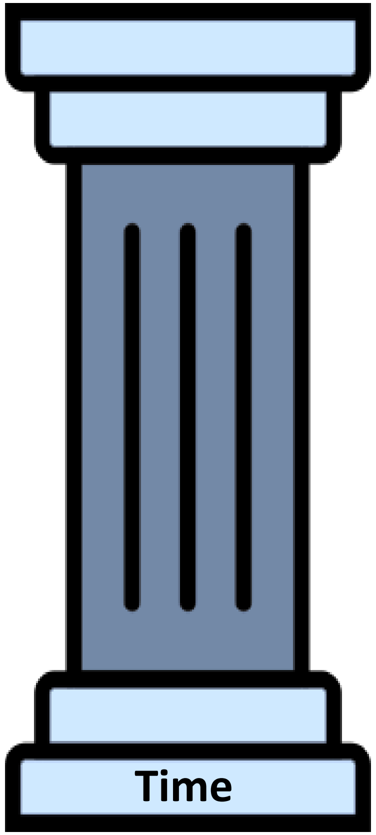


Table 2 - Guidance on Initiation and Duration of Release

Time from the initiating event to start of atmospheric release	0.5 hours to one day
Time period over which radioactive material may be continuously released	0.5 hours to several days
Time at which major portion of release may occur	0.5 hours to 1 day after start of release
Travel time for release to exposure point (time after release)	5 miles - - 0.5 to 2 hours 10 miles - - 1 to 4 hours

NUREG-0396, "Planning Basis for the Development of State and Local Government Radiological Emergency Response Plans in Support of Light Water Nuclear Power Plants," November 1978

Conservatively bounds timing of severe accidents

TABLE V 2-1 SUMMARY OF ACCIDENTS INVOLVING CORE

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							Xe-Kr	Org. I	I	Cs-Rb	Te-Sb	Ba-Sr	Ru[b]	La[c]
PWR 1	$9x10^{-7}$	2.5	0.5	1.0	25	520[d]	0.9	$6x10^{-3}$	0.7	0.4	0.4	0.05	0.4	$3x10^{-3}$
PWR 2	$8x10^{-6}$	2.5	0.5	1.0	0	170	0.9	$7x10^{-3}$	0.7	0.5	0.3	0.06	0.02	$4x10^{-3}$
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PWR 4	$5x10^{-7}$	2.0	3.0	2.0	0	1	0.6	$2x10^{-3}$	0.09	0.04	0.03	$5x10^{-3}$	$3x10^{-3}$	$4x10^{-4}$
PWR 5	$7x10^{-7}$	2.0	4.0	1.0	0	0.3	0.3	$2x10^{-3}$	0.03	$9x10^{-3}$	$5x10^{-3}$	$1x10^{-3}$	$6x10^{-4}$	$7x10^{-5}$
PWR 6	$6x10^{-6}$	12.0	10.0	1.0	0	N/A	0.3	$2x10^{-3}$	$8x10^{-4}$	$8x10^{-4}$	$1x10^{-3}$	$9x10^{-5}$	$7x10^{-5}$	$1x10^{-5}$
PWR 7	$4x10^{-5}$	10.0	10.0	1.0	0	N/A	$6x10^{-3}$	$2x10^{-5}$	$2x10^{-5}$	$1x10^{-5}$	$2x10^{-5}$	$1x10^{-6}$	$1x10^{-6}$	$2x10^{-7}$
PWR 8	$4x10^{-5}$	0.5	0.5	N/A	0	N/A	$2x10^{-3}$	$5x10^{-6}$	$1x10^{-4}$	$5x10^{-4}$	$1x10^{-6}$	$1x10^{-8}$	0	0
PWR 9	$4x10^{-4}$	0.5	0.5	N/A	0	N/A	$3x10^{-6}$	$7x10^{-9}$	$1x10^{-7}$	$6x10^{-7}$	$1x10^{-9}$	$1x10^{-11}$	0	0
BWR 1	$1x10^{-6}$	2.0	2.0	1.5	25	130	1.0	$7x10^{-3}$	0.40	0.40	0.70	0.05	0.5	$5x10^{-3}$
BWR 2	$6x10^{-6}$	30.0	3.0	2.0	0	30	1.0	$7x10^{-3}$	0.90	0.50	0.30	0.10	0.03	$4x10^{-3}$
BWR 3	$2x10^{-5}$	30.0	3.0	2.0	25	20	1.0	$7x10^{-3}$	0.10	0.10	0.30	0.01	0.02	$3x10^{-3}$
BWR 4	$2x10^{-6}$	5.0	2.0	2.0	25	N/A	0.6	$7x10^{-4}$	$8x10^{-4}$	$5x10^{-3}$	$4x10^{-3}$	$6x10^{-4}$	$6x10^{-4}$	$1x10^{-4}$
BWR 5	$1x10^{-4}$	3.5	5.0	N/A	150	N/A	$5x10^{-4}$	$2x10^{-9}$	$6x10^{-11}$	$4x10^{-9}$	$8x10^{-12}$	$8x10^{-14}$	0	0

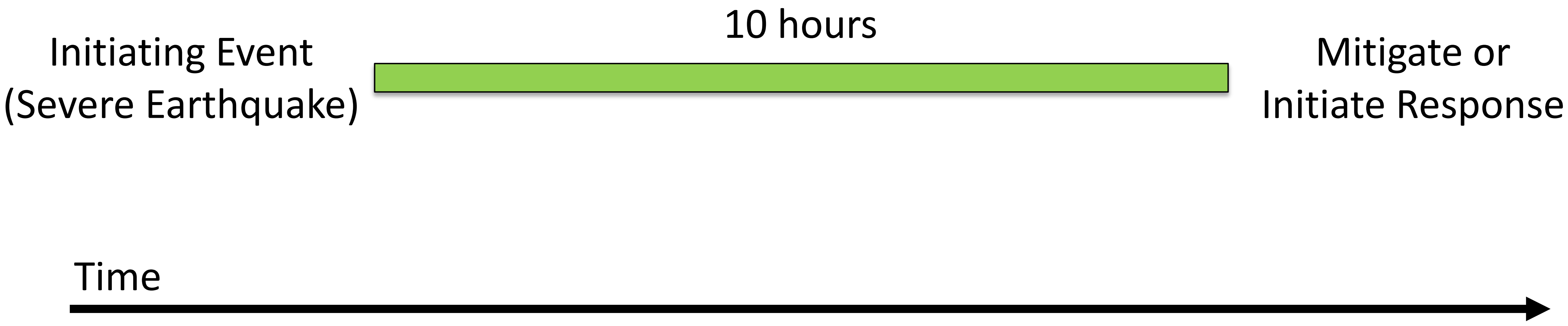
NUREG-075/014 (WASH-1400), "Reactor Safety Study: An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants," October 1975

***<u>Time</u>* basis informs functional requirements**

- …nuclear power reactor licensees shall establish and maintain the capability to assess, classify, and declare an emergency condition within **15 minutes** after the availability of indications to plant operators that an emergency action level has been exceeded…
- A licensee shall have the capability to notify responsible State and local governmental agencies within **15 minutes** after declaring an emergency.
- The design objective of the prompt public alert and notification system shall be to have the capability to essentially complete the initial alerting and initiate notification of the public within the plume exposure pathway EPZ within about **15 minutes**.

Applying the Time basis to regulation

Proposed rule for power reactors based on the reduction in risk at four levels of decommissioning, including the time when spent fuel has sufficiently decayed such that it would not reach self-ignition temperature in 10 hours under adiabatic heatup conditions



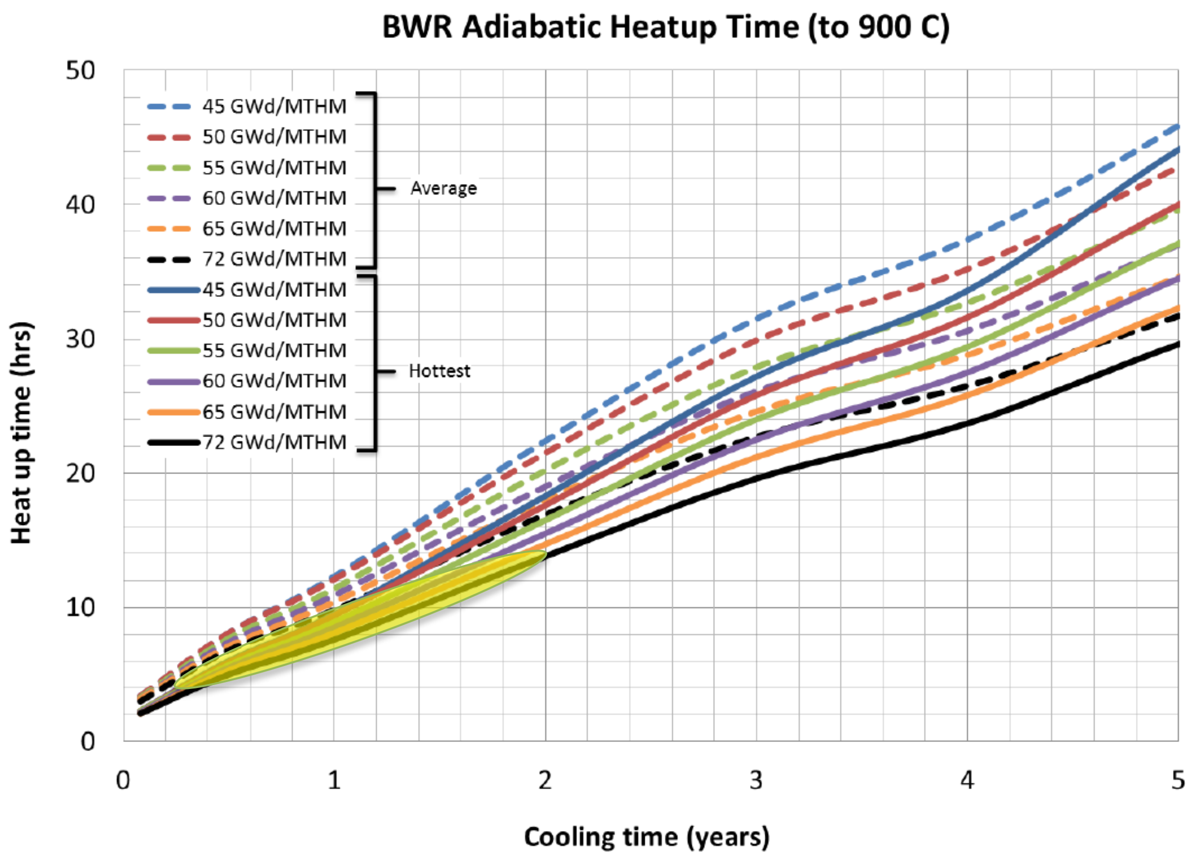
Conservatively assumes spent fuel pool damaged and drains instantaneously

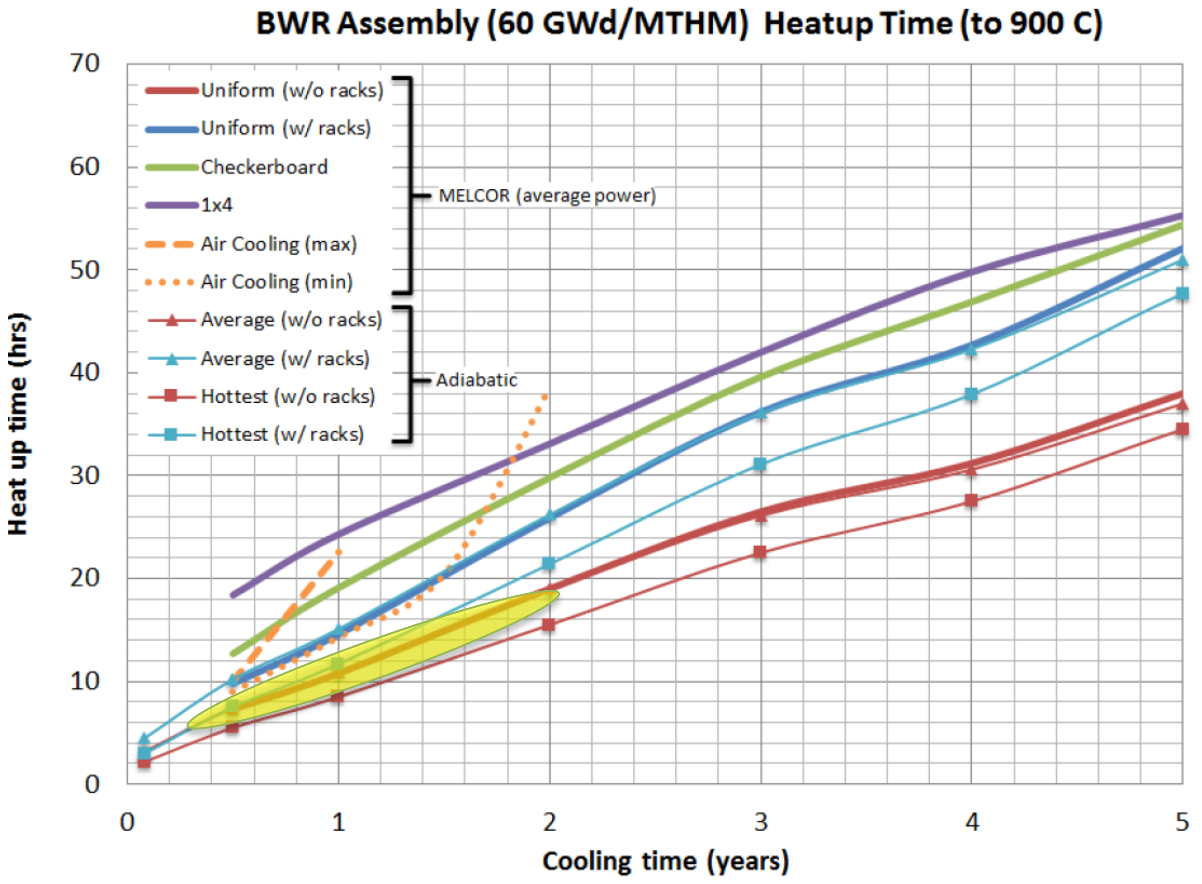
Table 41 Approximate Time of Fuel Uncovery

Time	No Leak	Small Leak	Moderate Leak
OCPs 1 and 2	> 7 days	40 hours	6 hours
OCPs 3, 4, and 5	> 7 days	19 hours	2.5 hours

NUREG-2161, “Consequence Study of a Beyond-Design-Basis Earthquake Affecting the Spent Fuel Pool for a U.S. Mark I Boiling Water Reactor,” September 2014

Conservatively assumes unfavorable heat transfer





Conservatively assumes instantaneous release

Table 2. Time to exceed threshold dose (2.3 Gy-eq) for hematopoietic syndrome, 10% of threshold dose for hematopoietic syndrome (0.23 Gy-eq), and PAG limit (0.05 Sv TEDE)

Source Term		0.1 mi	1 mi	5 mi
OCP 3.4 HD	Red Bone Marrow Dose > 2.32 Gy-Eq	> 24 hrs	> 24 hrs	> 24 hrs
	Red Bone Marrow Dose > 0.23 Gy-Eq	16-17 hrs	> 24 hrs	> 24 hrs
	Whole Body ED > 0.05 Sv	3-4 hrs	6-7 hrs	9-10 hrs
OCP 3.6 HD (RB open at 16.9 hrs)	Red Bone Marrow Dose > 2.32 Gy-Eq	> 24 hrs	> 24 hrs	> 24 hrs
	Red Bone Marrow Dose > 0.23 Gy-Eq	14-15 hrs	> 24 hrs	> 24 hrs
	Whole Body ED > 0.05 Sv	< 1 hr	2-3 hrs	8-9 hrs

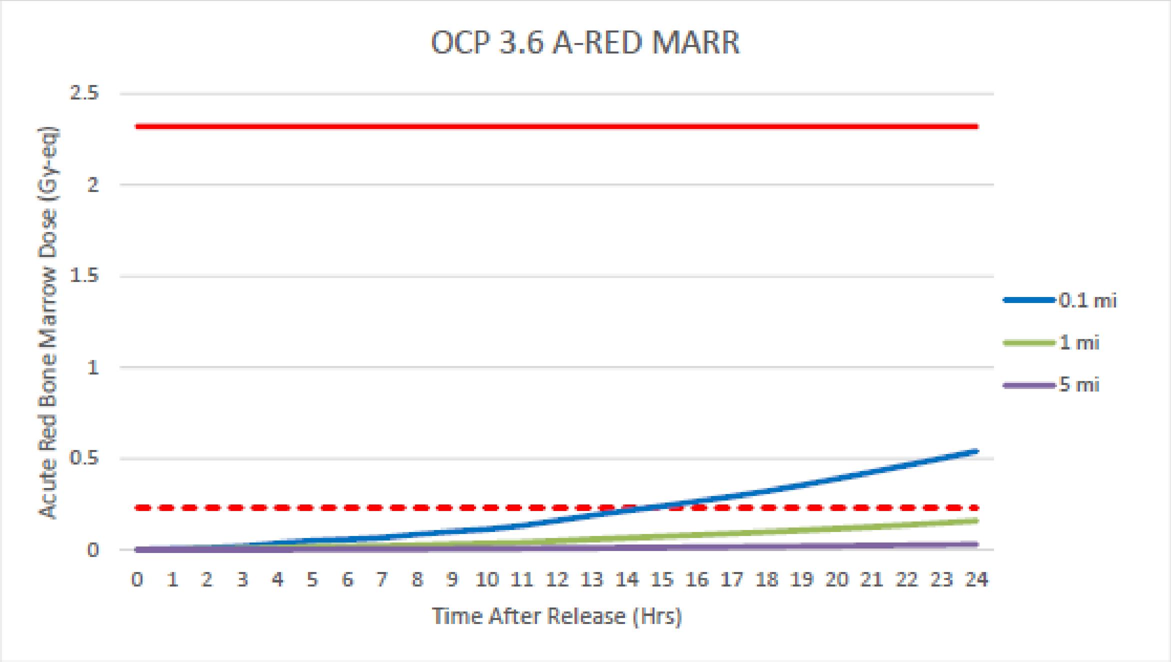
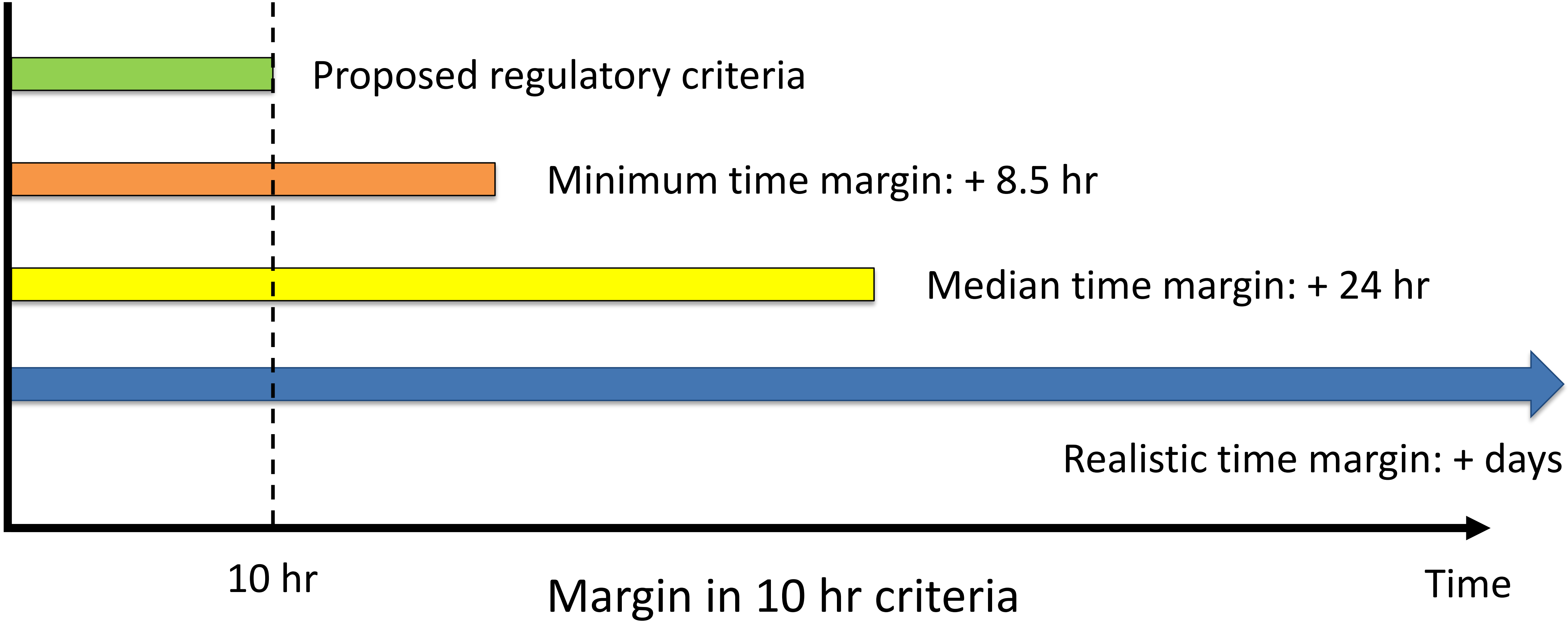


Figure 2: Cumulative acute bone marrow dose received at 0.1 mile, 1 mile, and 5 miles from the release point. Dashed line at 0.23 Gy-eq represents 1/10 of threshold dose for hematopoietic syndrome; solid line at 2.3 Gy-eq represents the threshold dose.

Transmittal of Reports to Inform Decommissioning Plant Rulemaking for User Need Request NSIR-2015-001, dated May 31, 2016 (ADAMS Accession No. ML16110A416)

Conservative regulations cover uncertainty



Release Characteristics

*The type of radioactive **materials***

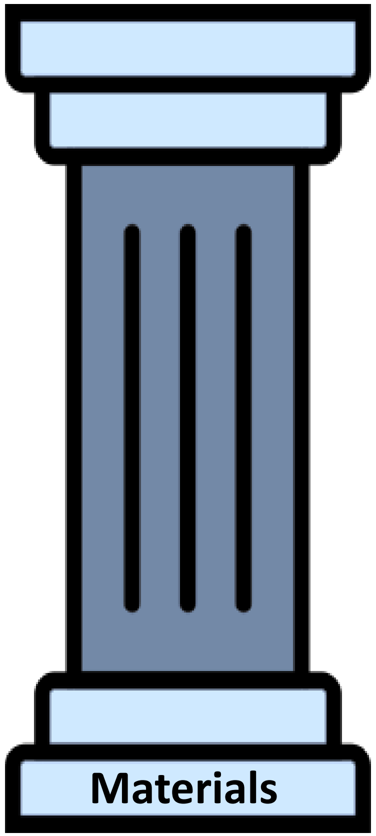


Table 3

RADIONUCLIDES WITH SIGNIFICANT CONTRIBUTION TO DOMINANT EXPOSURE MODES

Radionuclides with Significant Contribution to Thyroid Exposure

Radionuclide	Half Life (days)
I-131	8.05
I-132	0.0858
I-133	0.875
I-134	0.0366
I-135	.028
Te-132	3.25
Kr-88	0.117

Radionuclides with Significant Contribution to Whole Body Exposure

Radionuclide	Half Life (days)
I-131	8.05
Te-132	3.25
Xe-133	5.28
I-133	0.875
Xe-135	0.384
I-135	.028
Cs-134	750
Kr-88	0.117
Cs-137	11,000

Radionuclides with Significant Contribution to Lung Exposure* (Lung only controlling when thyroid dose is reduced by iodine blocking or there is a long delay prior to releases).

Radionuclide	Half Life (days)
I-131	8.05
I-132	0.0858
I-133	0.875
I-134	0.0366
I-135	.028
Cs-134	750
Kr-88	0.117
Cs-137	11,000
Ru-106	365
Te-132	3.25
Ce-144	284

NUREG-0396, "Planning Basis for the Development of State and Local Government Radiological Emergency Response Plans in Support of Light Water Nuclear Power Plants," November 1978

Our understanding of accidents has evolved…

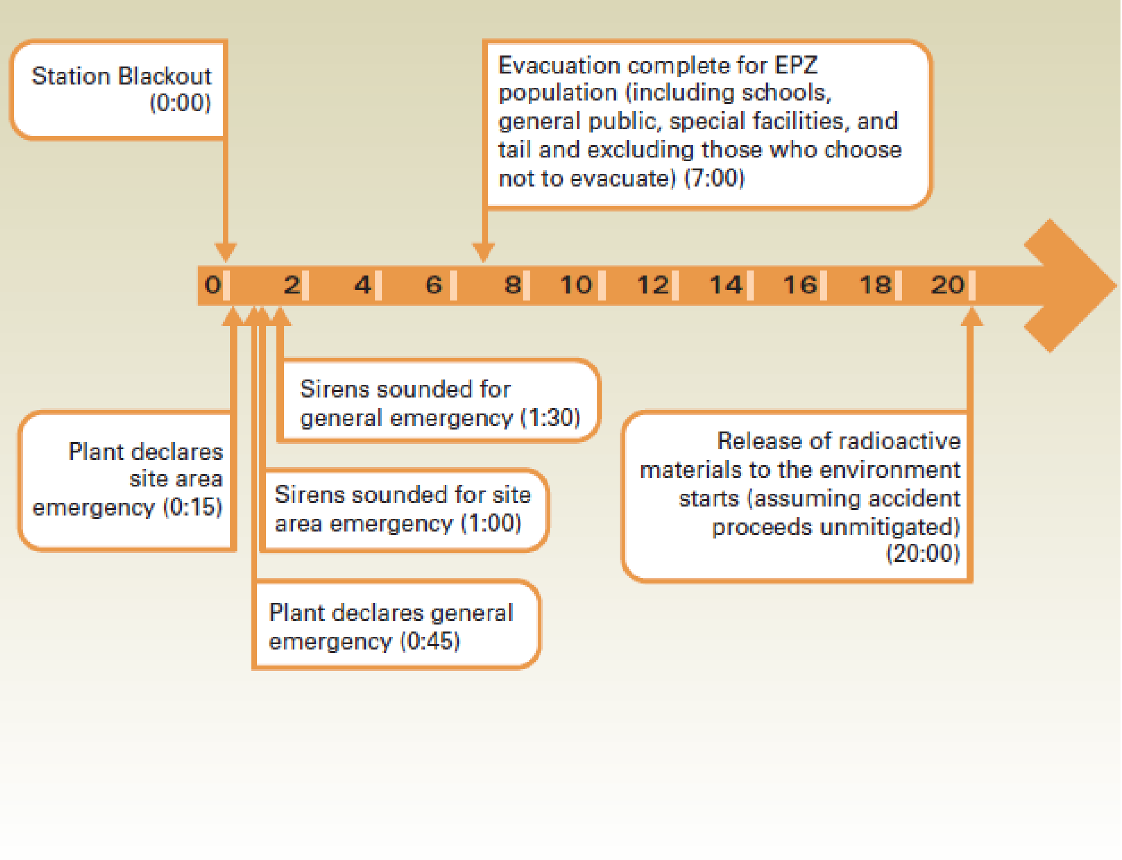
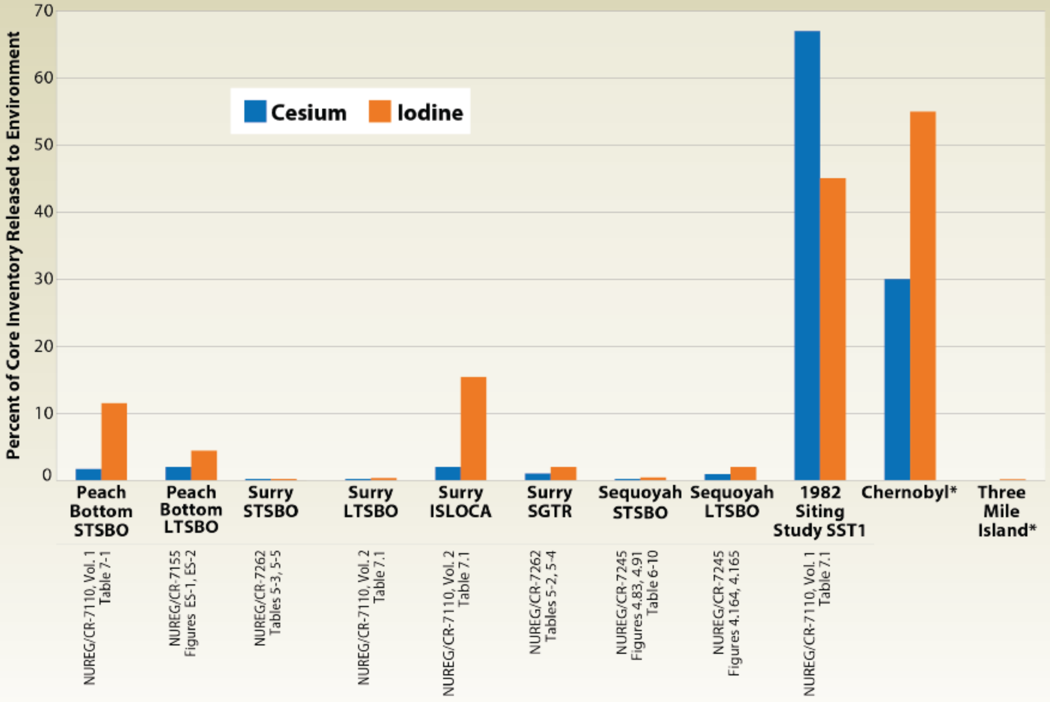


Figure 4.1 Percentages of Cesium and Iodine Released to the Environment for SOARCA Unmitigated Scenarios, 1982 Siting Study (SST1), and Historical Accidents

The SOARCA unmitigated release of Cesium-137 and Iodine-131, for each of the modelled scenarios, are much smaller than estimated in the earlier 1982 Siting Study Source Term 1 (SST1) case. Some of these releases develop over a period of time and are also much smaller than those from the Chernobyl accident.

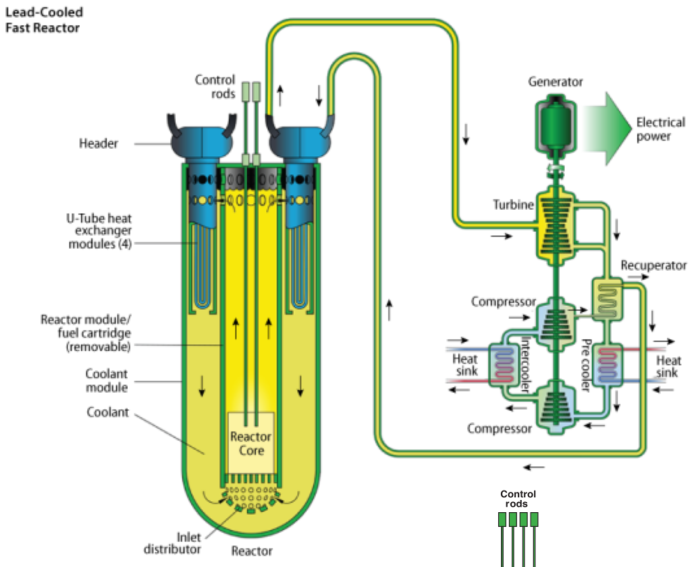


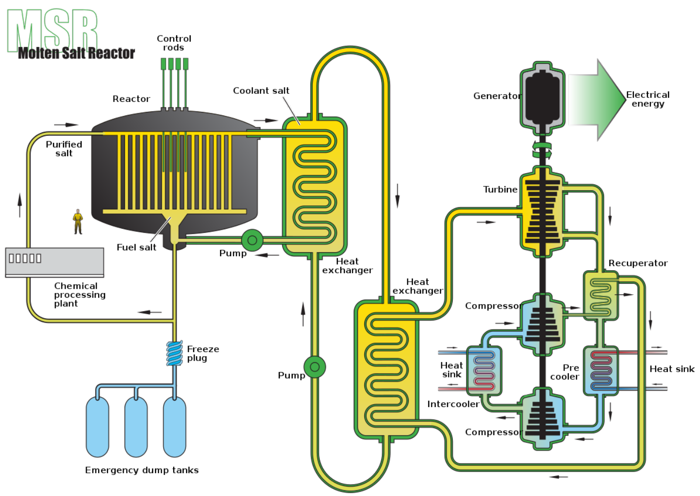
* Chernobyl release data is estimated at 20-40 percent for cesium-137 and 50-60 percent for iodine-131. Three Mile Island released an extremely small quantity of iodine-131 (~ 15 curies) and zero cesium-137. Fukushima releases are estimated to be approximately one-tenth of releases from Chernobyl [IAEA Report GC(59)/14].

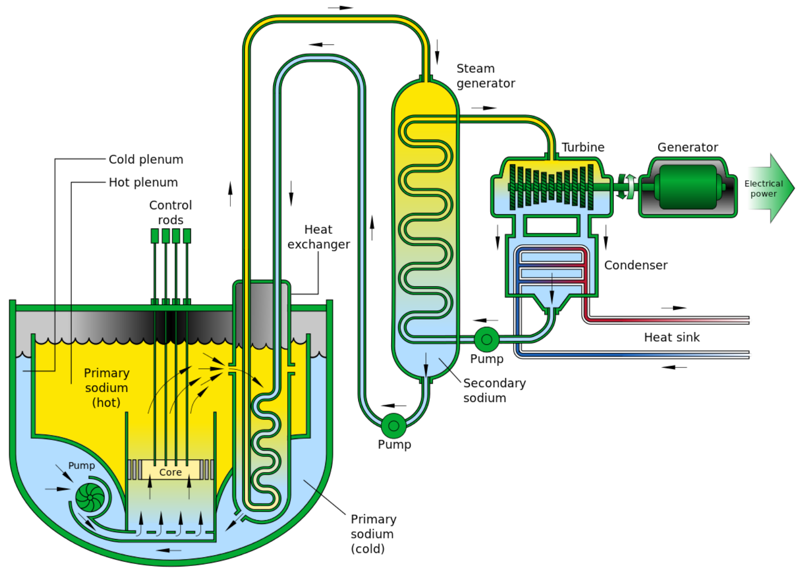
NUREG/BR-0359, Revision 3, "Modeling Potential Reactor Accident Consequences—State-of-the-Art Reactor Consequence Analyses: Using decades of research and experience to model accident progression, mitigation, emergency response, and health effects," October 2020

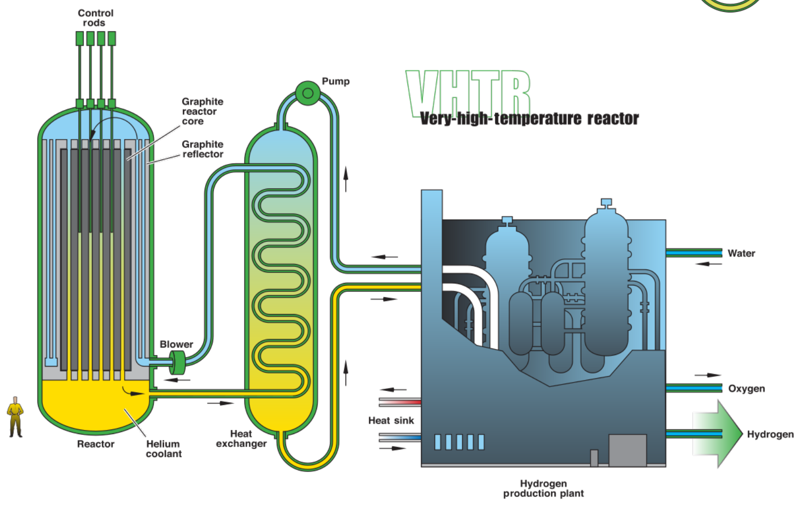
U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

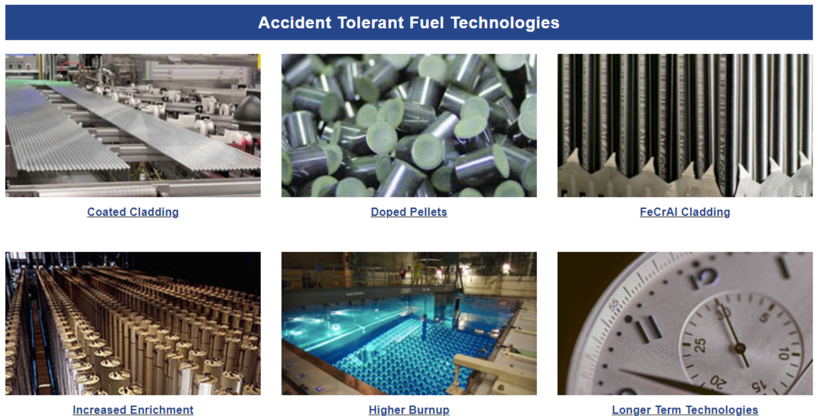
...and will continue to evolve







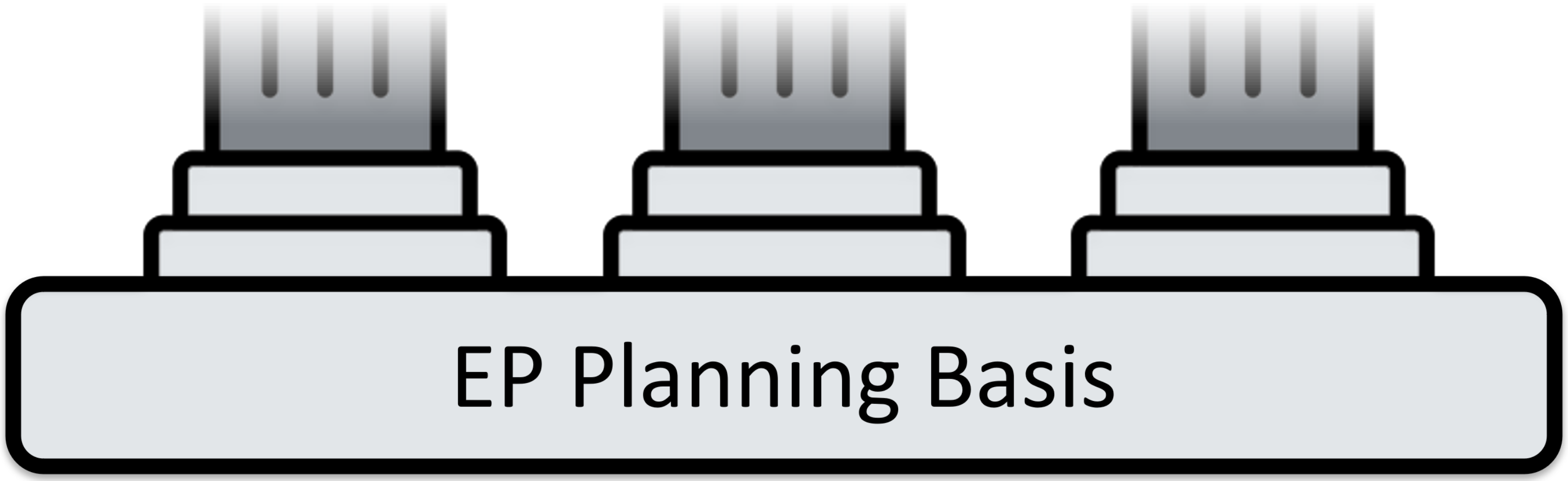




The planning basis informs EP planning functions

Prescriptive and/or Performance-Based

Ensure capabilities exist to detect, classify, notify, assess, mitigate, and effectively respond to an emergency



Probabilistic vs. Deterministic Approach

Pillars of EP:

"If it were possible to identify a single accident on which to base emergency response planning, one could use the release characteristics of that single accident in connection with site specific characteristics and other generic information to specify the planning effort."

Deterministic approach can be used

- Fuel Cycle and Other Radioactive Material Licensees
- Spent Fuel Storage Facilities

Pillars of EP (NUREG-1140):

We have intentionally not defined an emergency planning zone for either the plume exposure pathway or the ingestion pathway as is done for nuclear power plant emergency planning.

- Research and Test Reactors

Pillars of EP:

Table 2 – Alternate method for determining the size of an EPZ*

Authorized power level	Acceptable EPZ size
≤2 MW	Operations boundary
>2 MW and ≤10 MW	100 m
>10 MW and ≤20 MW	400 m
>20 MW and ≤50 MW	800 m
>50 MW	Will be determined on a case-by-case basis

*Table 2 calculations are based on the following:

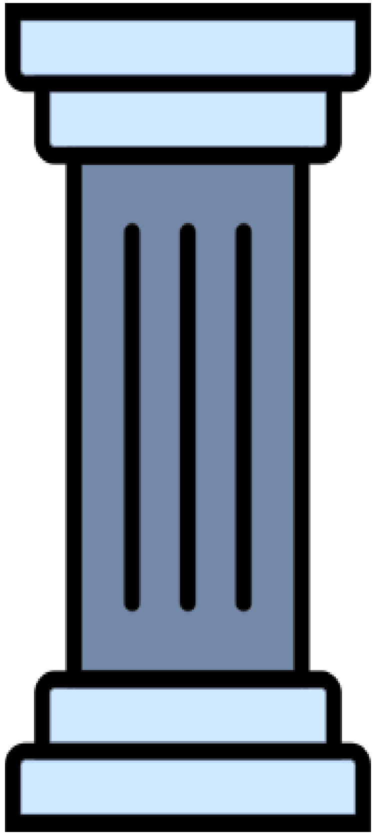
D. Bruce Turner, *Work Book of Atmospheric Dispersion Estimates*, Office of Air Programs, U.S. Environmental Protection Agency, Washington, D.C. (1970).

D. H. Blade, Ed., "Meteorology and Atomic Energy," U.S. Atomic Energy Commission, Washington, D.C. (1968).

"Reactor Safety Study," WASH-1400 (NUREG 761014), Appendix VI, U.S. Nuclear Regulatory Commission (1975).

NUREG-1140, "A Regulatory Analysis on Emergency Preparedness for Fuel Cycle and Other Radioactive Material Licensees," August 1991
ANSI/ANS-15.16-2008, "American National Standard: Emergency Planning for Research Reactors," September 23, 2008

EP has always been a whole community approach



Pillars of EP:

"The planning basis…includes some of the key characteristics of very large releases to assure that site specific capabilities could be effectively augmented with general emergency preparedness (response) resources of the Federal government should the need arise."

NUREG-0396, "Planning Basis for the Development of State and Local Government Radiological Emergency Response Plans in Support of Light Water Nuclear Power Plants," November 1978

NRC regulations are built upon the foundational pillars for preparedness and response