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November 13, 2019

Docket No. 52-048

U.S. Nuclear Regulatory Commission
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SUBJECT: NuScale Power, LLC Submittal of Presentation Materials Entitled "ACRS Subcommittee Presentation: NuScale Topical Report – Accident Source Term Methodology," PM-1119-67927, Revision 0

The purpose of this submittal is to provide presentation materials to the NRC for use during the upcoming Advisory Committee on Reactor Safeguards (ACRS) NuScale Subcommittee Meeting on November 20, 2019. The materials support NuScale's presentation of the "Accident Source Term Methodology" topical report.

The enclosure to this letter is the nonproprietary version of the presentation titled "ACRS Subcommittee Presentation: NuScale Topical Report – Accident Source Term Methodology," PM-1119-67927, Revision 0.

This letter makes no regulatory commitments and no revisions to any existing regulatory commitments.

If you have any questions, please contact Carrie Fosaaen at 541-452-7126 or at cfosaaen@nuscalepower.com.

Sincerely,

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Enclosure: "ACRS Subcommittee Presentation: NuScale Topical Report – Accident Source Term Methodology," PM-1119-67927, Revision 0

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Enclosure:

"ACRS Subcommittee Presentation NuScale Topical Report – Accident Source Term Methodology," PM-1119-67927, Revision 0

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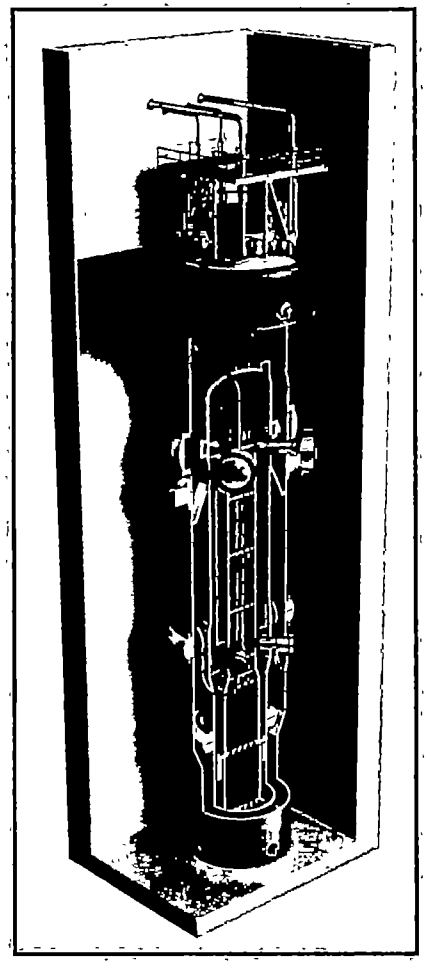
ACRS Subcommittee Presentation



NuScale Topical Report

Accident Source Term Methodology

November 20, 2019

PM-1119-67927
Revision. 0

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Template # 0000-21727-F01 R5

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Agenda

- NuScale AST Methodology Overview
- Closed Session

Acronyms

Term	Definition
AST	accident source term
CDE	core damage event
CDST	core damage source term
CNV	containment vessel
DBA	design basis accident
DBST	design basis source term
EAB	exclusion area boundary
EQ	environmental qualification
FHA	fuel handling accident
LPZ	low population zone
MSLB	main steam line break
NEI	Nuclear Energy Institute
PCA	primary coolant activity
REA	rod ejection accident
SAS	surrogate accident scenario
SGTF	steam generator tube failure

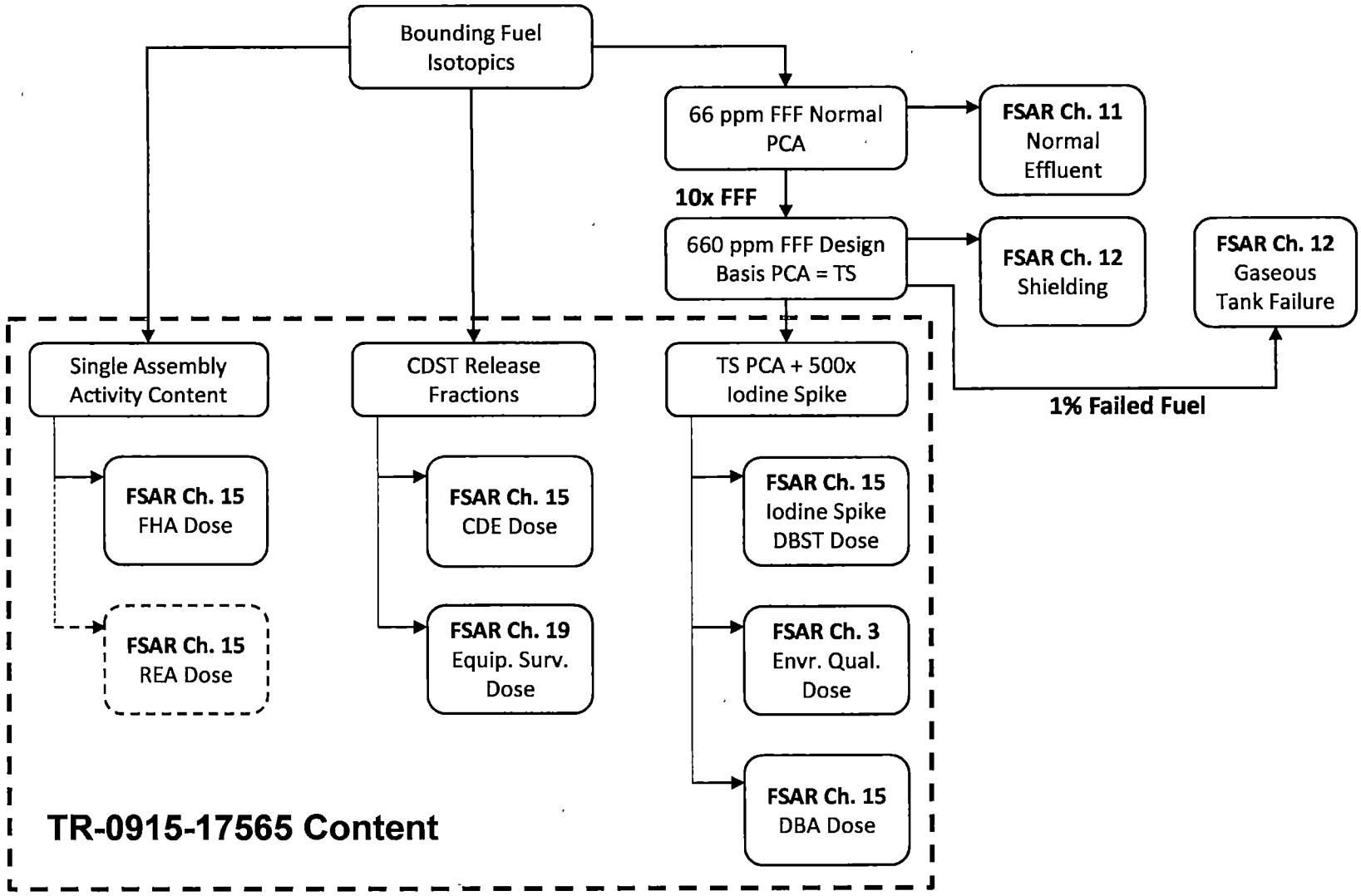
NuScale AST Methodology

- Unique radiological consequence analysis methods within TR-0915-17565 include:
  - Atmospheric dispersion
  - Core damage source term
  - Containment aerosol transport and removal
  - Post-accident pH_T
  - Iodine spike design basis source term (DBST)
  - EQ dose within CNV and bioshield envelope
- Industry standard radiological consequence analysis methods within TR-0915-17565 include:
  - Design basis accident source terms
    - REA, FHA, MSLB, SGTF, and small line break accident methodologies

NuScale AST Methodology

- Application of core damage event (CDE) limited by classifying it as a beyond design basis event
  - CDE used for control room dose evaluation and 10 CFR 52.47(a)(2)(iv) offsite dose evaluation
  - CDE not used for EQ
  - CDE used for equipment survivability evaluation
- Unique design basis event "iodine spike source term"
  - Surrogate for LOCA in containment without fuel damage events
    - Assumes 100% of radionuclides in primary (plus an iodine spike) are in containment
    - Used in conjunction with CDE to evaluate MHA radiological consequences for acceptability
    - Used in EQ

Source Term Overview



Software Utilized

- General application software:
  - SCALE 6.1, TRITON, and ORIGEN-S – used to calculate the time-dependent isotopic source term for all evaluated radiological events
  - ARCON96 – used to calculate onsite and offsite atmospheric dispersion factors all evaluated radiological events
  - RADTRAD – used to estimate radionuclide transport and removal for all evaluated radiological events
- DBA application software:
  - NRELAP5 – used to provide event-specific thermal-hydraulic data for design basis events
- CDE application software:
  - MELCOR – used to model the progression of severe accidents for the CDE
  - STARNAUA – used to perform aerosol removal calculations for the CDE
  - NuScale pH_T Code – used to calculate post-accident aqueous molar concentration of hydrogen ions for iodine re-evolution evaluation in the CDE
  - MCNP6 – used for evaluating potential shine radiological exposures or doses to operators in the control room following a radiological release event

Atmospheric Dispersion

- TR-0915-17565 position: ARCON96 (RG 1.194) methodology used for the calculation of offsite atmospheric dispersion factors
- ARCON96 and PAVAN compared to demonstrate conservative application of ARCON96 for NuScale site distances
- Unique NARCON atmospheric dispersion model created to apply ARCON96 model results which incorporate RG 1.145 (PAVAN methodology) modeling conservatisms

Core Damage Source Term

- Methodology based on state-of-the-art (post-RG 1.183) SAND2011-0128 severe accident modeling and the approach of the 2012 Nuclear Energy Institute (NEI) position paper on SMR source terms
- TR-0915-17565 positions:
  - CDE treated as beyond-design-basis event for the NuScale design, but evaluated in concert with iodine spike DBST to constitute a bifurcated maximum hypothetical accident
  - CDST derived from range of five surrogate accident scenarios taken from Level 1 PRA intact-containment internal events
    - SAND2011-0128 radionuclide groups for the CDST release groups
    - CDST release fractions taken as medians from SAS spectrum
    - CDST release timing from scenario of quickest core damage onset

CDST Evaluation

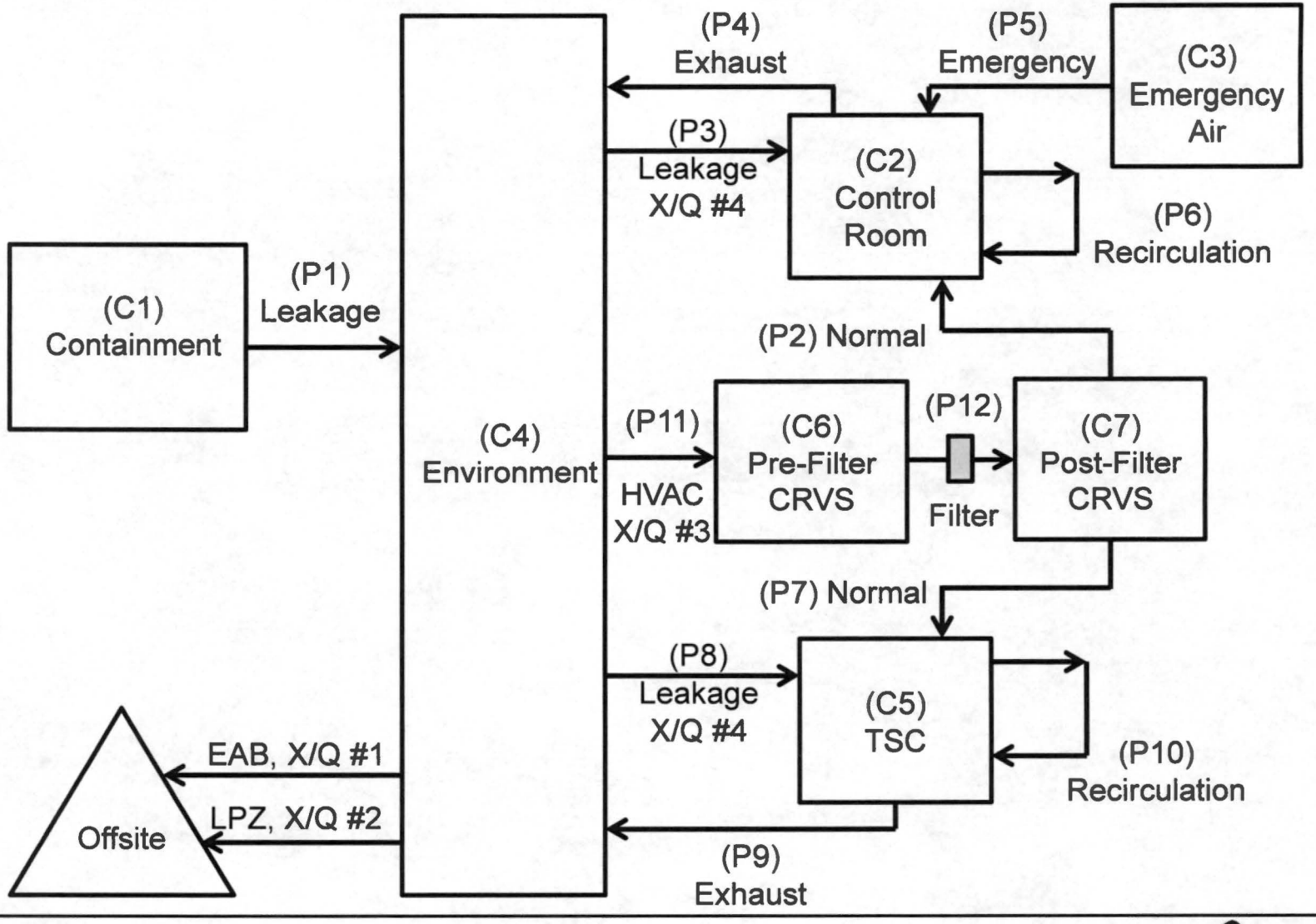
- SAND2011-0128-based representative (median) release fractions from the spectrum of surrogate accident scenarios used as the CDST release fractions

SAND2011-0128 Radionuclide Groups		
Group Number	Chemical Group Name	Elements in Group
1	Noble Gases	Kr, Xe
2	Halogens	Br, I
3	Alkali Metals	Rb, Cs
4	Tellurium Group	Se, Sb, Te
5	Alkaline Earths	Sr, Ba
6	Molybdenum Group	Mo, Nb, Tc
7	Noble Metals	Ru, Rh, Pd, Co
8	Lanthanides	La, Nd, Eu, Pm, Pr, Sm, Y, Cm, Am
9	Cerium Group	Ce, Pu, Np, Zr

CDST Evaluation (continued)

Comparison of release timing and magnitudes of example surrogate accident scenario cases									
Description		Case 1	Case 2	Case 3	Case 4	Case 5	Median Value	RG 1.183 Current	SAND 2011-0128
Onset of gap release (hr)		17.6	**3.8**	8.1	6.2	21.3	8.1	30 sec	30 sec
Duration of gap plus early in-vessel release (hr)		12.0	**1.0**	9.0	1.3	14.0	9.0	1.8	5.63
Fraction of initial core inventory released into containment	Noble Gases	0.39	0.19	0.41	0.19	0.48	**0.39**	1	0.872
	Halogens	0.21	3.5E-2	0.16	1.9E-2	0.14	**0.14**	0.4	0.307
	Alkali Metals	0.25	5.9E-2	0.22	3.1E-2	0.20	**0.20**	0.3	0.235
	Alkaline Earths	5.9E-3	2.8E-3	6.7E-3	2.4E-3	5.3E-3	**5.3E-3**	0.02	0.0054
	Tellurium Group	0.22	3.8E-2	0.16	2.3E-2	0.15	**0.15**	0.05	0.267
	Molybdenum Group	6.4E-2	1.3E-2	5.3E-2	5.8E-3	4.9E-2	**4.9E-2**	0.0025	0.1
	Noble Metals	1.2E-3	1.2E-4	1.5E-3	4.9E-5	7.9E-4	**7.9E-4**	0.0025	0.006
	Lanthanides	3.3E-8	2.6E-9	3.1E-8	1.1E-9	2.1E-8	**2.1E-8**	0.0002	1.1E-7
	Cerium Group	3.3E-8	2.6E-9	3.1E-8	1.1E-9	2.1E-8	**2.1E-8**	0.0005	1.1E-7

RADTRAD Model Nodalization



Aerosol Transport and Removal

- TR-0915-17565 positions:
  - STARNAUA is appropriate for modeling natural removal of containment aerosols for the NuScale design
  - Utilizing thermal-hydraulic data associated with the surrogate accident scenario with the minimum time to core damage is appropriate for use in STARNAUA
  - No maximum limit on iodine decontamination factor for natural removal of containment aerosols
- Methodology credits sedimentation, diffusiophoresis, and thermophoresis removal mechanisms
- Accident-specific natural deposition coefficient outputs of STARNAUA provided to RADTRAD dose transport model

STARNAUA Removal Rate Error

- Error identified when evaluating RAI 9224 (12/2017)
  - Time-dependent aerosol removal rate values appeared nonphysical
- Immediate actions:
  - Condition extent evaluation initiated (12/11/2017)
  - Notified NRC staff of identification (~12/15/2017)
  - Error discovery letter transmitted to code vendor (12/21/2017)
- Subsequent actions:
  - Completed extent evaluation to identify removal rate output issue as only impact
  - Developed alternative output postprocessing workaround
  - Rededicated code

STARNAUA Error Extent

- Limited to incorrect post-processed aerosol removal (λ) values; internal NAUA subroutines not affected
- STARNAUA built as an extension of NAUAHYGROS 1.0
  - Thermophoretic deposition and spray removal models added
  - Changed output plot file generation to include calculated λ values
- NAUA-based codes historically demonstrated to predict aerosol mass concentration behavior reasonably well
- STARNAUA confirmed to predict aerosol mass concentration well by multiple experiment benchmarks
  - LACE 4, LACE 6, ABCOVE 5, ABCOVE 7 included
- Removal calculation validated by manual calculation

Post-Accident pH_T

- TR-0915-17565 position: For pH_T values of 6.0 or greater, the amount of iodine re-evolution that could occur between pH_T values of 6.0 and 7.0 is negligible and not included in the dose calculation
- Considers acids and bases expected in post-accident environment, including:
  - lithium hydroxide, cesium hydroxide, hydrochloric acid, nitric acid, hydriodic acid, and boric acid
- Given pH_T, amount of iodine re-evolution estimated using NUREG/CR-5950 methods and shown to be negligible (<1 %) with respect to other iodine modeling conservatisms

Iodine Spike DBST

- Iodine spike design basis source term:
  - Bounding surrogate source term for any design-basis event involving primary coolant loss inside containment; postulated to enable deterministic evaluation of the response of a facility's engineered safety features.
    - Assumes 100% of radionuclide inventory within 100% of primary coolant volume instantaneously, homogenously mixed release
    - Primary coolant inventory contains radionuclide concentrations at tech spec limits, plus iodine spike
    - Conservative evaluation-dependent leakage treatment
    - Additional conservative treatments available for discussion in closed session

Environmental Qualification Dose

- TR-0915-17565 position: methodology described in TR-0915-17565, Appendix B is appropriate for calculating environmental qualification doses in the containment vessel (CNV) and bioshield envelope regions
- Surrogate source term bounding for all primary coolant loss design basis events
  - Assumes 100% of radionuclide inventory within 100% of primary coolant volume instantaneously released inside containment
  - Primary coolant inventory contains radionuclide concentrations at tech spec limits, plus iodine spike
  - Multiple additional conservative treatments summarized in TR-0915-17565, Appendix B

Other Positions

- TR-0915-17565 positions:
  - Utilizing the iodine spiking assumptions of RG 1.183 is appropriate
  - Utilizing the iodine decontamination factor assumptions of RG 1.183 for the fuel handling accident is appropriate
  - Secondary coolant source negligible with regards to primary coolant source
  - Containment shine to the environment is negligible for the NuScale design

Design Basis Accidents

- Small line break outside containment
  - Follows SRP § 15.6.2
- Steam generator tube failure
  - Follows RG 1.183 App. F
- Main steam line break
  - Follows RG 1.183 App. E
- Rod ejection accident
  - Follows RG 1.183 App. H
- Fuel handling accident
  - Follows RG 1.183 App. B

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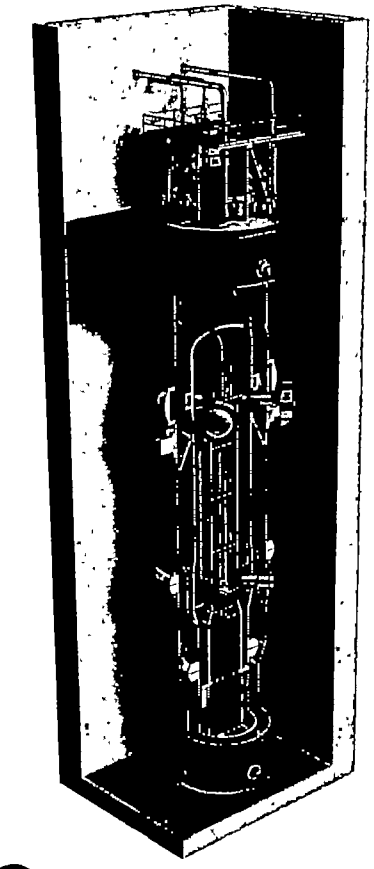

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Backup Slides

Overview of Different Boundaries

- Restricted Area Boundary
  - 10 CFR 50 Appendix I normal releases
- Low Population Zone (LPZ) and Exclusion Area Boundary (EAB)
  - 10 CFR 50.34(a)(1) and 52.17(a)(1) accident releases
- Emergency Planning Zone (EPZ)
  - Independent of DCA

Figure 2.3-1: Limiting Analytical Distance to EAB and LPZ Outer Boundary