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# U.S. NRC Regulatory Process for Decommissioning & Actions Related to Damaged Facilities after Accident


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***Decommissioning and Remediation after Nuclear Accident***

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# 10 CFR 20.1003 Definition Decommissioning

- Safely removing a facility from service and reducing residual radioactivity to a level that permits either one of the following actions:

  (a) release the property for unrestricted use, and terminate the license; or

  (b) release the property under restricted conditions, and terminate the license

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# License Termination Criteria

- **License Termination Standards for Unrestricted Use**

  **10 CFR 20.1402**: Total Effective Dose Equivalent (TEDE) ≤ 0.25 mSv/a and As Low As is Reasonably Achievable (ALARA); Average member of the critical group (AMCG); All pathways; Period of performance - 1000 years

- **License Termination Standards for Restricted Use**

  **10 CFR 20.1403:** ≤ 0.25 mSv/a TEDE and ALARA, with institutional controls in Effect . If institutional controls were no longer in effect, the TEDE would be ALARA and dose to AMCG would not exceed 1 mSv/a; or 5 mSv/a, under provisions of § 20.1403 (e).

- **Alternate Criteria for License Termination**

  **10 CFR 20.1404:** > 0.25 mSv/a, but < 1 mSv/a TEDE, with institutional controls in Effect Similar requirements for license termination under restricted conditions Licensee must demonstrate doses to public from all man-made sources other than medical will be < 1 mSv/a and ALARA, Unusual, site-specific circumstances

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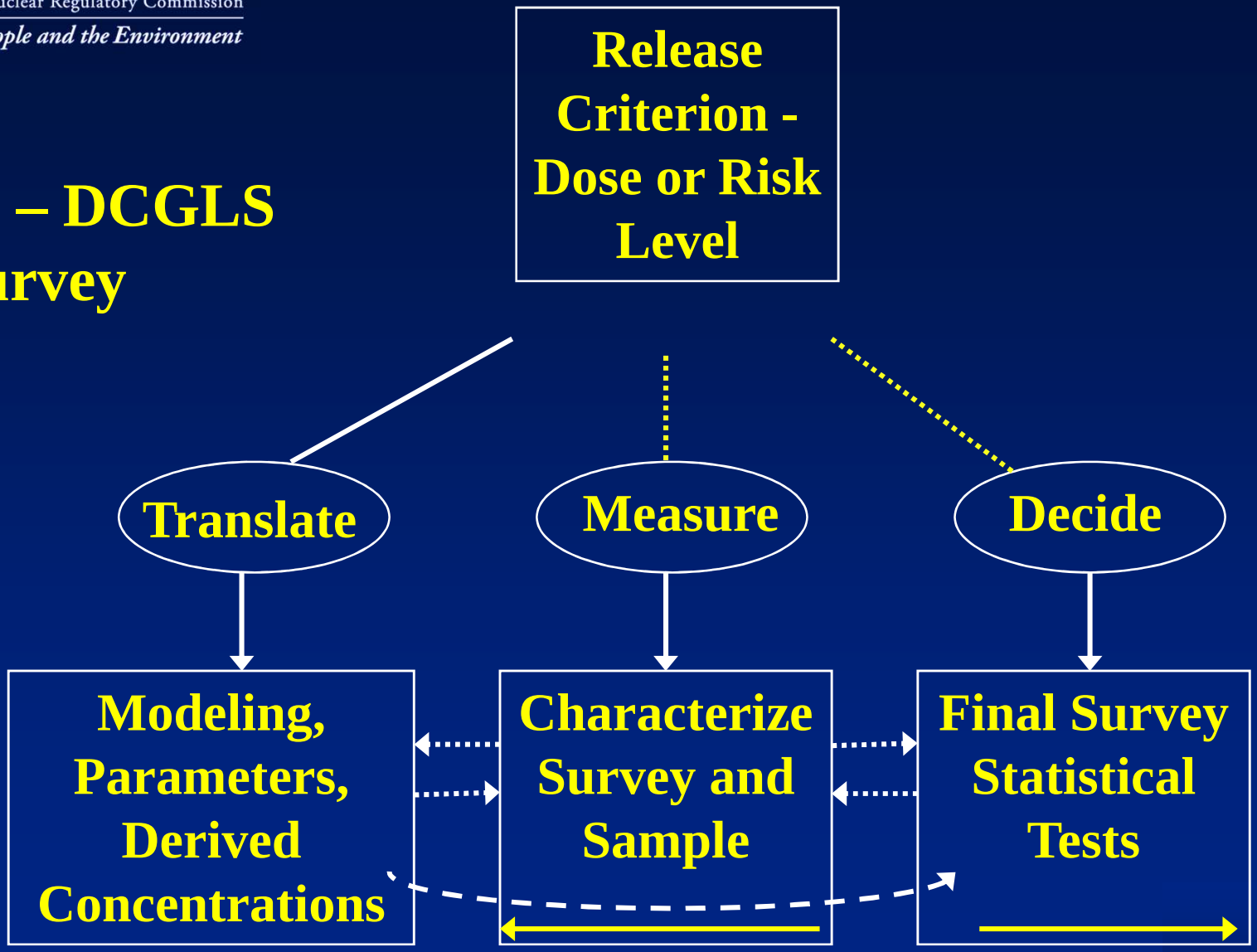
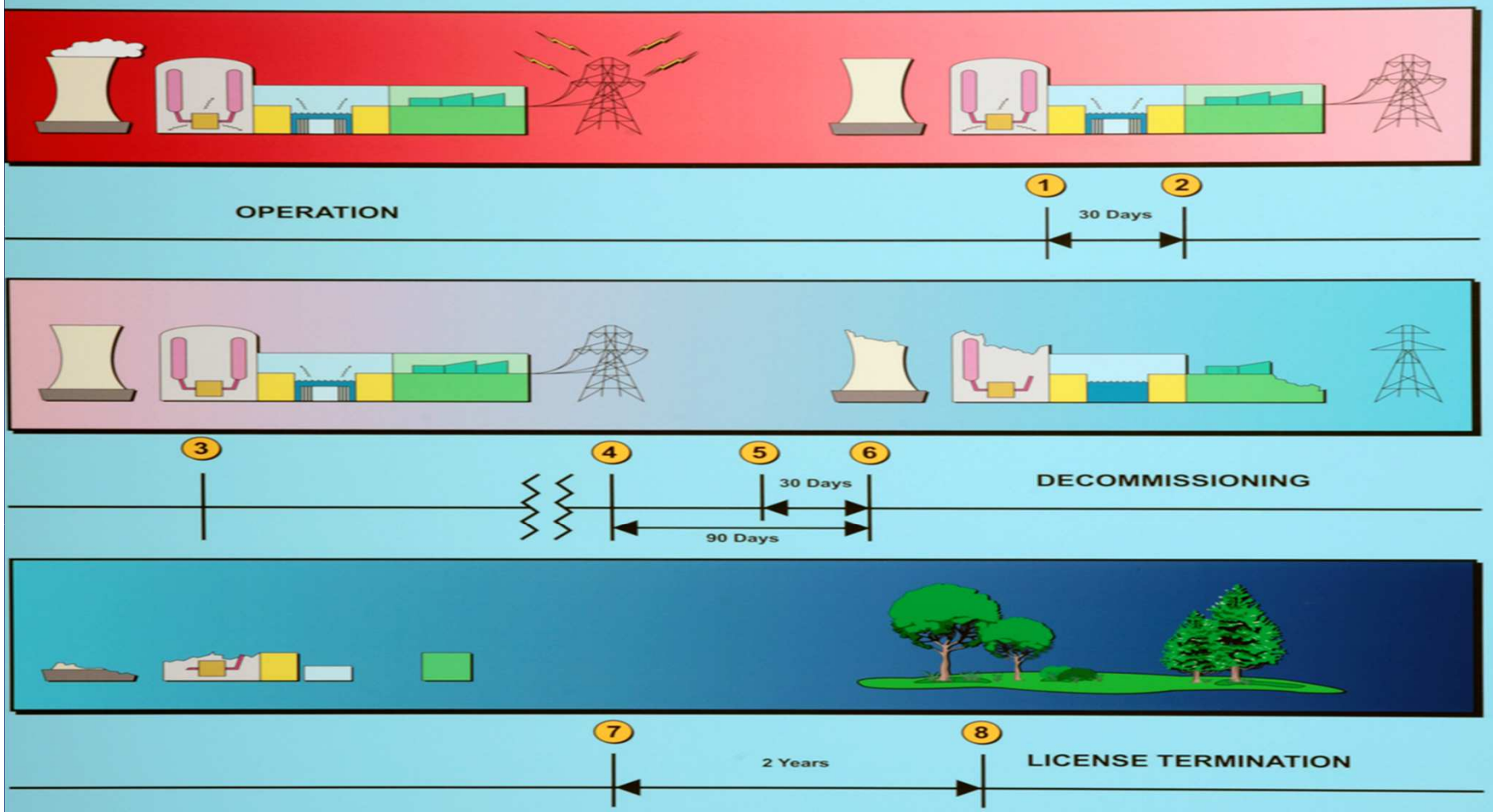
# Dose – DCGLS & Survey




MARSSIM

# Decommissioning of Nuclear Power Reactors




1. Permanent Cessation of Operations
2. Certification of Permanent Cessation of Operation
3. Certification of Permanent Fuel Removal (Variable)
4. Post Shutdown Decommissioning Activity Report (PSDAR) Submittal
5. Public Meeting 30 Days
6. Major Decommissioning Activities/Preparation for Storage or Dismantlement
7. License Termination Plan Submitted
8. License Termination

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# Big Rock Point

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# Maine Yankee

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# Protective Actions Approaches after Accidental Releases

- Actions for protection of workers and the public
- Protection of food sources and water supplies
- Minimization of contamination and protection of environment
- Cleanup based on risk prioritization and socio-economic impacts
- A graded approach to achieve stabilized risk/dose impacts at normal decommissioning conditions.

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# Emergency Planning Zones and Exposure Pathways

- If a release occurs, the first 10 miles from the plant is considered to be the plume exposure pathway, or the path for airborne radioactive material in the plume. The plume would commonly contain radioactive noble gases and might also contain radioiodine and radioactive particulate materials. Many of these materials emit gamma radiation and can expose people nearby as the plume passes.
- For a 50-mile radius, an ingestion exposure pathway has been defined as the most likely area where radioactive material would settle out from the plume and fall to earth. Principal exposure in this emergency planning zone (EPZ) would come from ingestion of contaminated water, milk,and food.

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# PAGs Early Phase Dose Criteria & Actions

| Protective Action | PAG (Projected Dose) | Comments |
|---|---|---|
| Evacuation or Sheltering | 10-50 mSv (1-5 Rem) | Evacuation or sheltering (initiated at 10 mSv, or 1Rem) |
| Administration of stable iodine | 0.25 mSv (25 Rem) | Require approval of State |

**EARLY PHASE OF NUCLEAR ACCIDENTS**

| Dose Limits (mSv, Rems) | Activity | Condition |
|---|---|---|
| 50 mSv (5 Rems) | all | |
| 100 mSv (10 Rems) | Protecting Valuable Property | Lower dose not practicable |
| 0.25 Sv (25 Rem) | Life Saving for Protection of Large Population | Lower dose not practicable |
| >0.25Sv (>25 Rem) | Life Saving for Protection of Large Population | Only on voluntary basis with full awareness of risk |

**Emergency Workers**

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# EPA PAGs for Exposure to Deposited Radioactivity during the Intermediate Phase of Nuclear Accident

| Protective Actions | PAGs (Projected Dose) | Comments |
|---|---|---|
| Relocate the general population | ≥ 20 mSv (≥ 2 rem) | Beta dose to skin may be up to 50 times higher |
| Apply simple dose reduction techniques | <20 mSv (< 2 rem) | These protective actions should be taken to reduce doses to as low as practicable levels |

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# Late Phase Clean-up Criteria

- Presently, no official radiation criteria for late phase
- Optimization approach to ultimately achieve decommissioning and cleanup criteria
- Protracted in nature
- Objectives:
  - 10 CFR Part 20, Subpart E (≤.25 mSv/a)
  - EPA Superfund excess cancer risk
- Stakeholder involvement/socio-economic considerations

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# TMI-2 Accident: Example of Remediation & Decommissioning: What Happened?

- The worst commercial accident in the United States occurred in 1979 at the Three Mile Island Unit #2 (TMI-2)nuclear station.
- As a result of equipment failures and operator error, a valve that was stuck open allowed coolant water that covered the reactor core to escape from the reactor system for over two hours. This radioactive water, nearly a million gallons, ended up on the basement floors of the containment building and auxiliary buildings.
- The loss of coolant water in the reactor core continued to the point that the fuel was no longer submerged in water. Without the cooling provided by the water, the cladding and some of the fuel pellets melted. Large quantities of radioactive material were released into the containment building. The containment building performed as designed and radioactive releases to the atmosphere were small. The releases resulted from leakage of the radioactive water that was carried outside the containment building.

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# TMI Accident

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# Regulatory Actions Taken After Accident

- Before the accident TMI-2 had a license, including Technical Specifications (tech specs) to meet the requirements of 10 CFR Part 50 – "Domestic Licensing of Production and Utilization Facilities."
- Following the March 1979 accident, the operating license and tech specs no longer represented the non-operational status of the facility and were inadequate to ensure the safe operation of clean-up activities at the TMI-2 facility.
- The NRC issued a number of Orders to amend the license and tech specs to permit licensee clean-up activities. In the first few months after the accident, the NRC issued the following Orders:
  - **July 20, 1979 – NRC issued an Order which suspends the TMI-2 facility operating license and requires maintenance of the facility in a shutdown condition in accordance with NRC approved operating and contingency procedures.**
  - **October 16, 1979 – NRC issued an Order amending the TMI-2 license to permit decontaminating intermediate-level waste water from TMI-2 by operating the EPICOR-II filtration and ion exchange decontamination system.**
  - **February 13, 1980 – NRC issued Order to amend TMI-2 license to incorporate a revised set of tech specs that reflect the damaged condition of TMI-2.**
  - **June 12, 1980 – NRC issued Order amending the license to permit the licensee to purge the reactor building of krypton-85 to the atmosphere.**
  - **In addition to the Orders described above, the NRC issued many other orders which amended the license and tech specs to permit the licensee to conduct cleanup activities.**
  - After clean-up activities had been concluded and the TMI-2 facility was decontaminated to the extent that the plant is in a safe, inherently stable PDMS condition, the NRC amended the TMI-2 license to incorporate the PDMS SAR, which described the requirements for maintaining TMI-2 in the SAFSTOR PDMS state.

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# Chronology of TMI-2 Specific Cleanup and Decommissioning Activities

- By 07/80 Approximately 43,000 curies of krypton were vented from the reactor building
- 07/80: The first manned entry into the reactor building took place.
- 11/80: An Advisory Panel for the Decontamination of TMI-2, composed of citizens, scientists, and State and local officials, held its first meeting in Harrisburg, PA.
- 07/84: The reactor vessel head (top) was removed; 10/85: Defueling began; 07/86: The off-site shipment of reactor core debris began
- 08/88: GPU submitted a request for a proposal to amend the TMI-2 license to a "possession-only" license and to allow the facility to enter long-term monitoring storage
- 01/90: Defueling was completed
- 07/90: GPU submitted its funding plan for placing $229 million in escrow for radiological decommissioning of the plant.
- 01/91: The evaporation of accident-generated water began
- 04/91: NRC published a notice of opportunity for a hearing on GPU's request for a license amendment; 02/92: NRC issued a safety evaluation report.
- 08/93: The processing of 2.23 million gallons accident's generated water was completed
- 09/93: NRC issued a possession-only license
- 09/93: The Advisory Panel for Decontamination of TMI-2 held its last meeting
- 12/93: Post-Defueling Monitoring Storage began.

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# Major Decommissioning/Decontamination Activities During Cleanup

- Removal of substantially all of the fuel from the reactor vessel and elimination of all potentially critical configurations. A significant amount of decontamination had to be completed prior to the beginning of defueling.
- Removal of water, to the extent practical, from the reactor coolant system and the fuel transfer canal, and the isolation of fuel transfer tubes.
- Shipment of all fuel and core debris to the DOE INEL facility in Idaho for disposal.
- Disposal of accident generated water.
- Modification of the contaminated cork seam construction joint located between the major structures at TMI-2 to allow monitoring of water levels, permit periodic water removal, and prevent water and contamination migration within the seam.

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# Cask for Shipment of Fuel Debris


**Shipping casks used to ship fuel debris by rail to the DOE's Idaho National Laboratory**

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# TMI Health & Environmental Effects

- The average dose to about 2 million people in the area was about 10 μSv (1 mRem)
- The maximum dose to a person at the site boundary would have been less than 1 mSv (100 mRem).
- Thousands of environmental samples of air, water, milk, vegetation, soil, and foodstuffs were collected by various groups monitoring the area. Very low levels of radionuclide could be attributed to releases from the accident
- Well respected organizations have concluded that in spite of serious damage to the reactor, most of the radiation was contained and that the actual release had negligible effects on the physical health of individuals or the environment

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# Conclusions

- NRC Decommissioning program, after cessation of normal operation, is a stable, mature, and a successful comprehensive regulatory program.
- Key factors to program success: clear and flexible regulations; skilled, experienced, and dedicated staff & management; timeliness requirements; adherence to schedules; transparency; lessons learned & self-assessment; enforcement; and coordination with Federal/State agencies, licensees, stakeholders, and the public.
- Decommissioning and cleanup activities after severe accident are coordinated under emergency conditions with multiple parties including operator, local government and State authorities, as well as multiple Federal agencies.

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# Conclusions (cont'd)

- After severe accident, cleanup and decommissioning activities are adapted based on specific situation and urgent needs and priorities to stabilize condition; and protect workers, the public, and surrounding environmental media. Emergency protective measures and safety guidelines are implemented under emergency situation.
- Transition from emergency situation to existing (normal) situation is achieved using a risk-based graded approach with emphasis on stabilization of conditions, containment of releases, and reduction of public dose limits. Socio-economic impacts on contiguous residents and surrounding population are also addressed in decision-making for zoning and evacuation.
- **http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/3mile-isle.html**