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DOE/NNSA Hazard Analysis

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What is "Hazard Analysis"

- ***In the DOE/NNSA system:***
  - Based loosely on the approaches developed for the nuclear power industry
  - A measure of both probability and consequence of selected events
  - Semi-quantitative, particularly in the probability domain
  - Focused on "possible" events (those that might occur more frequently than once in a million years)
  - Very conservative
  - Very subjective
  - **NOT** focused on blame, liability, or punishment
- ***Fundamentally, it is a tool to help the decision maker (usually NNSA) determine if the benefits of an operation warrant accepting the risks of that operation***
- ***It is not, and cannot be, an approach to ensure operations are "safe". The term "safe" should be stricken from your vocabulary!***

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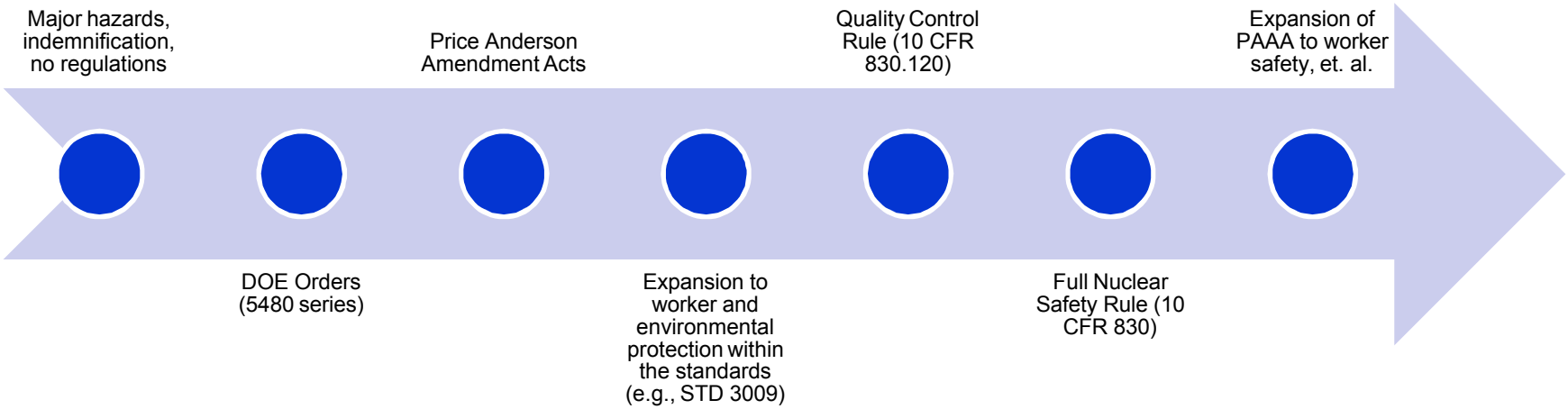
History of DOE/NNSA Hazard Analysis



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Major regulatory documents (not an exhaustive list)

- **Law**
  - 10 CFR 830
    - Subpart A: Quality Assurance Requirements
    - Subpart B: Safety Basis Requirements
  - 10 CFR 835
    - Radiation Protection Program
- **DOE Orders**
  - 5480 Series
    - All are obsolete, replaced by 10 CFR 830
- **DOE Standards**
  - 1027: Hazard Categorization
  - 3009: Preparation Guide for Safety Analysis Reports (SARs)
  - 3011: Developing TSRs
  - 3016: Hazard Analysis Reports (HARs) for Nuclear Explosives Operations (NEOs)

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10 CFR 830 Safety Basis Requirement

- ***In establishing the safety basis for a hazard category 1, 2, or 3 DOE nuclear facility, the contractor responsible for the facility must:***
  - (1) Define the scope of the work to be performed;
  - (2) Identify and analyze the hazards associated with the work;
  - (3) Categorize the facility consistent with DOE–STD–1027–92 ;
  - (4) Prepare a documented safety analysis for the facility; and
  - (5) Establish the hazard controls upon which the contractor will rely to ensure adequate protection of workers, the public, and the environment.

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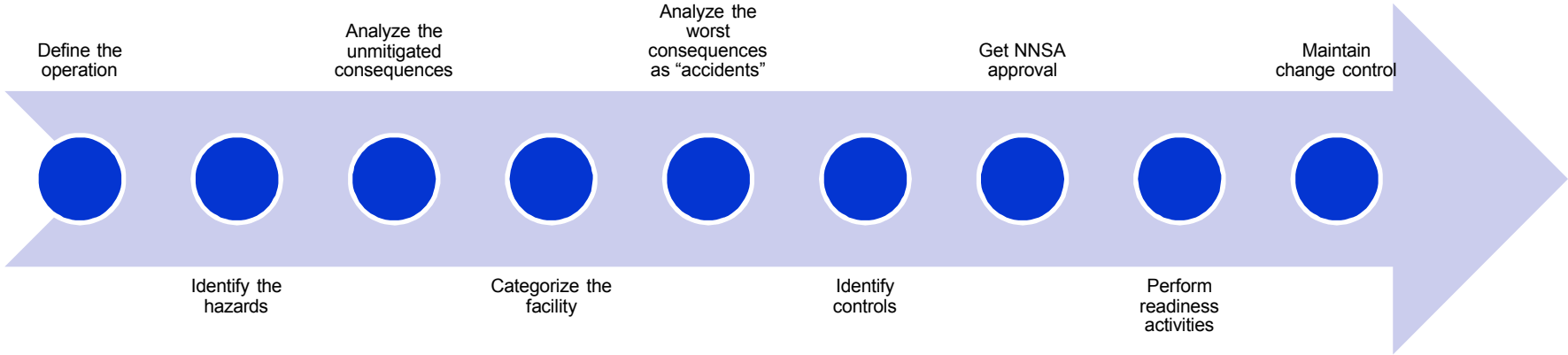
Hazard Analysis Process



Hazard Categorization (DOE-STD-1027)

- ***Based on inventory limits of radiological materials and a sum of fractions process***
- ***Category 1***
  - Hazard Analysis shows the potential for significant off-site consequences (Category A Reactors).
- ***Category 2***
  - Facilities with the potential for nuclear criticality events or with sufficient quantities of hazardous material and energy, which would require on-site emergency planning activities. (1 rem @ 100M)
- ***Category 3***
  - Hazard Analysis shows the potential for only significant localized consequences. (10 rem @ 30 m)
- ***Less than Category 3 (radiological facilities)***
  - Still subject to QA requirements of 10 CFR 830, Subpart A

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DOE STD-1027, Appendix A Excerpt

Table A.1 Thresholds for Radionuclides

Isotope	Category 2 [1] Curies	Threshold Grams	Category 3 [2] Curies	Threshold Grams
H-3	3.0E+05	3.0E+01	1.6E+04*	1.6E+00*
C-14	1.4E+06	3.1E+05	4.2E+02	9.4E+01
Na-22	6.3E+03	1.0E+00	2.4E+02	3.8E-02
P-32	4.4E+03	1.5E-04	1.2E+01	4.2E-05
P-33	3.0E+04	1.9E-01	9.4E+01	6.0E-04
P-32, acid**	2.2E+06	7.7E-02	1.2E+01	4.2E-05
P-33, acid**	1.5E+07	9.6E+01	9.4E+01	6.0E-04
S-35	2.5E+04	5.8E-01	7.8E+01	1.8E-03
Cl-36	1.4E+03	4.3E+04	3.4E+02	1.0E+04
K-40	4.7E+03	6.8E+08	1.7E+02	2.4E+07
Ca-45	4.7E+06	2.6E+02	1.1E+03	6.2E-02
Ca-47	4.8E+06	7.8E+00	7.0E+02	1.1E-03
Sc-46	1.4E+06	4.0E+01	3.6E+02	1.1E-02

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Output of a hazard analysis

- ***A report (SAR, HAR, etc.) that:***
  - Defines the "environment"
  - Identifies approved operations
  - Identifies "limits"
    - Number of personnel
    - Types of materials
    - Quantities (amount of materials, number of operations, etc.)
  - Defines the controls
    - Key controls are called Technical Safety Requirements (TSRs)
      - Safety class controls protect off-site consequences
      - Safety significant controls protect on-site consequences
      - Defense-in-depth are for worker protection or are "backups"
    - Includes maintenance, inspections or surveillances, tests, and other programs (e.g., radiation protection program)
  - Key concepts:
    - Engineered vs. administrative controls
    - Active vs. passive controls

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Sample Process Hazard Analysis

Facility: Example Refinery Date: 04/07/90 Page 3 of 30
Area: HF Alkylation
Unit: Unloading HF from Supply Tanker

Hazard	Cause	Protection and mitigative systems	Consequence	Frequency	Ranking	Action item/ Comment
(1) Anhydrous HF, 5,000 gallons. (2) <100 psi potential energy from nitrogen blanket.	(1) Leak at connection point. (2) HF hose ruptures. (3) HF hose ruptures, flow not immediately shut off. (4) Truck relief valve fails open. (5) Truck relief valve opens; over-pressure conditions. (6) Tanker failure from over-pressure. (7) N_2 hose ruptures. (8) N_2 hose ruptures, check valve fails. (9) HF line not swept after unloading.	(A) Operators in chemical suits with respirators for emergency use. (B) Specific procedures, trained operators. (C) HF detectors. (D) HF line remote shutoff valve on truck. (E) Emergency relief valve capping kit available. (F) Two N_2 pressure regulators. (G) Check valve on N_2 gas line. Maximum N_2 pressure less than tanker design pressure. (H) Emergency water deluge system.	(1) Minor operator exposure – **LOW**. (2) Minor operator exposure off site <ERPG-2 – **LOW**. (3) Operator exposure, possibly ERPG-2 off site – **MEDIUM**. (4) Typically (a) **LOW** if capped. Possibly (b) **MEDIUM** if not capped and no deluge. (5) Typically (a) **LOW** if short duration. Possibly (b) **MEDIUM** if longer and no change. (6) Possible operator fatalities and ERPG-3 off site – **HIGH**. (7) N_2 leak – **LOW**. (8) See item #5 above. (9) Minor operator exposure – **LOW**.	(1) **HIGH** (2) **MEDIUM** (3) **LOW** (4) (a) **MEDIUM** (4) (b) **LOW** (5) (a) **LOW** (5) (b) **LOW** (6) **LOW** (7) **MEDIUM** (8) See #5 frequency (9) **HIGH**	4 2 3 2 3 1 3 6 2 See item #5 4	(1) Verify that procedures provide consistent leak-check on fitting. (2) Verify that procedures provide appropriately defined interaction between plant personnel and truck operators. (3) Area should be roped off and access controlled during unloading. (4) Specific evacuation routes for operators should be defined in procedures.

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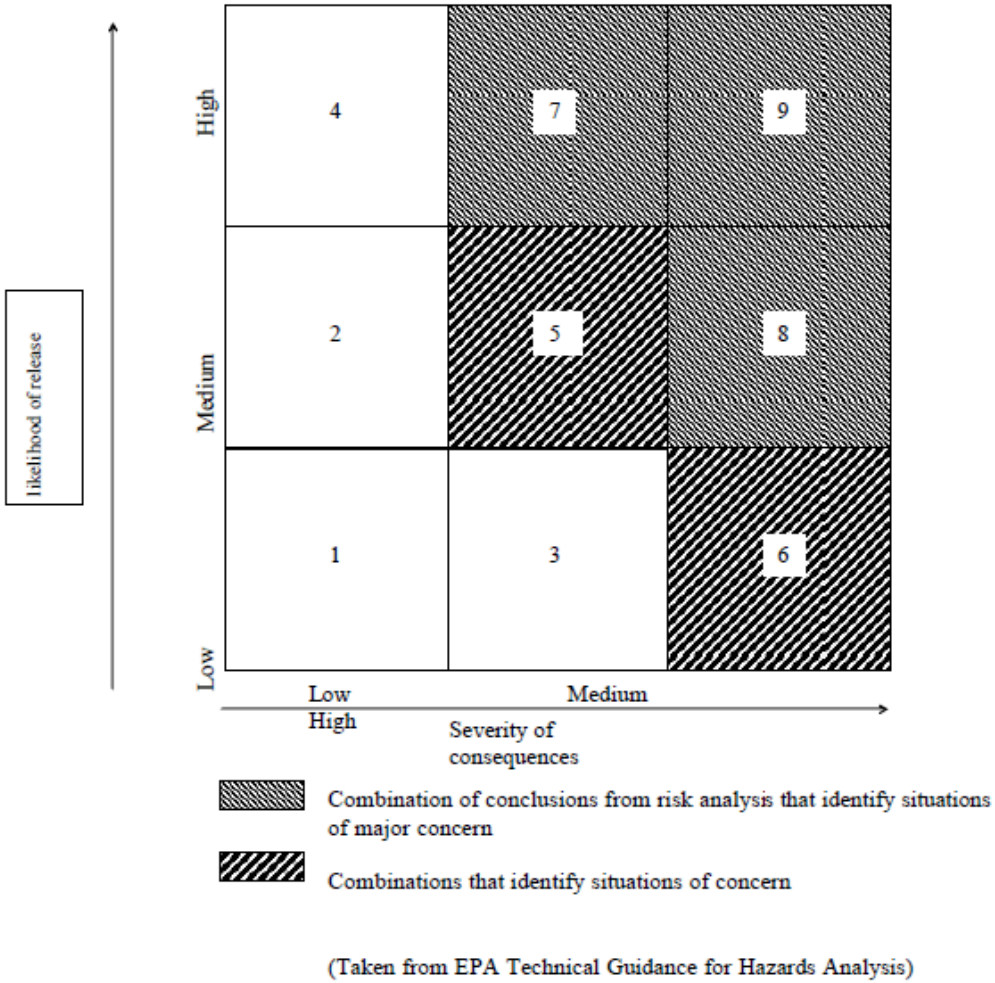
Hazard Analysis Binning Matrix (example)



(Taken from EPA Technical Guidance for Hazards Analysis)

Example Consequence Bins

Public Consequence Bins and Definitions

CATEGORY	DEFINITION	
A	Radiological Hazard:	Offsite DOE Evaluation Guideline exceeded. TEDE ≥ 25 rem[2]
	Other Hazards:	Potential for life-threatening health effects.
	Chemical Limit[3]:	Offsite Concentration ≥ ERPG/TEEL-3.
B	Radiological Hazard:	Offsite DOE Evaluation Guideline challenged. 25 rem > TEDE ≥ 5 rem
	Other Hazards:	Potential for irreversible or serious health effects; ability to take protective action could be impaired.
	Chemical Limit:	ERPG/TEEL-3 > Offsite Conc. ≥ ERPG/TEEL-2.
C	Radiological Hazard:	Offsite DOE Evaluation Guideline not challenged. 5 rem > TEDE ≥ 0.1 rem
	Other Hazards:	Irritation or discomfort but no permanent health effects.
	Chemical Limit:	ERPG/TEEL-2 > Offsite Conc. ≥ ERPG/TEEL-1.
D	Radiological Hazard:	Less than the DOE Public Dose Limit. 0.1 rem[4] > TEDE ≥ 0.01 rem
	Other Hazards:	Mild and transient health effects possible.
	Chemical Limit:	ERPG/TEEL-1 > Offsite Concentration ≥ TEEL-0.
E	Radiological Hazard:	DOE Public Dose Limit not challenged. TEDE < 0.01 rem
	Other Hazards:	No appreciable risk of health effects.
	Chemical Limit:	Offsite Concentration < TEEL-0.

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Example Frequency Bins

Frequency Categories and Definitions

Frequency Category	Approximate Range	Label	Description
I	$\geq 10^{0}$/yr.	FREQUENT	Events predicted to occur every, or almost every, year during the facility lifetime (50 years). Only normal operations should be frequent events.
II	$<10^{0}$/yr. to $\geq 10^{-2}$/yr.	OCCASIONAL	Events expected to occur once to several times during the facility lifetime. Simple events, such as a single human error, could be categorized as occasional.
III	$<10^{-2}$/yr. to $\geq 10^{-4}$/yr.	PROBABLE	Events not expected to occur during the facility lifetime but the possibility cannot be ruled out. If 100 to 200 identical facilities were operating, then the incident would be expected once in the entire population during the operating lifetime of the facilities.
IV	$<10^{-4}$/yr. to $\geq 10^{-6}$/yr.	IMPROBABLE	Events that are unlikely to occur during the facility lifetime. Even for 100 to 200 identical facilities operating, the incident is not expected to occur during the operating lifetime of the facilities.
V	$<10^{-6}$/yr.	REMOTE	Events that are inconceivable of occurring during the facility lifetime.

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Readiness Activities

- ***Readiness verification, management self-assessment, etc.***
  - Not necessarily independent of the operation
  - Can be performed in parallel with efforts to become “ready”
- ***Contractor Readiness Assessment (CRA)***
  - Must be conducted by personnel independent of the organization responsible for the operation(s)
  - Should be “ready” before beginning
- ***Operational Readiness Review (ORR)***
  - Conducted by DOE/NNSA, often with the support of contractors
  - Must be “ready” before beginning
- ***CRA and ORR will identify:***
  - Requirement-based pre-starts that must be corrected before operations are approved
  - Requirement-based post-starts that must have a corrective action plan approved before operations are approved
  - Sometimes, observations that identify good practices is place or suggestions for improvement

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Change Control

- ***A formal, comprehensive process to evaluate potential changes to a facility or its operations BEFORE they are implemented***
- ***Designed to***
  - Allow the facility or operation to make small, inconsequential changes, but
  - Ensure larger, more significant changes are approved at the appropriate level
  - This includes, but is much bigger than, the Unreviewed Safety Question (USQ) process
  - May require approval by NNSA
- ***Related concepts:***
  - "As described in"
  - Potentially inadequate safety analysis (PISA)

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What works (one opinionated person's view)

- STD-1027 hazard categorization, in general
- Probability bands
- Risk binning
- Hazard screening
- Change control
- Expert judgment
- Most DNFSB members

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What doesn't work (one opinionated person's view)

- *Preliminary vs. final hazard categorization*
- *Assignment of probabilities to initiating events only*
- *"The EG is 25 rem total effective dose equivalent (TEDE). The value of 25 rem TEDE is not to be used as a 'hard' pass/fail level."*
- *Change control*
- *Expert judgment*
- *DOE/NNSA approval by non-program personnel*
- *Some DNFSB staff*
- *Inclusion of worker and environmental protection*
  - Coordination of Safety Basis, OSHA Process Safety Management, EPA Risk Management Planning, and Emergency Management

Note the repeats and subtleties from the previous list.

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