



Parallel Development of Critical Enablers: Strategic Integration of Consensus Standards Development and Regulation Updates to Facilitate Deployment and Acceptance of New D&D Technologies

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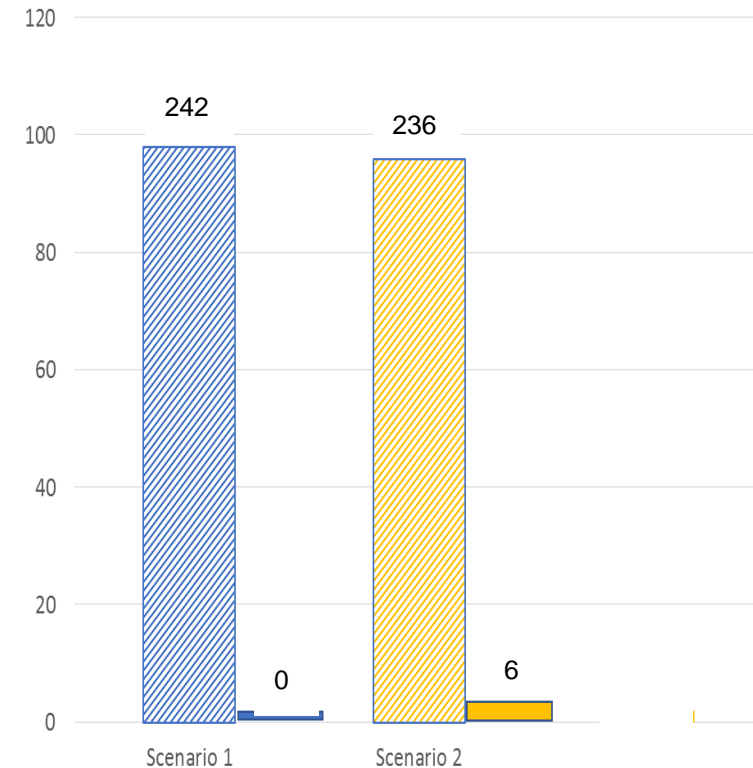


- Choose between the two fixative technologies based on the given information:

- Technology 1: Incombustible fixative intended to maintain stabilization of residual radioactive material when exposed to fire contingency scenarios outlined in safety basis documents. \$0.75 / square foot. Met ASTM E84, NFPA 701, and UL723 fire test standards.
- Technology 2: Incombustible fixative intended to maintain stabilization of residual radioactive material when exposed to fire contingency scenarios outlined in safety basis documents. \$0.75 / square foot.

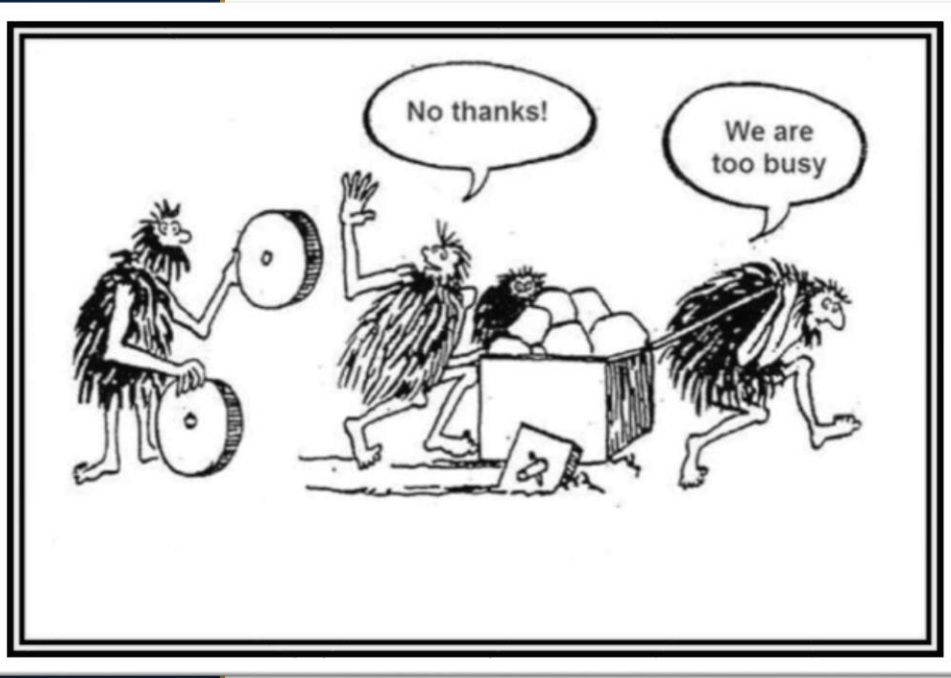
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Consensus standards impact technology selection, particularly in safety-critical, risk adverse industries





Researcher Perspective



"Not without inventing a helmet, you don't!"

End User Reality



DOE EM Case Study: Key Findings from Incombustible Fixative Technology Deployment at SRS 235-F PUFF Facility

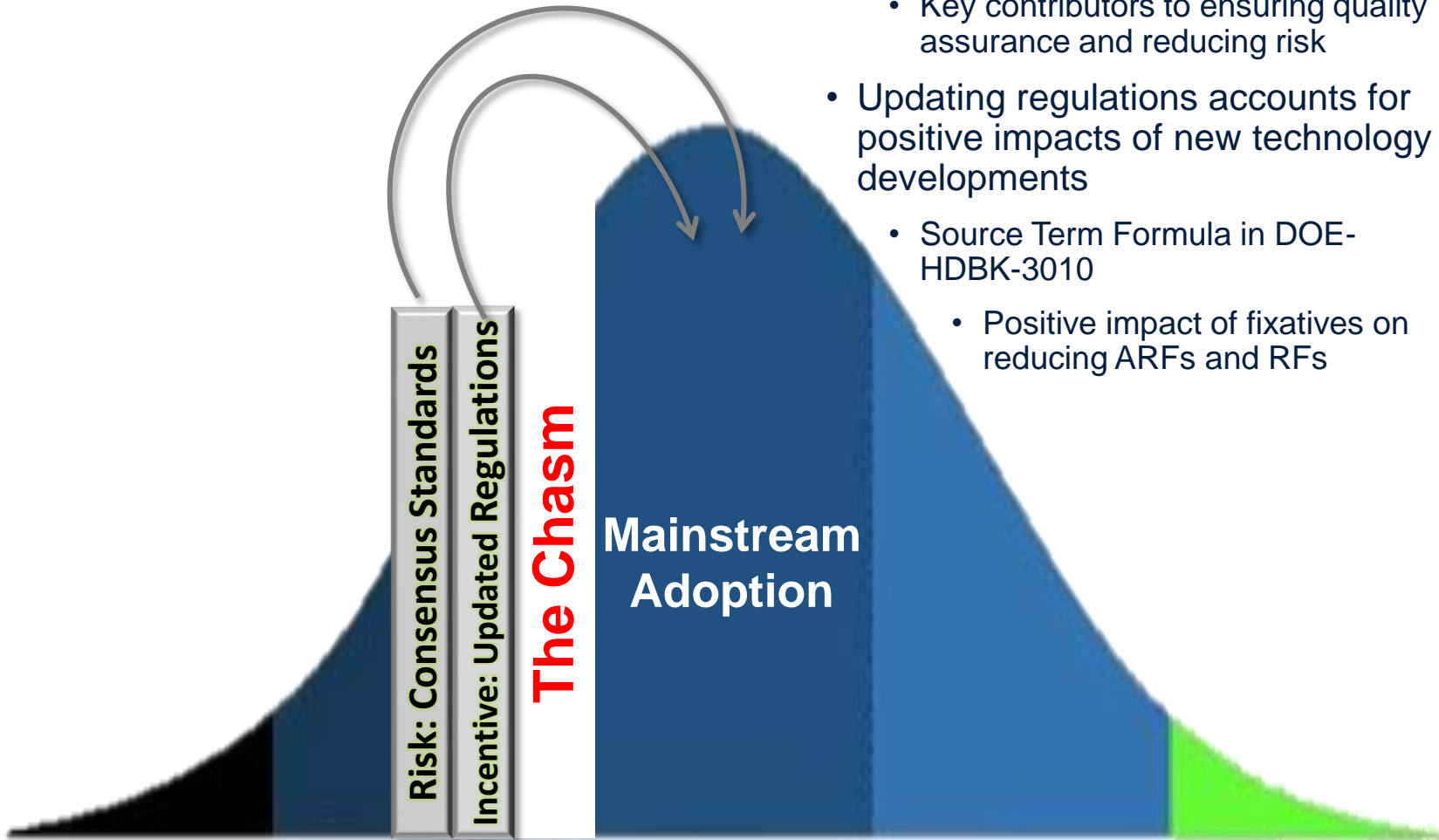
- ROI / value creation occurs when technology is adopted and operationally deployed
 - Mandates a targeted, parallel focus on advancing the critical enablers for the technology deployment

- Not just about the technology
 - Holistic approach required to also address critical enablers such as regulation updates, standards development, etc.
 - Human factors play crucial role
 - Risk aversion
 - Incentive-seeking

- *“There is nothing more difficult to plan, more doubtful of success, nor more dangerous to manage than the creation of a new order of things.” Niccolo Machiavelli, The Prince*



Application of Fire Resilient Fixative in 235-F PUFF Facility



- Standard specifications and testing protocols mitigate information asymmetry and improve trust
 - Key contributors to ensuring quality assurance and reducing risk
- Updating regulations accounts for positive impacts of new technology developments
 - Source Term Formula in DOE-HDBK-3010
 - Positive impact of fixatives on reducing ARFs and RFs



- Quacks, Lemons, and Licensing: A Theory of Minimum Quality Standards, H.E. Leland
 - Empirically demonstrated the positive impacts of minimum quality standards and uniform testing protocols on mitigating Akerlof's concept of information asymmetry
 - Particularly advantageous in highly risk averse industries
- GAO report, DOE's Program to Develop New Technologies for Environmental Cleanup
- Public Law 104-113 and the Office of Management and Budget's Circular A-119, "Federal Participation in the Development and Use of Voluntary Consensus Standards and in Conformity Assessment Activities."

We are now in a position to examine the effects on social welfare of changing L . From (14) it can be seen that

$$W = \int_0^{\hat{q}-L} p(\bar{q}, y') dy' - \int_L^{\hat{q}} R(q) dq. \quad (20)$$

Differentiating W with respect to L , using (19), and combining terms gives

$$\frac{dW}{dL} = \left[\int_0^{\hat{q}-L} \frac{1}{2} p_q(\bar{q}_e, y') dy' \right] \left(\frac{d\hat{q}_e}{dL} + 1 \right) + R(L) - R(\hat{q}_e). \quad (21)$$

We need only show that (21) is positive at $L = 0$ to conclude that some level of minimum quality $L > 0$ is desirable. In general, the sign of (21) is ambiguous. But further light is shed on the problem by the example (10). In this case,

$$\begin{aligned} \frac{dW}{dL} \Big|_{L=0} &= \left(\int_0^{\hat{q}_e} \frac{1}{2} \beta dy' \right) \left[\frac{\gamma + (\beta/2)}{2\delta\hat{q}_e + \gamma - (\beta/2)} + 1 \right] - \delta\hat{q}_e^2 \\ &= \beta\hat{q}_e \left(\frac{\gamma + \delta\hat{q}_e}{2\delta\hat{q}_e + \gamma - (\beta/2)} \right) - \delta\hat{q}_e^2. \end{aligned} \quad (22)$$

Since $L = 0$ in (22), we may substitute directly for \hat{q}_e from (12).

At $\alpha = \beta = \gamma = \delta = 1$, we compute $dW/dL = 0.064 > 0$. For this set of parameter values, social welfare is increased by the imposition of a minimal quality standard $L > 0$.

Leland's mathematical confirmation of positive effects of standards





Policy Makers and Regulators

- Establishes technology performance requirements
- Supports compliance oversight
- Aligns w/Public Law / Code
 - Public Law 104-113
 - OMB Circular A-119, "Federal Participation in the Development and Use of Voluntary Consensus Standards and in Conformity Assessment Activities"

End Users

- Reduces risk
- Instills confidence and trust
- Improves analysis, comparison, and decision making in technology selection

Producers, Manufacturers, and R&D Funding Agencies

- Clearly defines performance parameters
- Standardizes quality assurance and testing
- Promotes a common understanding
- Increases ROI on private sector / federally-funded R&D investments

Public

- Significantly improves trust and confidence
- Promotes common understanding
- Enhances public safety and good stewardship

The Mandate – Parallel Development of Consensus Standards

“There is general acceptance by the community on the utility of fixatives to immobilize residual contamination and mitigate risk during D&D activities, **but a more formal process needs to be available for site personnel and regulators to certify their capabilities and performance. Uniform standards can play a significant role in this effort.**”

- Andrew Szilagyi, Director, DOE EM’s Office of Infrastructure and D&D



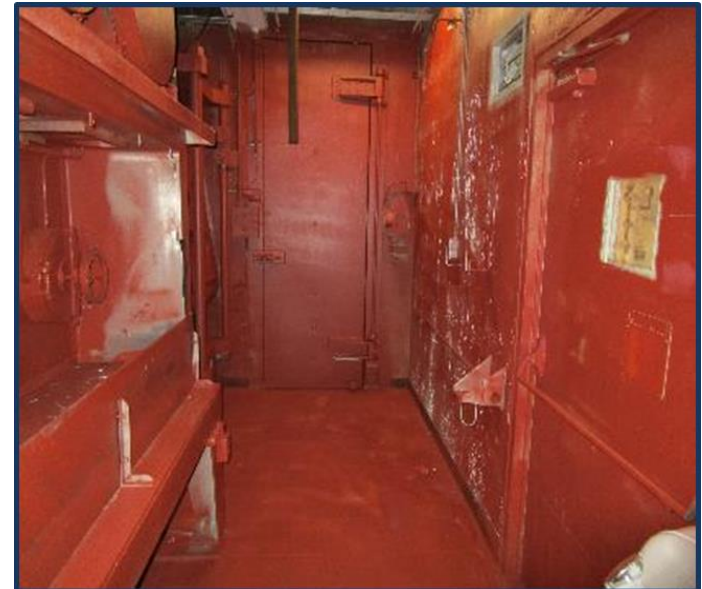
Application of Fire Resilient Fixative in 235-F PUFF Facility

"The operational requirement for standards-based performance specifications and testing protocols was consistently emphasized throughout the test and evaluation process by safety personnel and end users.

- SRNL-STI-2021-00115

"We need to **confirm the technology works as advertised to facilitate onsite deployment.**"

- Rod Rimando, DOE EM's Director of Technology Development



SRS 772-F Shielded Area Room Application of Fire Resilient Fixative

- E10.03 Subcommittee
 - Focuses on D&D technologies (e.g. fixatives) and addresses two fundamental concerns:
 - What must the technology do (performance specifications)?
 - How does the community confirm it does it (uniform testing methods)?
 - SMEs from industry, government, national labs, international testing agencies, academia
 - Independent, universally-recognized standards and testing protocols significantly mitigate risk and facilitate comparison for end-user
- Consensus-based development process with rigorous checks and balances
- Extensive peer-review and independent verification

Primary types of ASTM standards

- ✂ **specification**, *n*—an explicit set of **requirements** to be satisfied by a material, product, system, or service.
- ✂ **test method**, *n*—a definitive procedure that produces a test result.



Defining Fixative Technology Standard Specifications and Testing Protocols

- ASTM Standard Specifications for fixative technologies ISO D&D activities formally published
 - E3104-17: Specifications for Strippable & Removable Coatings to Mitigate Spread of Radioactive Contamination
 - E3105-17: Specifications for Permanent Coatings Used to Mitigate Spread of Radioactive Contamination
 - Referenced in SRNL'S Incombustible Fixative and ACE 2.0 Test Plan: Radiological Hot Field Test of Intumescent Coating Fixatives and Electrostatic Precipitators
 - MSIPP RFPs
- E3191-18: Specification for Permanent Foaming Fixatives Used to Mitigate the Spread of Radioactive Contamination
 - Referenced in FIU ARC Test Plan of technology
- 5-year update cycle

ASTM Standardization News

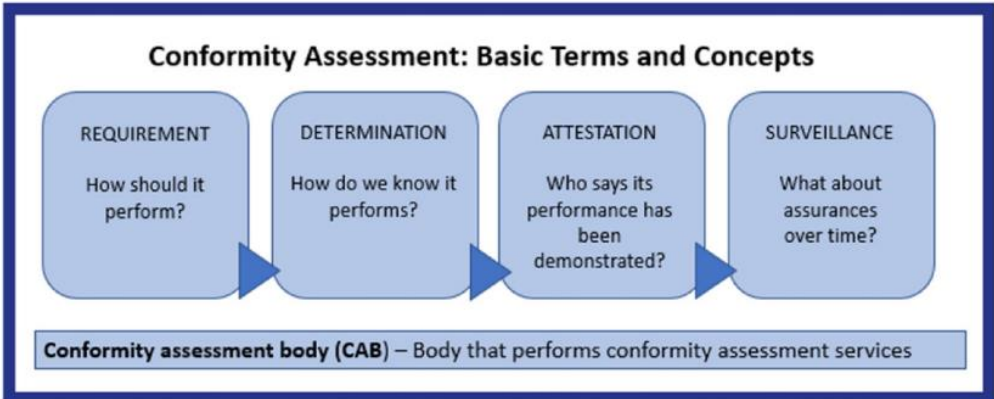


Coatings Help Prevent Radioactive Contamination in Decommissioning

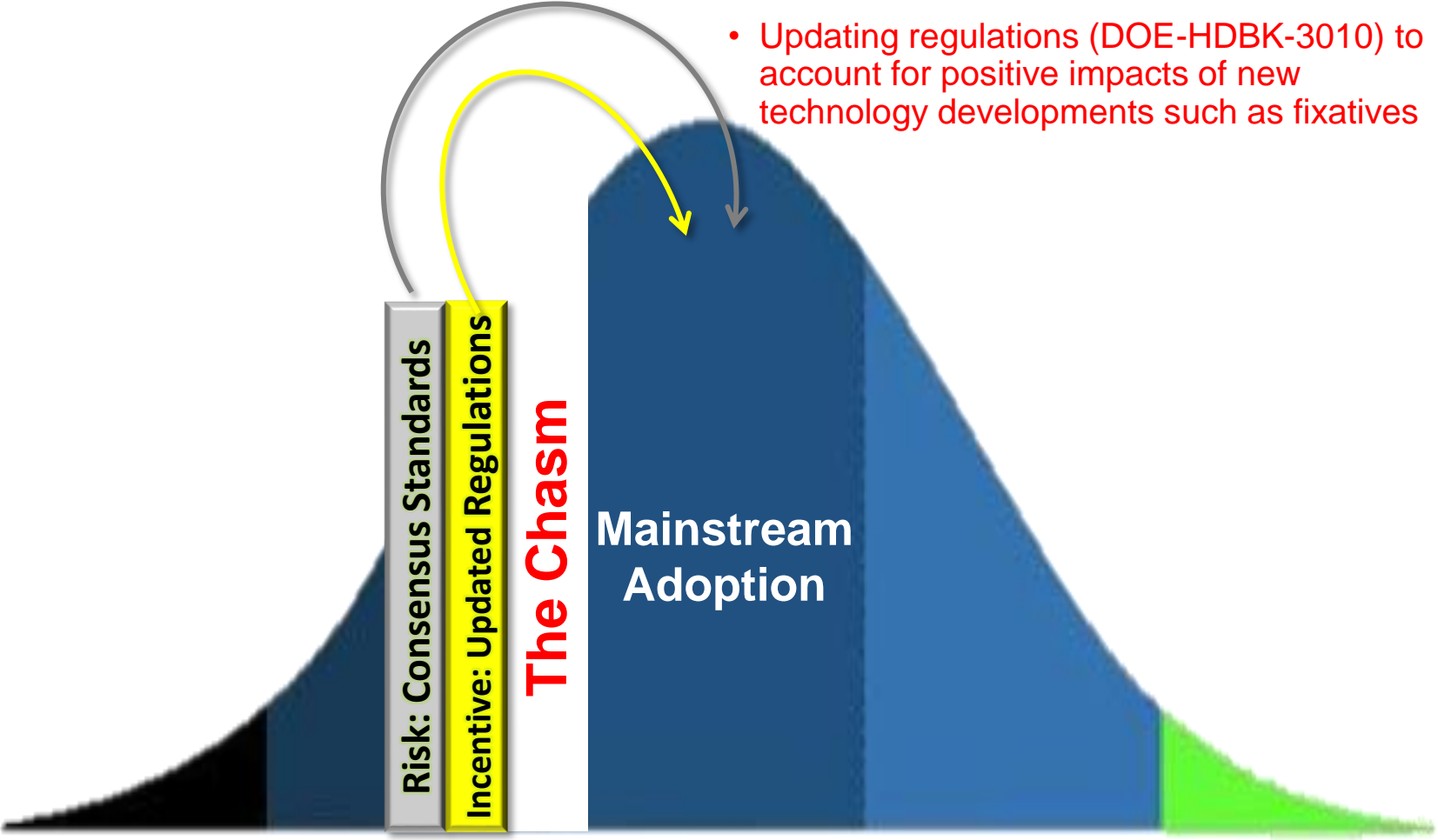


- Way Ahead: 1) Continue engaging ASTM E10.03 for standards development of fixative technologies, and 2) Explore potential to develop a Conformity Assessment Program for Fixative Technologies
 - Successful integration of consensus standards in a Conformity Assessment Program for nuclear protective coatings
 - Performance results are referenced in almost every coating system technology / product being offered in the industry
 - Significantly reduces information asymmetry, mitigates risk, establishes trust and confidence, facilitates self-regulation and compliance evaluation, and improves product comparison analysis

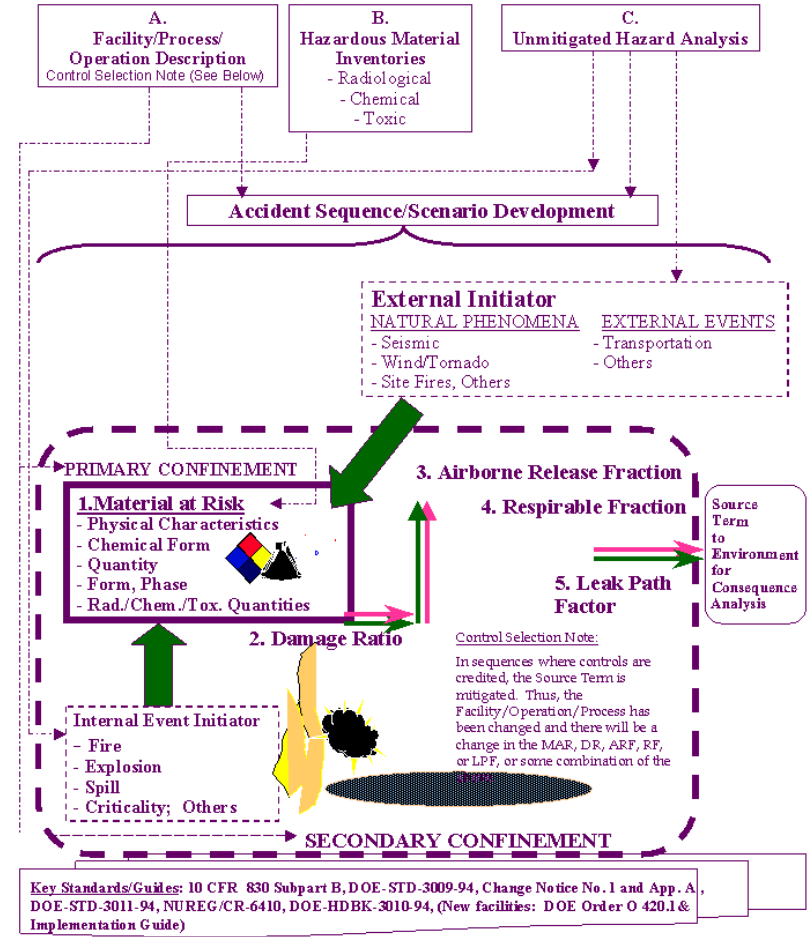
PERFORMANCE CHARACTERISTICS		
Test Name	System	Results
Abrasion Resistance ASTM D4060	646N	120 mg loss
Adhesion ASTM D4541 ASTM D7234	646N	3,180 psi (steel); 482 psi (concrete)
Chemical Resistance ASTM D3912	646N	No Effect
Decontamination ASTM D4256	646N	99%
Direct Impact Resistance ASTM D2794	646/646	120 in. lb.
Effects of Gamma Radiation* ASTM D4082	646N	Pass
Salt Fog* ASTM B117	646N	2,000 hours
Simulated DBA ASTM D3911	646N Steel and Concrete	Pass
Slip Coefficient, RCSC	646N	Class A
Surface Burning ASTM E84/NFPA 255	646N	Flame Spread Index 5; Smoke Development Index 20 (at 10.0 mils or 250 microns)
Thermal Conductivity* ASTM E1530	646N	@ 100°F = 0.21 BTU/h ft °F; @ 200°F = 0.21 BTU/h ft °F



- Standard specifications and testing protocols mitigate information asymmetry and improve trust
 - Key contributors to ensuring quality assurance and reducing risk
- Updating regulations (DOE-HDBK-3010) to account for positive impacts of new technology developments such as fixatives



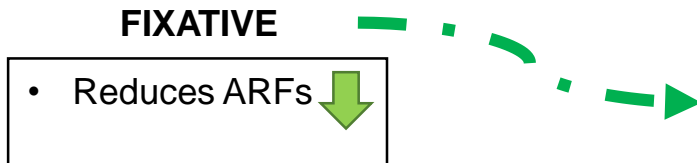
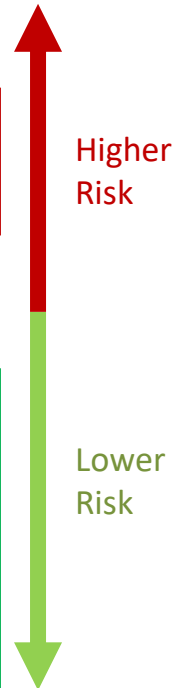
- DOE-HDBK-3010
 - Contains methodology for Source Term Formula
 - Serves as foundation to: 1) safety basis calculations; 2) computer modeling programs; 3) remediation methods and safety control measures; 4) schedule and costs
 - Last update was circa 1994
- **Current version does not account for use of fixative technologies**
 - Assumes MAR remains in a loose powder state
 - However, fixative technologies immobilize and stabilize residual powder
 - **Does not allow end users to take credit for positive impacts of fixative technologies on reducing ARFs under a variety of conditions and stressors**



$$Source\ Term\ Formula = MAR \times DR \times \text{ARF} \times RF \times LPF$$

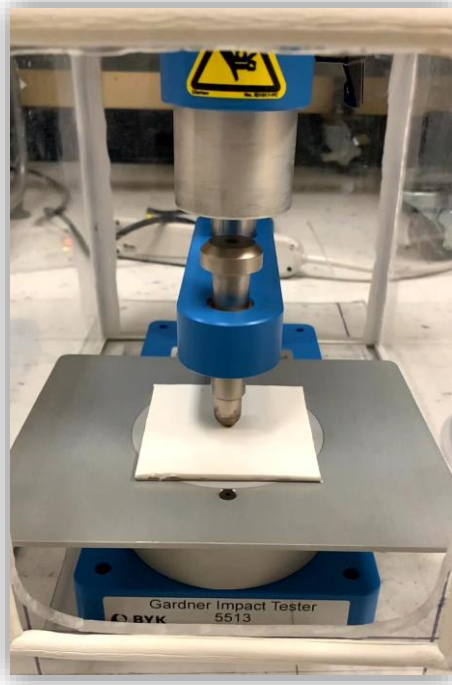
- Intuitively fixatives reduces risk through stabilization of contaminants.
- Quantitative data that proves fixatives reduce ARFs and therefore a “polymer or fixative” form should be considered.
 - Credited in the safety calculations.
 - Incentivize use & increase safety.

Contaminant Form	Impact ARF
Gas / Vapor	1.0
Powder	4E-4
Liquid	4E-5
Metal / Solid	No significant airborne release is postulated for this accident configuration.



Invest in Empirical Research to Support Update of Regulations and Directives

- No visual contamination release.
 - Little to no coupon deformation.
- **Correlated to much lower ARFs.**

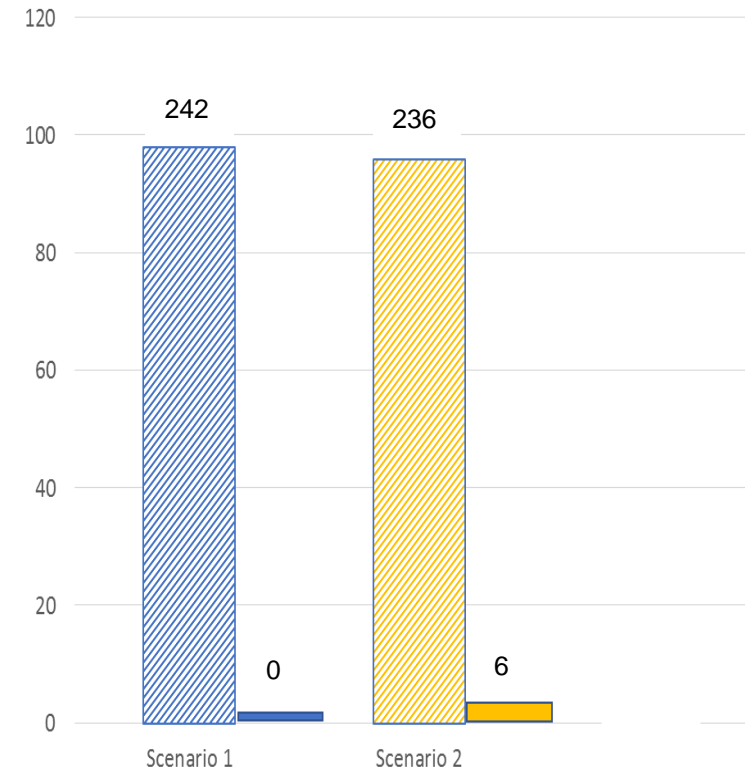


	Impact (in-lb.)	Average ARF	Standard Deviation
PBS	320	4.06E-07	1.62E-07
	240	3.08E-07	1.13E-07
	200	2.28E-07	1.26E-07
	160	1.61E-07	3.66E-08
Total Average		1.10E-06	

Stabilization of Powder due to Polymer Fixative

	Impact (in-lb.)	Average ARF	Standard Deviation
FD	320	4.46E-08	4.36E-08
	240	2.61E-08	9.88E-09
	200	1.92E-08	1.15E-08
	160	1.52E-08	7.32E-09
Total Average		1.05E-07	

- Parallel development of critical enablers is key to improving the ROI of any technology development program
 - Robust engagement with relevant standards development organizations
 - Supporting investment in providing research data to update regulations where appropriate
- Explore the feasibility of developing and implementing a Conformity Assessment Program for Fixative Technologies



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