



International Standards as Critical Enablers to End User Acceptance of New Nuclear Decommissioning Technologies

Joseph Sinicrope, ASTM International E10.03 Subcommittee Chairman





An Informal Survey



- Choose between the two technologies based on the given information:
 - Technology 1: Fixative intended to stabilize residual radioactive material when exposed to fire. \$0.75 / square foot.
 - Technology 2: Fixative intended to Stabilize residual radioactive material when exposed to fire. \$0.75 / square foot. Met ASTM E84, NFPA 701, and UL723 fire test standards.

- Choose between the two technologies based on the given information:
 - Technology 1: Fixative intended to stabilize residual radioactive material when exposed to fire. \$0.75 / square foot.
 - Technology 2: Fixative intended to stabilize residual radioactive material when exposed to fire. \$1.00 / square foot. Met ASTM E84, NFPA 701, and UL723 fire test standards.

Fire Risk

- “It is now established that at many nuclear facilities, fires are the dominant source of risk to workers and the public.” (DNFSB/TECH-27, June 14, 2000)
- Risk categories:
 - New construction – New and challenging requirements
 - Aging legacy facilities – great challenge
 - May not have met codes in effect at time of construction
 - Fire risk not always understood and recognized
 - May not have been upgraded over time to keep pace with risk changes
 - Facilities undergoing decommissioning
 - Overall fire risk associated with D&D
 - Impairment of fire protection systems

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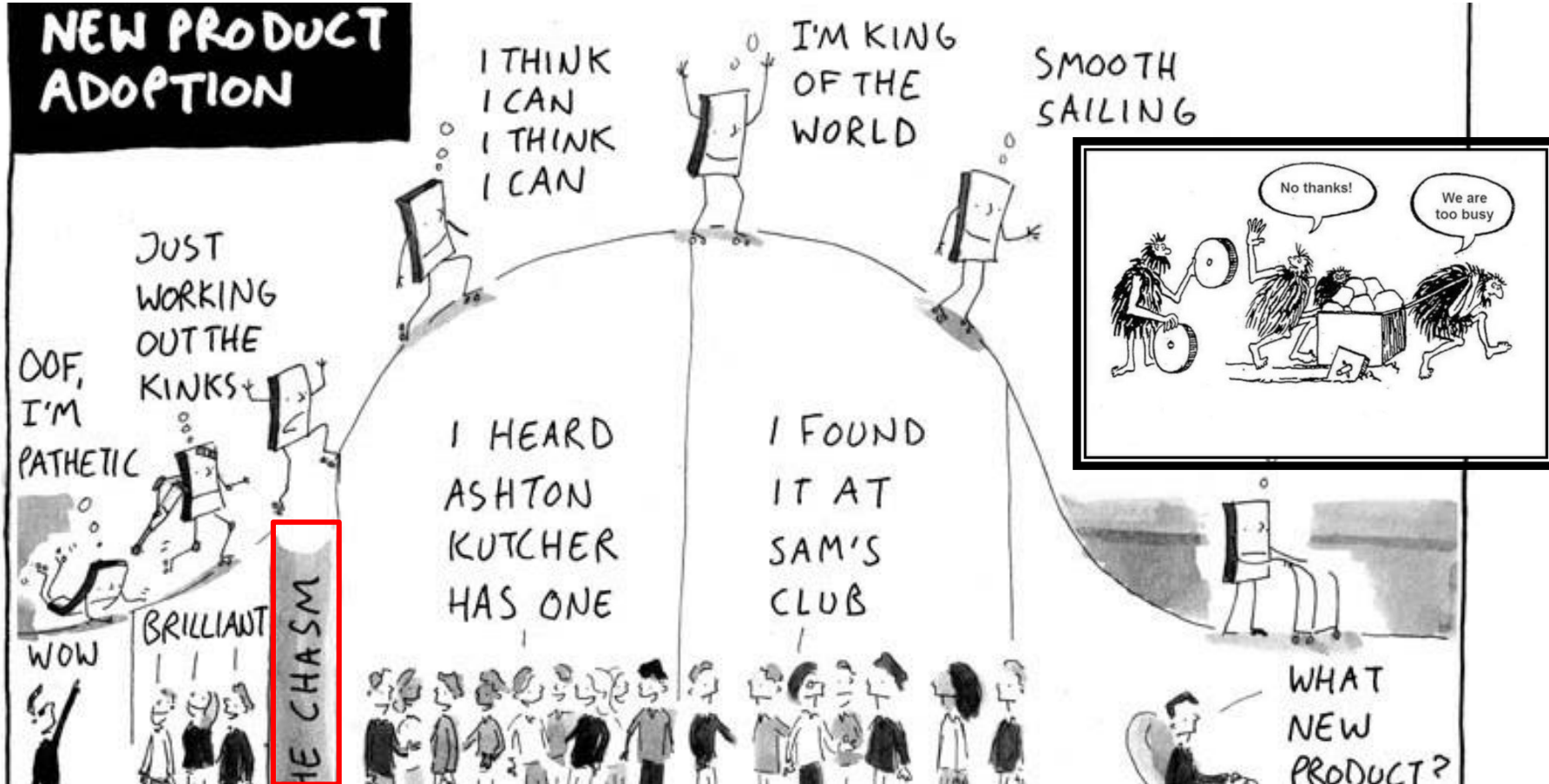
Table 1. Types of Accidents (and Frequencies) Summarized

DOE Site/Facility	Fire Events	Explosion Events	Loss of Confinement (Spill) Events	Natural Phenomena Hazards	Other Events
RFETS Bldg 440	<ul style="list-style-type: none"> 1,200 Drum Fire (EU) 15 Crate Fire (U) Truck Fire (EU) 		<ul style="list-style-type: none"> LLW Repack Spill (U) Drum Spill (A) 	<ul style="list-style-type: none"> Earthquake Collapse (U) 	<ul style="list-style-type: none"> Aircraft Crash (EU)
RFETS Bldg 664	<ul style="list-style-type: none"> 3 Drum Fire (U) 15 Crate Fire (U) 336 Drums + 72 Crates Fire (EU) Truck Fire (EU) 		<ul style="list-style-type: none"> Multi-Container Drop 	<ul style="list-style-type: none"> Earthquake Collapse (U) 	<ul style="list-style-type: none"> Aircraft Crash (worst-case) (EU) Aircraft Crash (realistic case) (EU)
SRS AP5F	<ul style="list-style-type: none"> Accountability Mem. Room Fire (U) 	<ul style="list-style-type: none"> Explosion in Repackaging Area (A) 		<ul style="list-style-type: none"> Seismic Induced Full Facility Fire (U) 	
SRS HB-Line	<ul style="list-style-type: none"> Full Facility Fire (EU) Full Facility Fire & Secondary Events (EU) Intermediate Fire (U) Intermediate Facility Fire & Secondary Events (EU) 		<ul style="list-style-type: none"> Spill (A) 	<ul style="list-style-type: none"> Earthquake with Secondary Events (EU) 	
SRS Bldg 235-F	<ul style="list-style-type: none"> Fire – Best Case (U) Fire – Worst Case (U) 			<ul style="list-style-type: none"> Design Basis Earthquake (EU) 	
SRS SWMP	<ul style="list-style-type: none"> TRU Pads - Internal Culvert Drum Fire (U) 	<ul style="list-style-type: none"> TRU Pads - Culvert Explosion (U) 	<ul style="list-style-type: none"> TRU Pads - High Energy Vehicle Impact (EU) TRU Pads - Dropped Steel Box (A) 	<ul style="list-style-type: none"> TRU Pads - Tornado (EU) 	<ul style="list-style-type: none"> 634-TE Buried Waste Helicopter Crash (EU)
Handorf WRAP Facility	<ul style="list-style-type: none"> 4 Drum Fire (U) Single Drum Fire in Glovebox (U) 	<ul style="list-style-type: none"> Drum Explosion with 4 Drum Fire (U) Single Drum Explosion in Glovebox (U) 	<ul style="list-style-type: none"> Solid Waste Box Failure (A) 	<ul style="list-style-type: none"> Design Basis Earthquake (U) Beyond DBE (EU) 	
INEEL RWMC	<ul style="list-style-type: none"> Vehicle Fire (U) 	<ul style="list-style-type: none"> Drum Explosion (A) 	<ul style="list-style-type: none"> Box Spill (A) 	<ul style="list-style-type: none"> Design Basis Earthquake (U) 	
LANL RAMROD Facility	<ul style="list-style-type: none"> Small Fire (A) Medium Fire (EU) Large Fire (EU) 	<ul style="list-style-type: none"> Small Natural Gas Explosion (A) Medium Natural Gas Explosion (EU) Large Natural Gas Explosion (EU) 	<ul style="list-style-type: none"> Coring Glovebox Spill (A) 	<ul style="list-style-type: none"> Design Basis Earthquake (U) 	<ul style="list-style-type: none"> Aircraft Crash (EU)

Note: Scenarios in *Italics* are risk dominant events, based on Risk Class I or II for the collocated worker. **Bold Italics** denotes that it is also risk dominant for the public.



Roger's Theory of Technology Adoption and Diffusion



Innovators 2.5%
Early Adopters 13.5%

Early Majority
34%

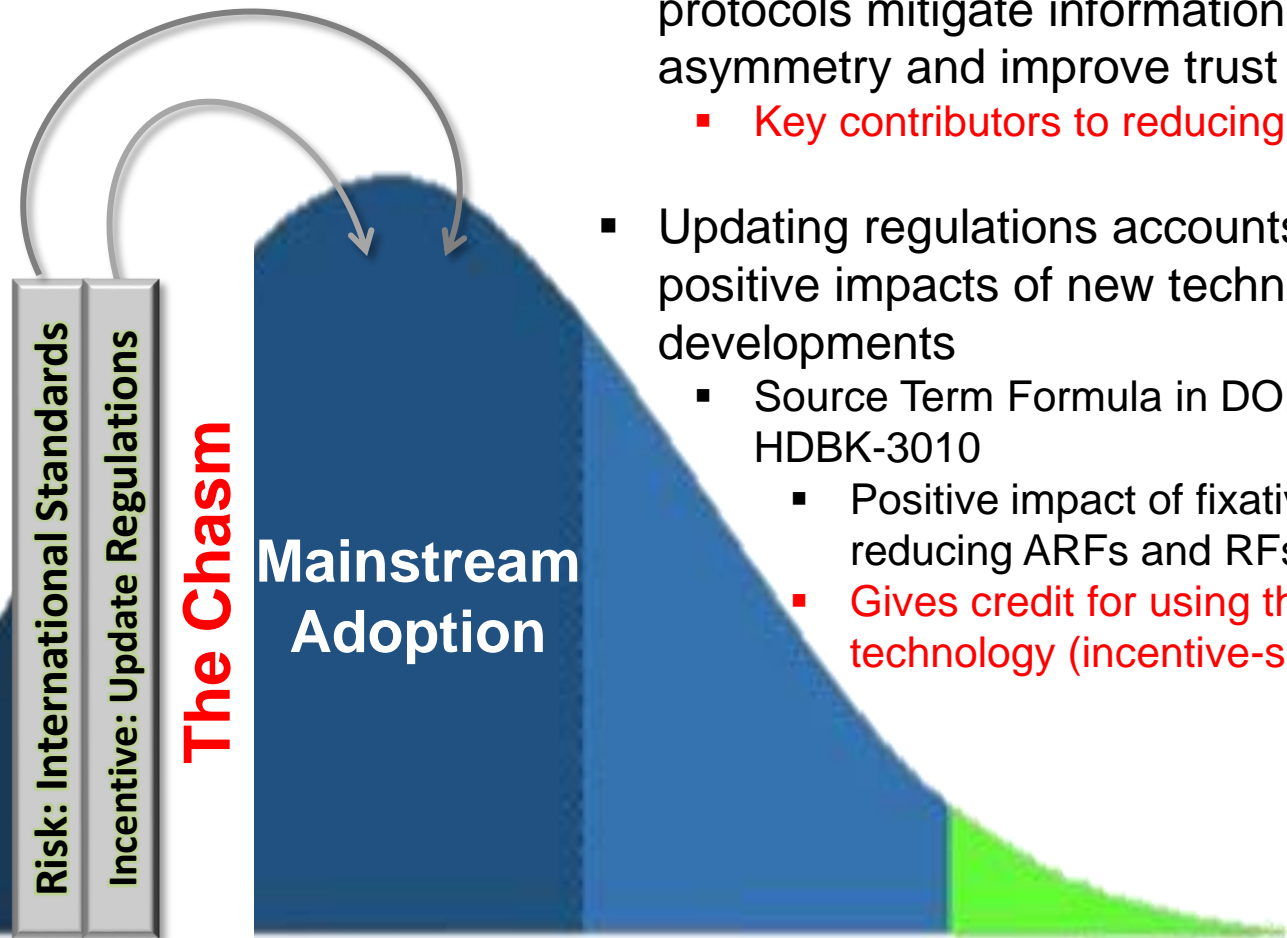
Late Majority
34%

Late Adopters and Laggards 16%



Crossing the Chasm: Mitigating Risk and Increasing Incentive

- Standard specifications and testing protocols mitigate information asymmetry and improve trust
 - **Key contributors to 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
 - **Gives credit for using the technology (incentive-seekers)**





Quacks, Lemons, and Licensing: A Theory of Minimum Quality Standards

H.E. Leland



- Researched the impacts of minimum quality standards and uniform testing protocols on mitigating Akerlof's concept of information asymmetry
 - Lack of trust and unacceptable risk by end users in a given technology
 - Highlighted as key obstacle to tech adoption in GAO report, DOE's Program to Develop New Technologies for Environmental Cleanup
- Two key relevant findings:
 - Social welfare is increased by the imposition of a minimal quality standard
 - Minimal quality standards are particularly advantageous in highly risk averse industries

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

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

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

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

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,

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

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 $L > 0$.

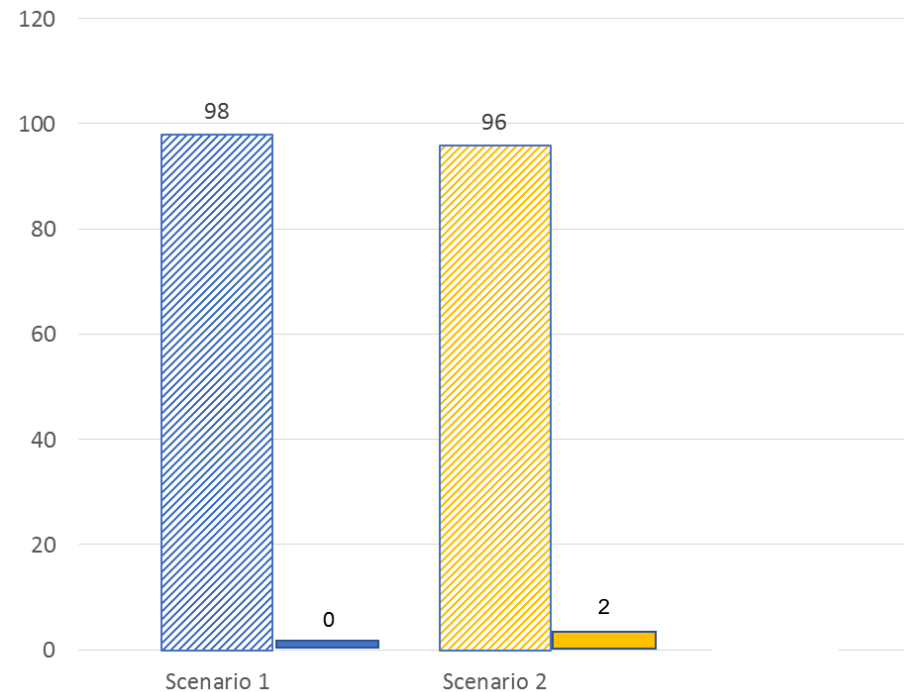
Leland's mathematical confirmation of positive effects of standards



Additional Supporting Literature and Guidance



- Regulation directs federal departments to achieve a greater reliance on voluntary consensus standards
 - Section 12(d) of the National Technology Transfer and Advancement Act (Public Law 104-113)
 - 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"
- 200+ academic publications highlighting the role of consensus-based standards in improving technology development efforts
- Informal survey results





The Mandate

FIUApplied Research
Center

“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 confirm their capabilities. Uniform standards can play a significant role in this effort.*”

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



Spraying fixative at the PFP/PRF and “Fixed” Contamination in Blue



ASTM International Standards for D&D Technologies



- 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.



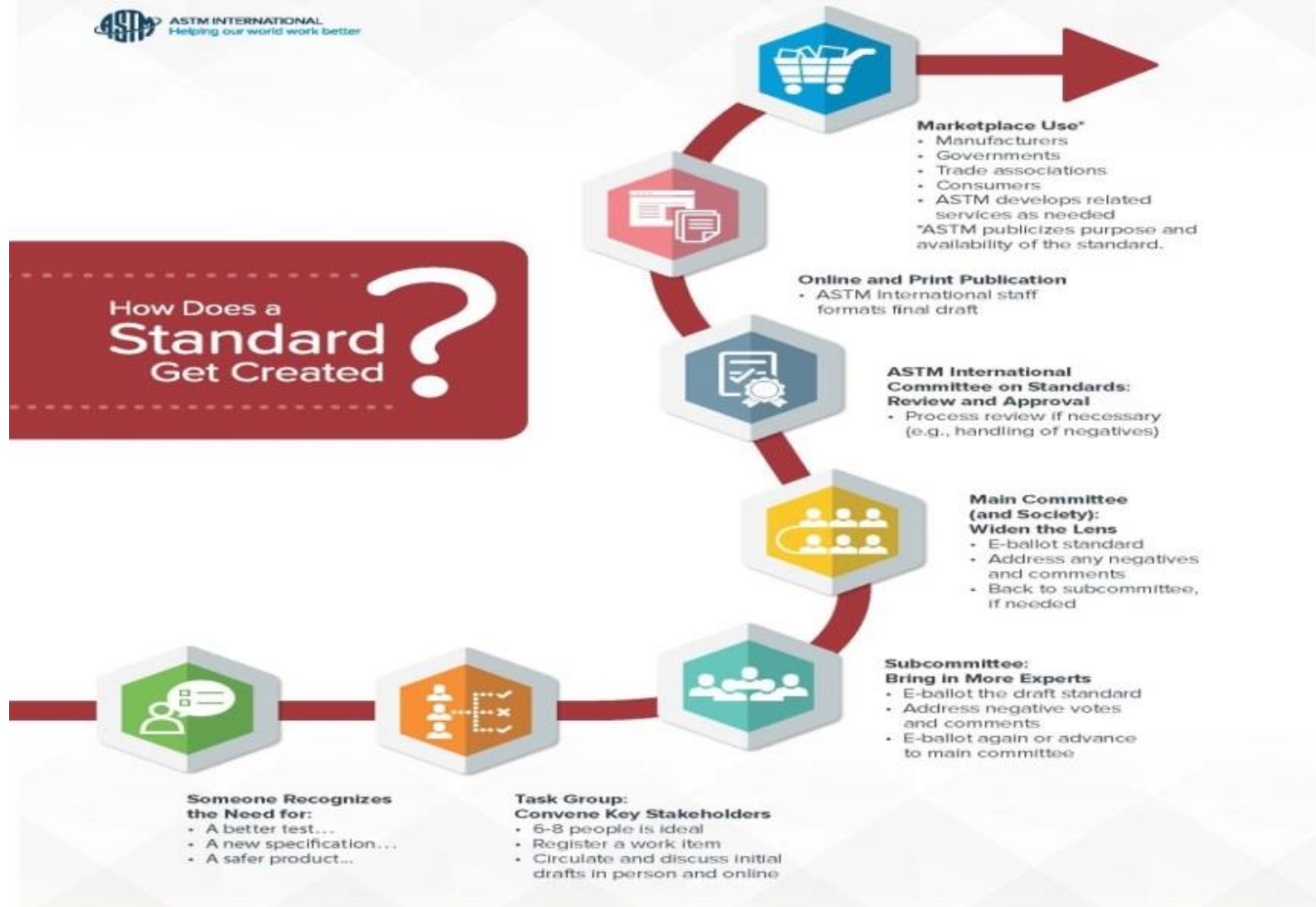
ASTM International Standards Development Process

FIU

Applied Research Center



How Does a
Standard
Get Created?





Defining Fixative Technology Standard Specifications and Testing Protocols



- 3 x 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
 - E3191-18: Specification for Permanent Foaming Fixatives Used to Mitigate the Spread of Radioactive Contamination
 - Referenced in FIU ARC Test Plan of technology
- 1 x test method currently being balloted
 - WK62177, Standard Practice for Preparation of Fixed Radiological/Surrogate Contamination on Porous Test Coupon Surfaces for Evaluation of Decontamination Techniques
 - Linked to E3104-17 above

ASTM Standardization News



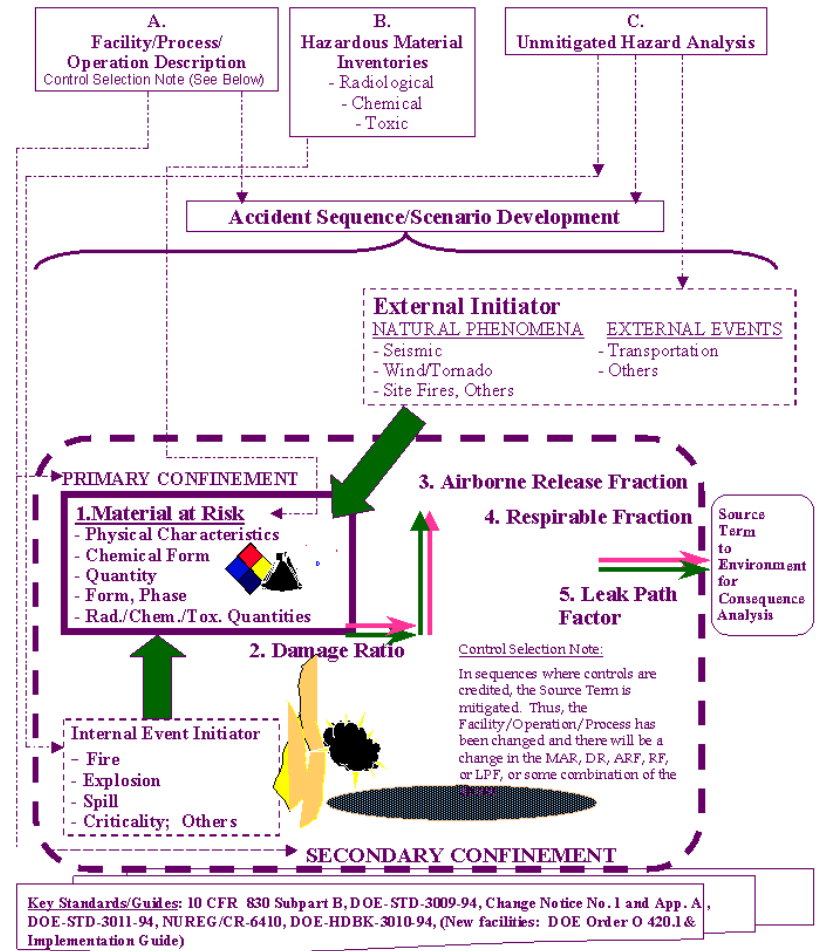
Coatings Help Prevent Radioactive Contamination in Decommissioning
 ASTM News Article Highlighting Newly Established ASTM Standards for D&D Technologies

Link: <https://www.astm.org/standardization-news/?q=update/coatings-help-prevent-radioactive-contamination-decommissioning>



Link Between Standards Development and Updating DOE Handbooks

- 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
- Calculations do not account for use of fixative technologies
 - Assumes MAR remains in a powder state
 - Premise: Change of state occurs with fixative technologies – powder to polymer
 - Validated testing protocols could confirm a given fixative's impact on ARFs/RFs under a variety of conditions and stressors
 - Treat as solid / polymer vice powder (change of state)
 - Can now **get credit for employing the technology (incentive-seekers)**





Way Ahead



- Continue leveraging ASTM E10 Committee and E10.03 Subcommittee to develop operationally relevant, high priority standards and testing protocols for D&D
 - E10.03 Symposia in Atlanta, Jan 2020: “Standards and Test Method Requirements Needed to Support High Priority D&D Technology Programs”
- Better link / integrate with other efforts such as a potential DOE-HDBK-3010 update
 - Addresses “incentive-seekers” to facilitate bridging The Chasm

