



Introduction to Enhanced Nuclear Detonation Safety (ENDS)

Project on Nuclear Issues (PONI)
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Presentation Outline

Part 1 Selected Nuclear Weapon (NW) Accidents

Part 2 Nuclear Safety Design Principles

Isolation

Incompatibility

Inoperability

Part 3 Safety Theme: Normal Environment

Part 3 Implementation Aide: Independence

Part 4 Safety Theme: Abnormal Environments

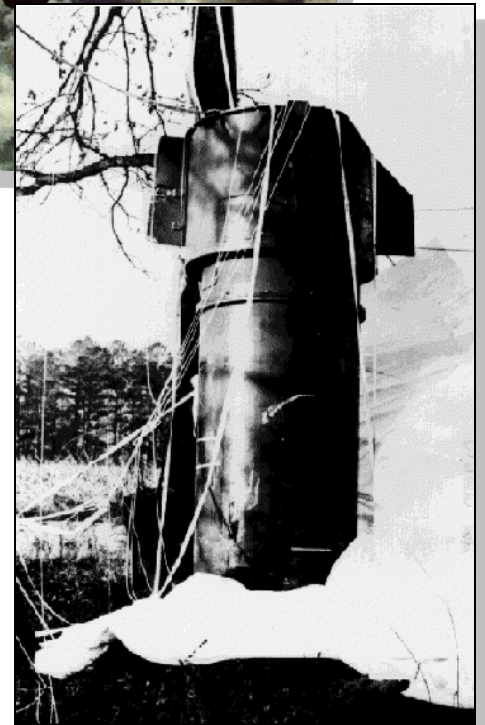
Electrical

Fire

Part 5 Summary

Nuclear Accidents Have Happened

- Goldboro, NC, USA
 - Jan. 24, 1961
 - Weapon breakup
- Bunker Hill, IN, USA
 - Dec. 8, 1964
 - Thermal environments
- Palomares, Spain
 - Jan 17, 1966
 - Dispersal of radioactive material
- Thule, Greenland
 - Jan 21, 1968
 - Dispersal – in a frigid environment



Nuclear Safety: Premature Detonation

- Carl Walske – 1968, Chair of Military Liaison Committee (precursor to current NW Council)
 - New safety requirements mandated for nuclear weapons
 - Probability of nuclear yield (> 4 lbs TNT equivalent) shall not exceed
 - *Prior to launch, for ... normal storage and operational environments ... 1 in 10^9 per warhead lifetime*
 - *Prior to launch, for ... abnormal environments, 1 in 10^6 per warhead exposure or accident*
- $1 \text{ in } 10^6 =$ a probability of 0.000001 , or 10^{-6}

Walske Criteria Required a New Approach

- 1 in 1,000,000
 - 136 pages of text in Encyclopedia Britannica (no spaces)
 - 2,200 lbs / 1,000 kg of US bills
 - One million seconds = 11.6 days
- 1 in 1,000,000,000
 - One billion minutes ago, Roman Empire flourishing
 - One billion seconds = 31.7 years
- How did the Labs meet these new requirements?
 - Developed a Safety Theme: ENDS*
 - Stan Spray, late 60's – early '70's, Sandia Labs
 - Three Nuclear Safety Design Principles

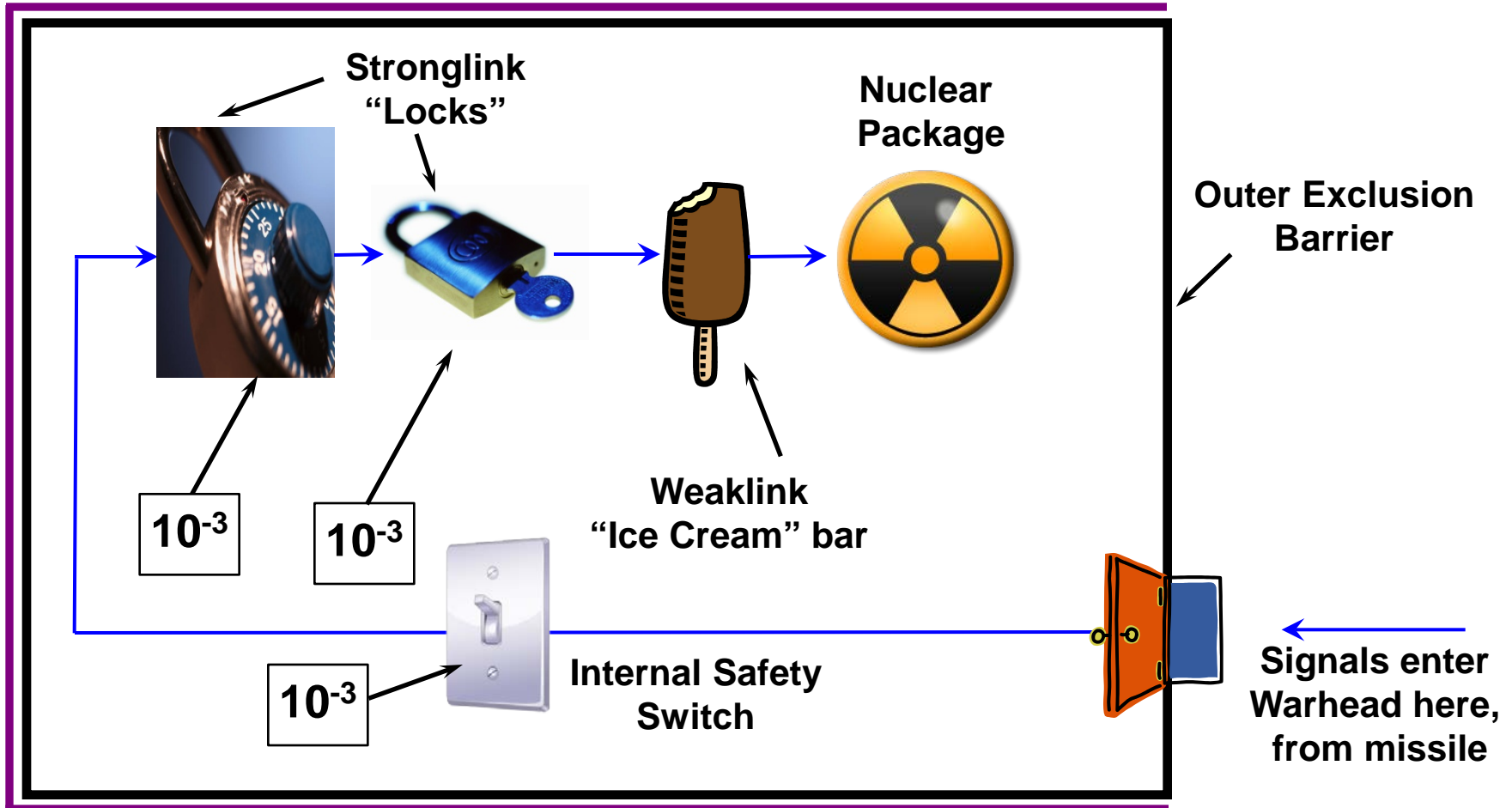


** S.D. Drell, J.S. Foster, and C. H. Tomes (1990), Report of The Panel of Nuclear Weapons Safety, of the House Armed Services Committee.*

Nuclear Safety Design Principles

- **Isolation**: Isolate detonation-critical components from unintended energy (electrical, thermal, mechanical)
 - Stronglinks, exclusion barriers, launch accelerometer
- **Incompatibility**: Design enabling stimuli to be unique and not found in nature
 - Pseudo-random signals used for key fuzing steps
 - Enforce electrical isolation where appropriate
 - Avoid: 60 Hz AC, low-voltage DC signals
- **Inoperability**: Make the weapon predictably and irreversibly inoperable before isolation is lost
 - Thermal weaklinks

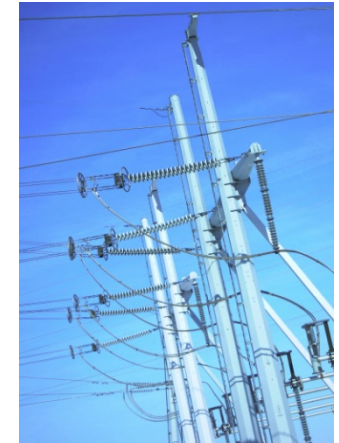
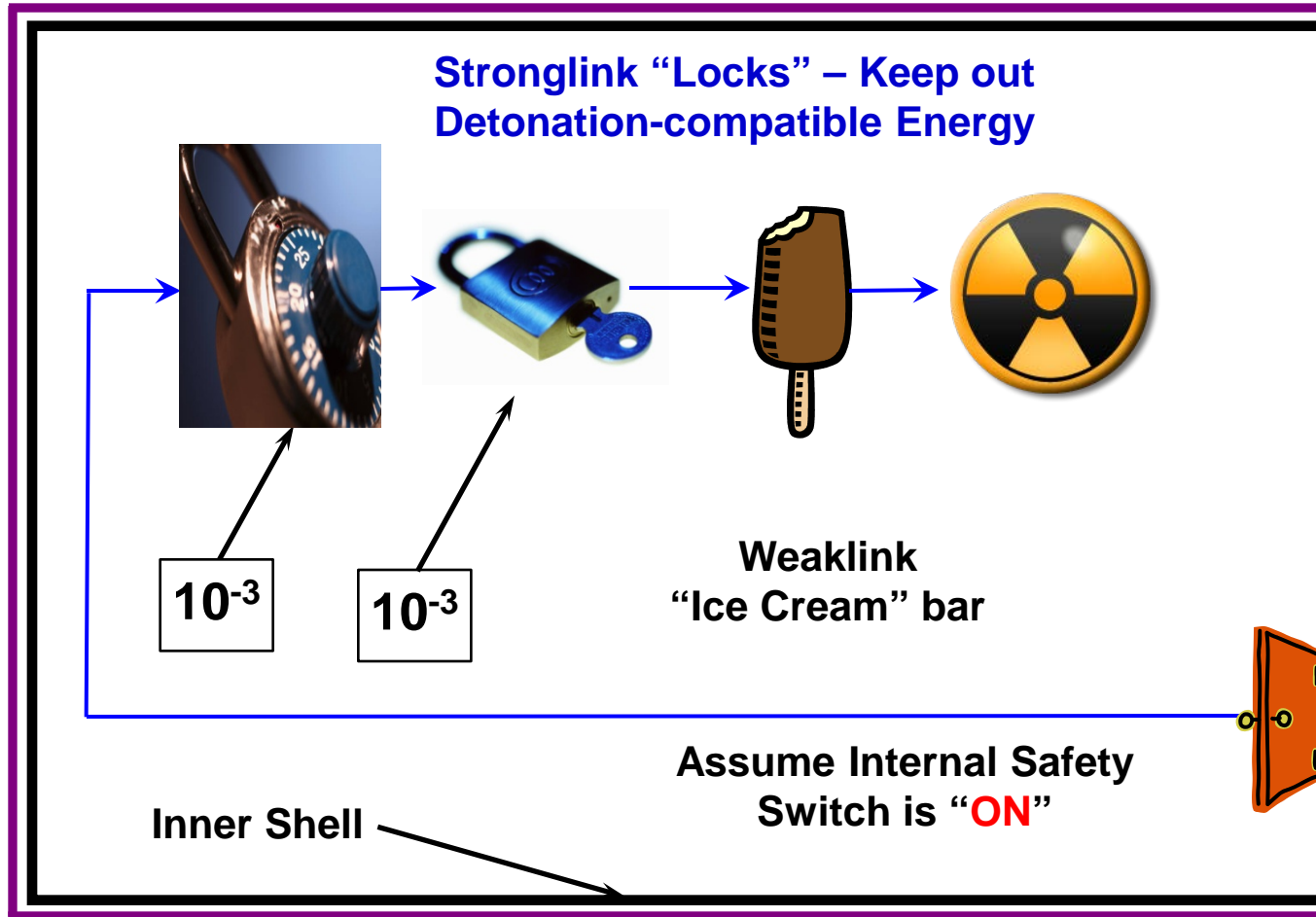
Safety Theme: Normal Environment



Implementation Aide: Independence

- Separate subsystems, independent operation, placed in series:
 - Internal Safety Switch – turned on with missile launch
 - Combination lock
 - Must spin the dial
 - Key lock
 - Need a key
 - Weaklink safety device
 - Small red tube for fire-protection sprinkler systems
 - Nothing to do with combo or key locks
- Easier to assure each component to 1 in 10^3 level
 - *Three of these in series = 1 in 10^9 safety.*
- **Must be NO common failure modes**

Abnormal Environment: Electrical Power Line

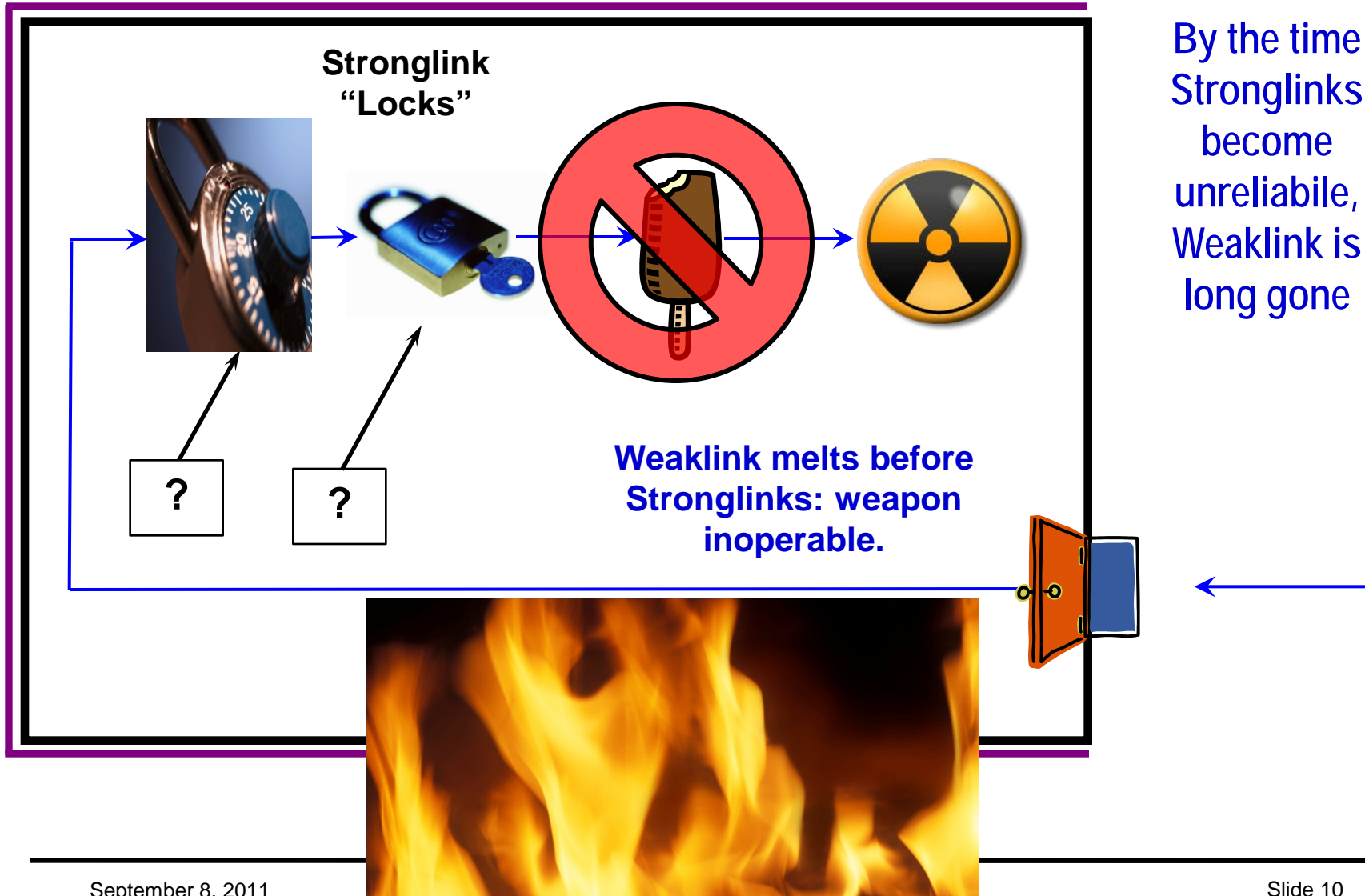


Unknown abnormal voltage and current possible



Outer Shell

Abnormal Environment: Fire



Summary

- Several Nuclear Weapon accidents caused a reassessment of design safety in the late '60's
- Walske Criteria
 - 1 in 10^9 for normal environments, 1 in 10^6 for abnormal
- New requirements met through a Safety Theme
 - Isolation, Incompatibility, Inoperability
 - Independence allows a realistic implementation
- Modern designs adhere to this theme
 - Future refurbishments, life extension programs

Safety to the Walske Criteria may be asserted by using Enhanced Nuclear Detonation Safety