SURVEY OF WEAPONS DEVELOPMENT AND TECHNOLOGY

WR708

SESSION IV

- HIGH EXPLOSIVES
- DETONATORS

PRIMARY

- **EASILY IGNITED WITH QUICK TRANSITION TO DETONATION**
- **SMALL QUANTITY REQUIRED**

SECONDARY

- **INSENSITIVITY**
- **HIGH ENERGY DENSITY**

PHYSICAL SEPARATION - TETRYL

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Material[a]	Chemical name	Other designations	Color
*BTF	Benzotris-[1,2,5] oxadiazole-[4,4,7]-trioxide	Benzotrifuroxan, hexanitrosobenzene	Buff
*DATB	1,3-Diamino-2,4,6-trinitrobenzene		Yellow
*DIPAM	3,3-Diamino-2,2',4,4',6,6'-hexanitrobiphenyl	Hexanitrodiphenyl-amine hexite, dipicrylamine	—
*DNPA	2,2-Dinitropropyl acrylate		Off-white
*EDNP	Ethyl-4,4-dinitropentanoate		Yellow
*FEFO	Bis(2-fluoro-2,2-dinitroethyl)-formal		Straw
**HMX	1,3,5,7-Tetranitro-1,3,5,7-tetraazacyclooctane	Cyclotetramethylene tetranitramine, octogen	White
*HNAB	2,2',4,4',6,6'-Hexanitroazo-benzene		Orange
*HNS	2,2',4,4',6,6'-Hexanitrostilbene		Yellow
**NC (12% N)[b]	Partially nitrated cellulose	Nitrocellulose (lacquer grade), cellulose trinitrate, piroksilin	White
*NC (13,35% N, min)[b]	Partially nitrated cellulose	Nitrocellulose, guncotton	White
*NG	1,2,3-Propanetriol trinitrate	Nitroglycerin	Clear
*NM	Nitromethane		Clear
*NQ	Nitroguanidine	Aminomethaneamidine	White
**PETN	Pentaerythritol tetranitrate	Penthrite, TEN	White
**RDX	1,3,5-Trinitro-1,3,5-triaza-cyclohexane, hexahydro-1,3,5-trinitro-s-triazine	Cyclotrimethylene trinitramine, hexogen cyclonite,Gh	White
*TACOT	Tetranitro-1,2,5,6-tetraazadi-benzocyclooctatetrene	Tetranitrodibenzo-1,3a,4,6a-tetraazapentalene	Red-orange
**TATB	1,3,5-Triamino-2,4,6-trinitro benzene		Bright yellow
**Tetryl	2,4,6-Trinitrophenylmethyl-nitramine		Yellow
**TNM	Tetranitromethane		Clear
**TNT	2,4,6-Trinitrotoluene	Trotyl,T,tol	buff to brown

**Denotes it has been used in nuclear weapons

Cast explosives: names and formulations.

Explosive[a]	Formulation (wt%)[b] TNT	RDX	Other ingredients	
Baratol	24		$Ba(NO_3)_2$	76
Boracitol	40		Boric Acid	60
*Comp B, Grade A[c]	36	63	Wax	1
Comp B-3	40	60		
*Cyclotol[d]	25	75		
H-6	30	45	Wax	5
			Al	20
			$CaCl_2$	0.5
*Octol	25		HMX	75
*Pentolite[d]	50		PETN	50
Tritonal	80		Al	20

[a]Properties of materials marked with asterisks are summarized in data sheets (Section IV).

[b]The weight percent values given in the table are nominal and subject to some variation.

[c]Comp B, Grade A is formulated as a 60/40 RDX/TNT mixture, but high-quality castings usually are higher in RDX content due to the removal of a TNT-rich section at the top of the casting.

[d]There are several cyclotols and pentolites. The most common cyclotol is RDX/TNT 75/25. The most common pentolite is PETN/TNT 50/50.

Plastic-bonded explosives: Names and formulations.

Explosive[a]	Other ingredients	Formulation Ingredient	wt%	Color
*LX-04-1	PBHV-85/15	HMX	85	Yellow
		Viton A	15	
*LX-07-2	RX-04-BA	HMX	90	Orange
		Viton A	10	
*LX-09-0	RX-09-CB	HMX	93	Purple
		pDNPA	4.6	
		FEFO	2.4	
LX-09-1		HMX	93.3	Purple
		pDNPA	4.4	
		FEFO	2.3	
*LX-10-0	RX-04-DE	HMX	95	Blue-green spots
		Viton A	5	on white
LX-10-1		HMX	94.5	Blue-green spots
		Viton A	4.5	on white
*LX-11-0	RX-04-PI	HMX	80	White
		Viton A	20	
*LX-14-0		HMX	95.5	Violet spots
		Estane 5702-FI	4.5	on white
*PBX-9007	PBX-9007 Type B	RDX	90	White or mottled
		Polystyrene	9.1	gray
		Di(2-ethyl-hexyl)-phthalate	0.5	

Plastic-bonded explosives: Names and formulations. (cont.)

		Formulation		
		Rosin	0.4	
*PBX-9010		RDX	90	White
		Kel-F	10	
*PBX-9011	X-0008	HMX	90	Off-white
		Estane 5740-X2		
*PBX-9205		RDX	92	White
		Polystyrene	6	
		Di(2-ethyl-hexyl)-phthalate	2	
*PBX-9404	PBX-9404-03	HMX	94	White or blue
		NC (12.0% N)	3	
		Tris (B-chloro-ehtyl)-phosphate	3	
*PBX-9407		RDX	94	White or black
		Exon 461	6	
*PBX-9501		HMX	95	White
		Estane	2.5	
		BDNPA	1.25	
		BDNPF	1.25	
PBX-9502		TATB	.05 Kel F	
LX-17		TATB	.075 Kel F	

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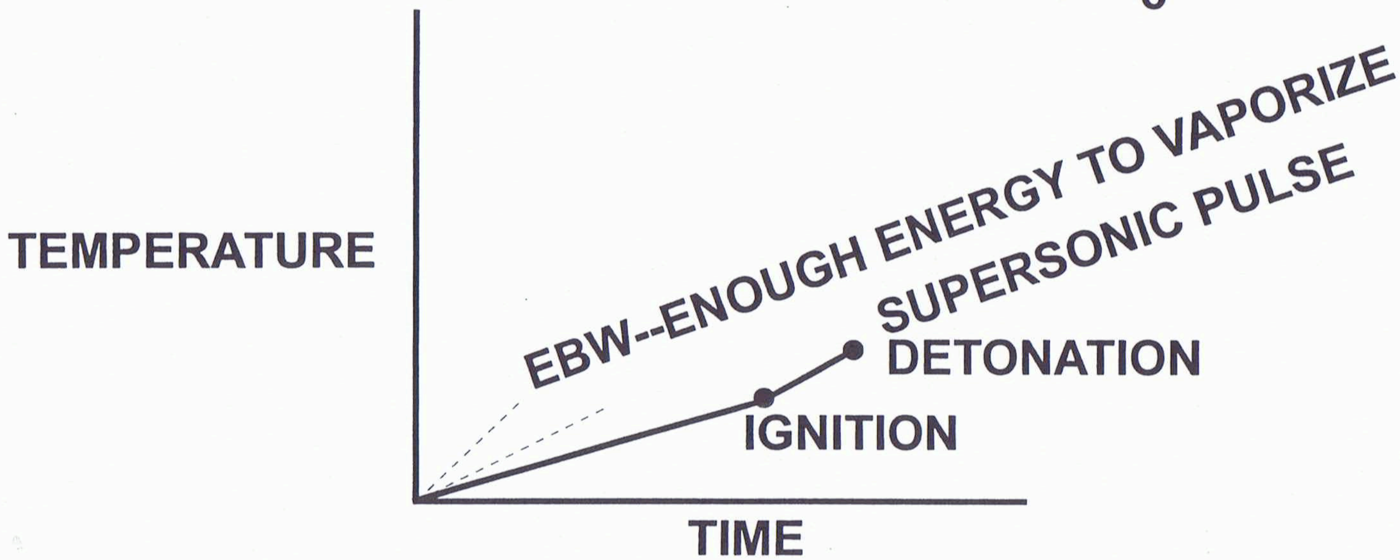
PbN_6



EBW (EXPLODING BRIDGEWIRE) EVOLVED

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REFERENCES

- AN INTRODUCTION TO NUCLEAR WEAPONS; WASH 1037 REVISED; GLASSTONE, JUNE 1972
- PROPERTIES OF CHEMICAL EXPLOSIVES AND EXPLOSIVE SIMULANTS; LLL JULY 31, 1974, DOBRATZ UCRL - 51319, REV 1
- SENSITIVITY OF INITIATION-SYSTEM DETONATORS: REVIEW OF CURRENT AND ADVANCED TECHNOLOGIES; R. E. SETCHELL; SAND91-1590

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- SOURCE BOOK ON ATOMIC ENERGY; GLASSTONE, 3rd EDITION

- NUCLEAR TEST SUMMARY TRINITY — HARDTACK DASA 1220; RS3141/10349

- VARIOUS WEAPON DEVELOPMENT REPORTS

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SURVEY OF WEAPONS DEVELOPMENT AND TECHNOLOGY

WR708

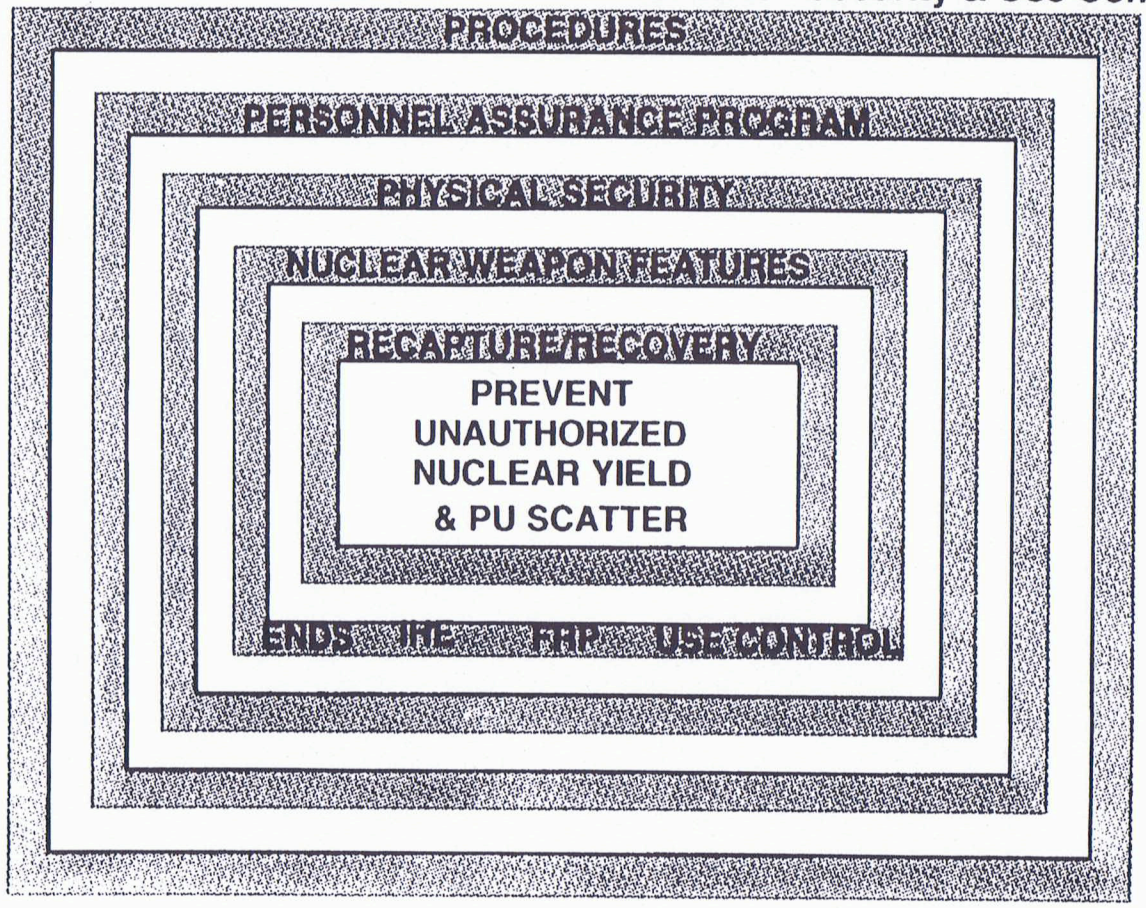
SESSION VII

- NUCLEAR DETONATION SAFETY
- NUCLEAR MATERIAL SCATTER

Surety

PART OF A LAYERED NATIONAL PROGRAM PROTECTING AGAINST UNAUTHORIZED NUCLEAR DETONATION OR PLUTONIUM SCATTER

THE ADVERSARY: → Accidents - Safety
Humans - Security & Use Control



Nuclear Weapon Surety aims to prevent three consequences

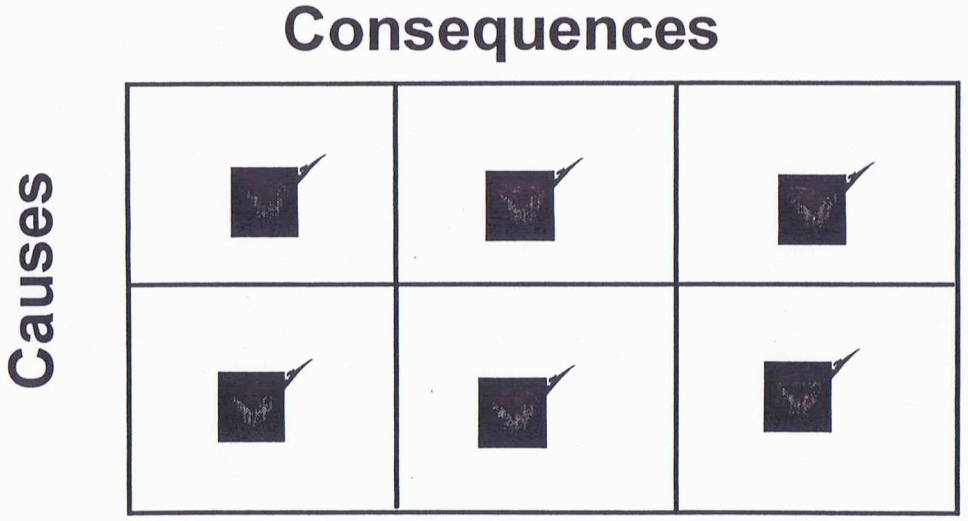
Nuclear yield - release of nuclear energy greater than the energy of four pounds of high explosive

Launch or release - sending a nuclear weapon toward a target

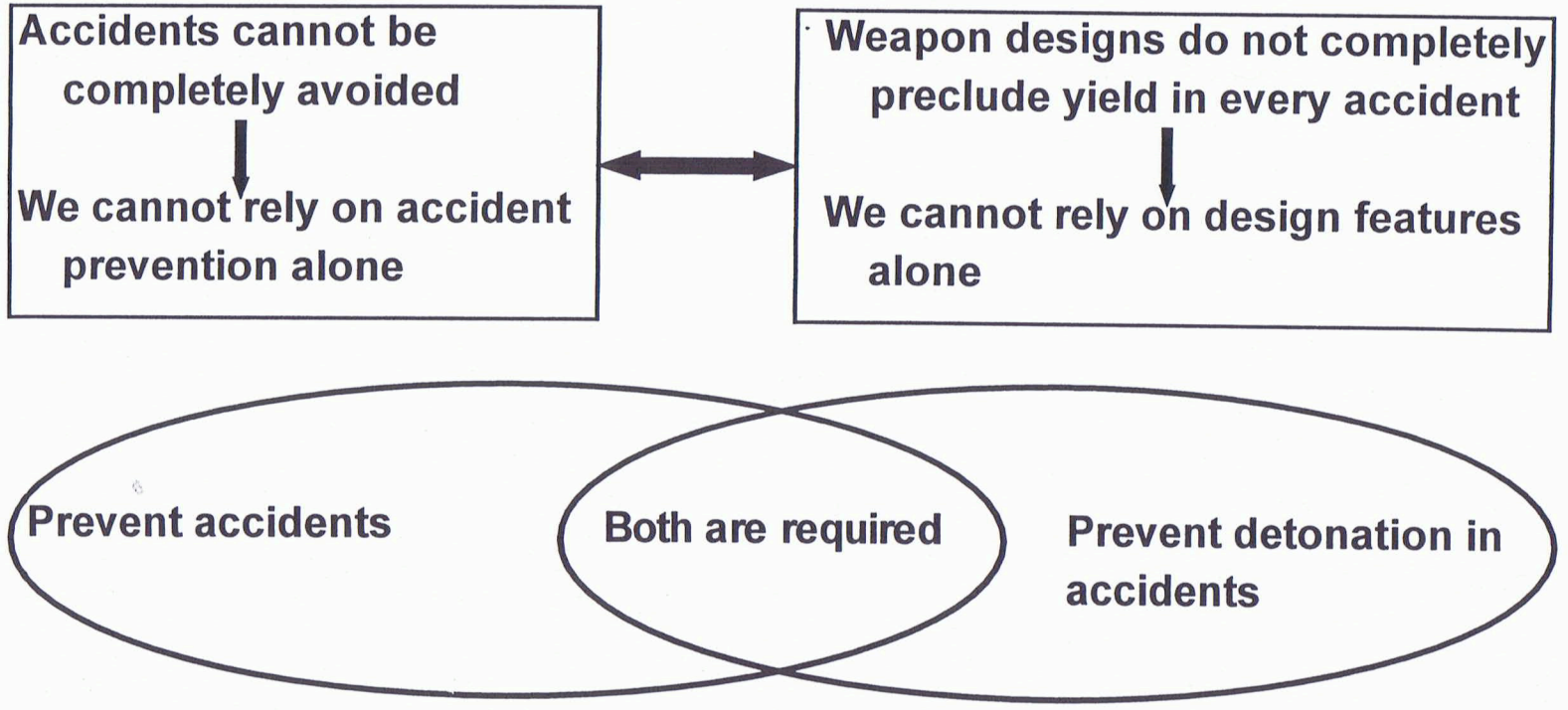
Pu dispersal - release of plutonium outside the weapon

The goal of surety standards

Compliance with nuclear weapon system surety standards should provide assurance against undesired consequences
(nuclear yield, launch, or Pu dispersal)
resulting from any causes
(either intended or unintended).



The dual approach to nuclear weapons safety



DOE shares responsibility for safety, security, and control

From the 1983 Memorandum of Understanding between DOE and DoD on Objectives and Responsibilities for Joint Nuclear Weapon Activities

"The obligation of the DoD and the DOE to protect public health and safety provides the basic premise for dual-agency judgment and responsibility for safety, security and control (S ^{2}C) of nuclear weapons. This check-and-balance role shall continue. The DoD and the DOE share the responsibility to:

1) Identify and resolve health and safety problems connected with nuclear weapons. In particular, the DOE has a continuing responsibility to participate with the DoD in the consideration of these health and safety problems for nuclear weapons in DoD custody.

2) Prevent unauthorized use of a nuclear weapon through the use of positive control measure...

3) Determine the adequacy and effectiveness of physical security measures..."

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Department of Defense Directive

3150.2

Replaces DoD 5030.15...February 8, 1984

SAFETY STANDARDS

1. There shall be positive measures to prevent nuclear weapons involved in accidents or incidents, or jettisoned weapons, from producing a nuclear yield.

2. There shall be positive measures to prevent deliberate prearming, arming, launching, firing, or releasing of nuclear weapons, except upon execution of emergency war orders or when directed by competent authority.

3. There shall be positive measures to prevent inadvertent prearming, arming, launching, firing, or releasing of nuclear weapons in all normal and credible abnormal environments.

4. There shall be positive measures to ensure adequate security of nuclear weapons, pursuant to DoD Directive 5210.41.

DOE Order 5610.10
10/10/90
Nuclear Explosive Safety Standards

a. There shall be positive measures to prevent nuclear explosives involved in accidents or incidents from producing a nuclear yield.

b. There shall be positive measures to prevent deliberate prearming, arming, or firing of a nuclear explosive except when directed by competent authority.

c. There shall be positive measures to prevent the inadvertent prearming, arming, launching, firing, or releasing of a nuclear explosive in all normal and credible abnormal environments.

d. There shall be positive measures to ensure adequate security of nuclear explosives pursuant to the DOE safeguards and security requirements.

e. There shall be positive measures to prevent accidents, inadvertent, or deliberate unauthorized dispersal of plutonium to the environment.

DOE Nuclear Explosive Surety Standard

All DOE nuclear explosive operations shall meet the the following qualitative surety standards to prevent unintended nuclear detonation, fissile material dispersal from the pit, or loss of control. There shall be positive measures to:

- Minimize the possibility of accidents, inadvertent acts, or authorized activities that could lead to fire, high explosive deflagration, or unintended high explosive detonation;
- Minimize the possibility of fire, high explosive deflagration, or high explosive detonation, given accidents or inadvertent acts;
- Minimize the possibility of deliberate unauthorized acts that could lead to high explosive deflagration or high explosive detonation;
- Ensure adequate security of nuclear explosives;
- Minimize the possibility of or delay unauthorized nuclear detonation.

Reference: DOE Order 452.1, October 4, 1996

Positive Measures

From DOE Order 5610.10

- Design features, safety rules, procedures, or other controls used individually or collectively to provide nuclear explosive safety.
- Positive measures are intended to assure a safe response in applicable operations and be controllable.
- Examples
  - strong-link switches
  - other safety devices
  - administrative procedures and controls
  - general and specific nuclear explosive safety rules
  - design control of electrical equipment and mechanical tooling physical, electrical, and mechanical restraints incorporated in facilities and transport equipment

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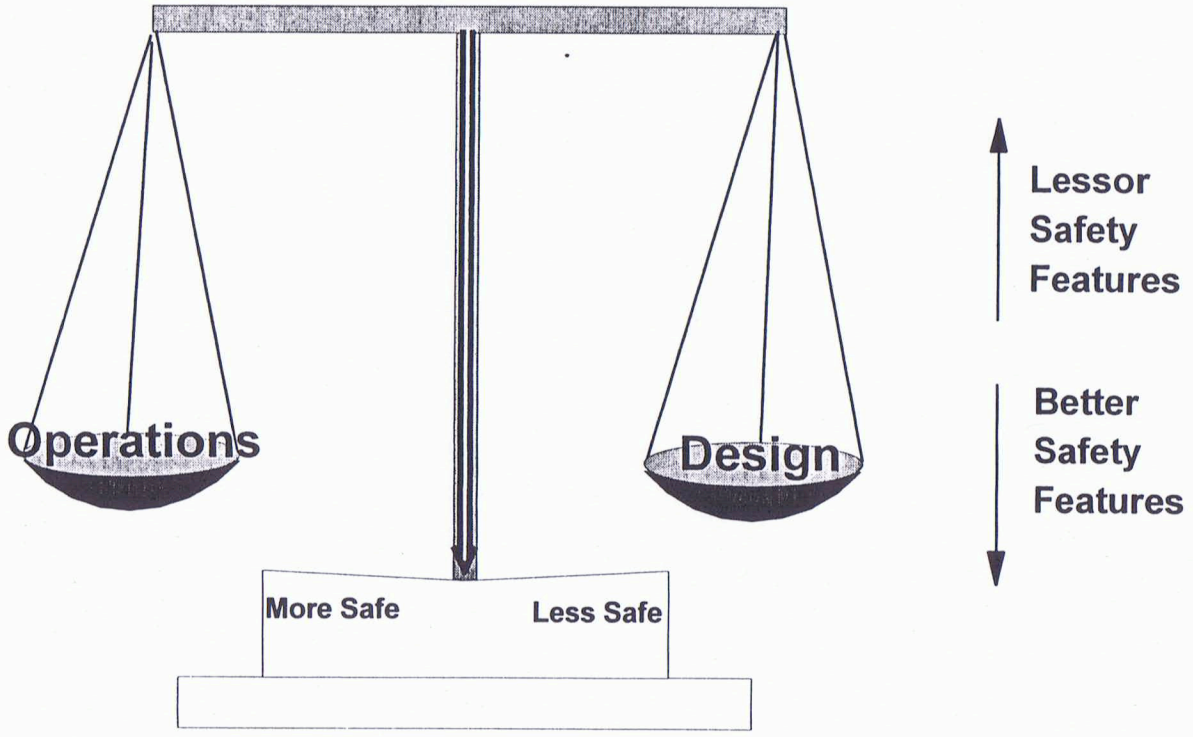
Explanation of normal and abnormal environments

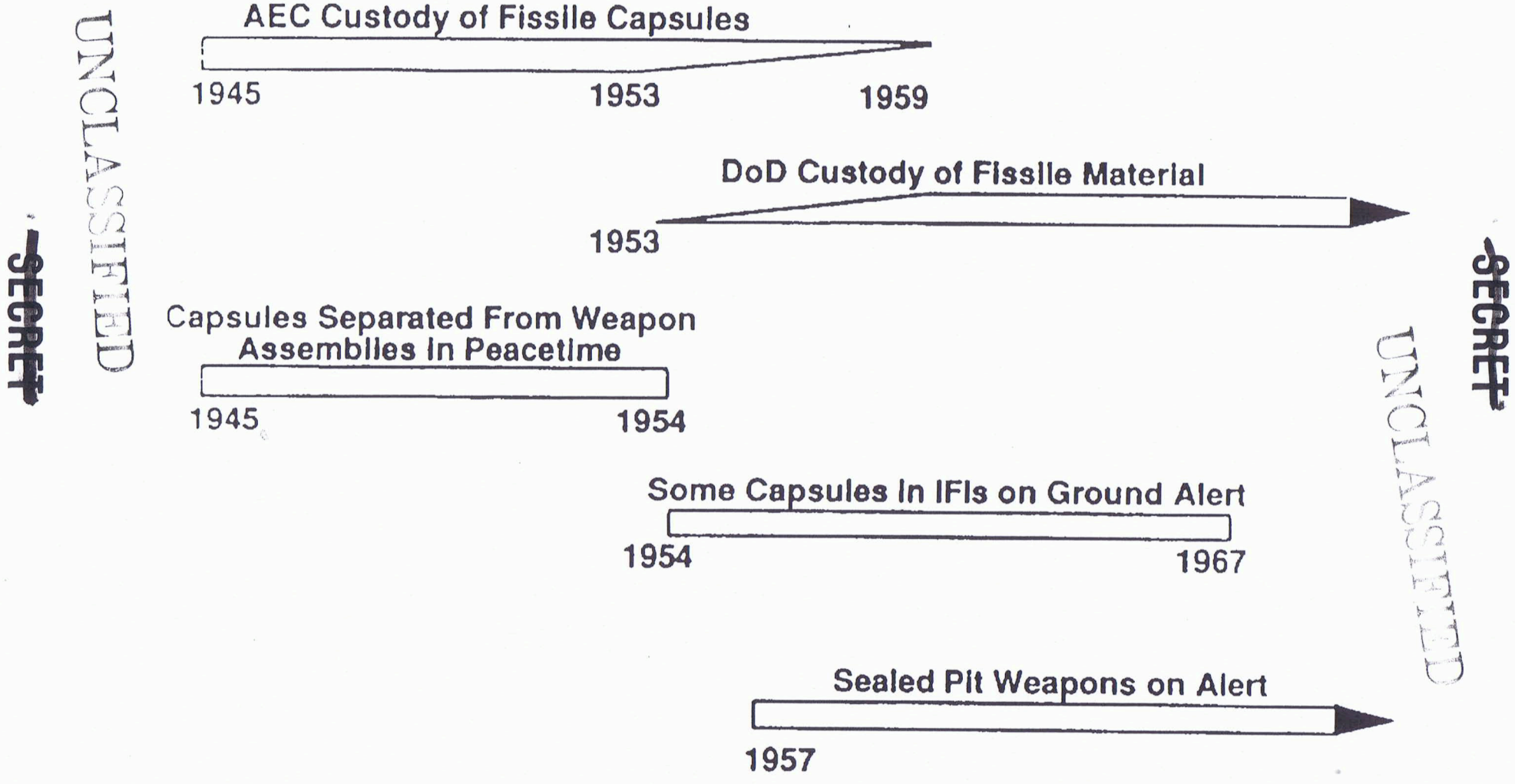
Normal environments (temperature, shock, electrical connections, etc.) are those defined in the weapon or system specifications and intended to be tolerated by the weapon or system. The system is designed to function normally during its entire lifetime if it experiences normal environments.

Abnormal environments are conditions experienced by the weapon or system that are outside the defined normal environments (more extreme temperatures, shocks, voltages, etc.). The weapon or system is not required to function after exposure to an abnormal environment.

OPERATIONS & SAFETY DESIGN MUST BE BALANCED

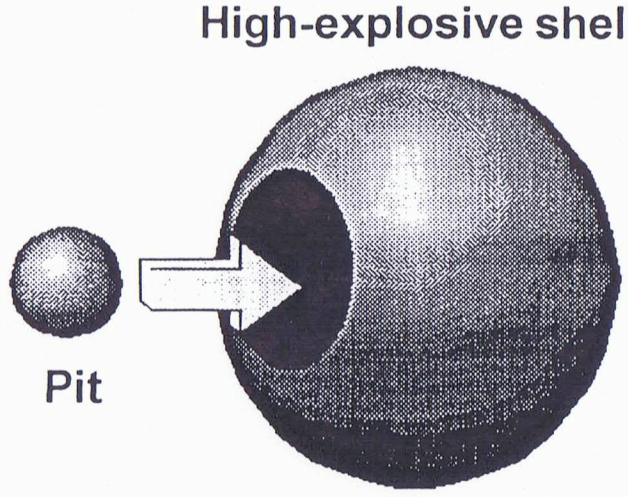


U. S. NUCLEAR DEPLOYMENTS CHANGED



Manually Inserted Capsules

1948 - 1951



- Safety Theme: Separation of fissile material and HE
- Analysis: Accident must assemble weapon

Mechanically Inserted Capsules

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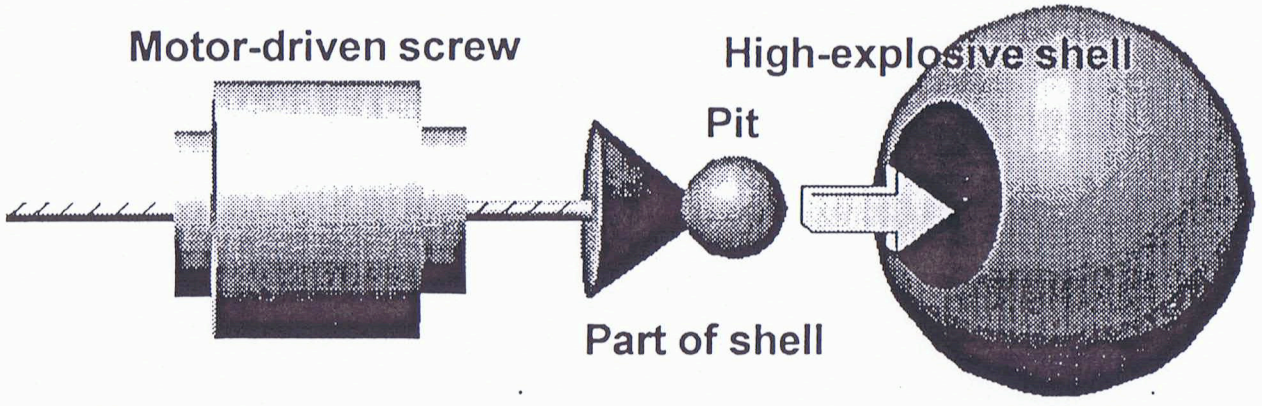
1952 - 1967



- Safety Theme: Separation of fissile material and HE and electrical isolation
- Analysis: Accident could assemble weapon by operating motor or by mechanical damage

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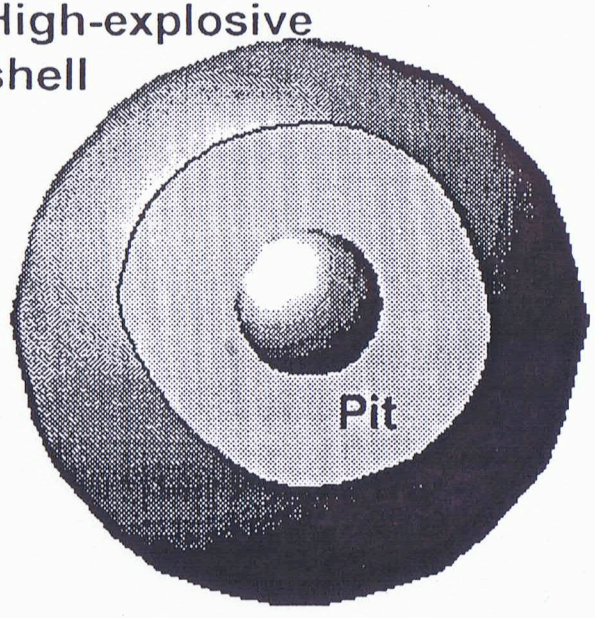
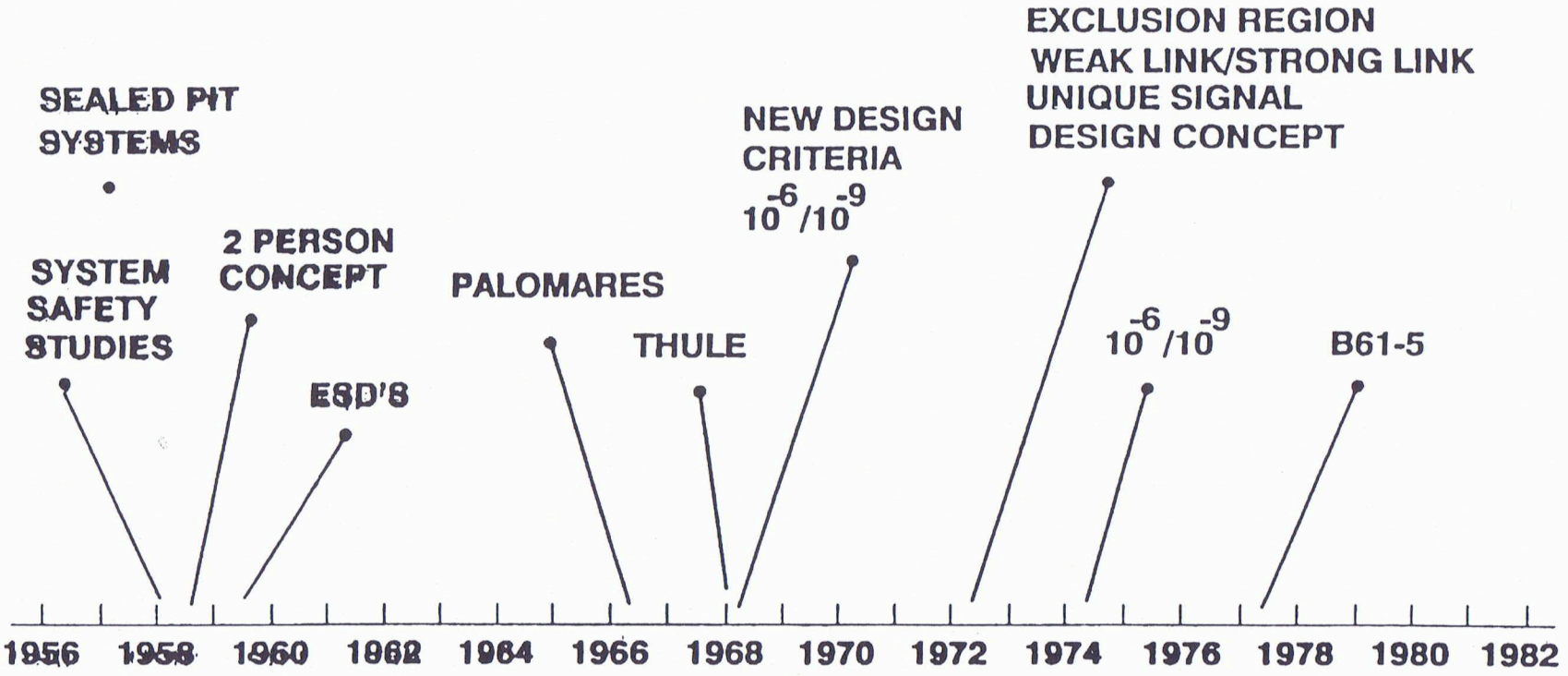
Sealed-pit Weapons

1957



- Safety Theme: Electrical isolation and one-point safety
- Analysis: Accident could generate firing signals; not one-point safe

EVOLUTION OF NUCLEAR SAFETY



Early Electrical Isolation Safety Features

1950 - 1970

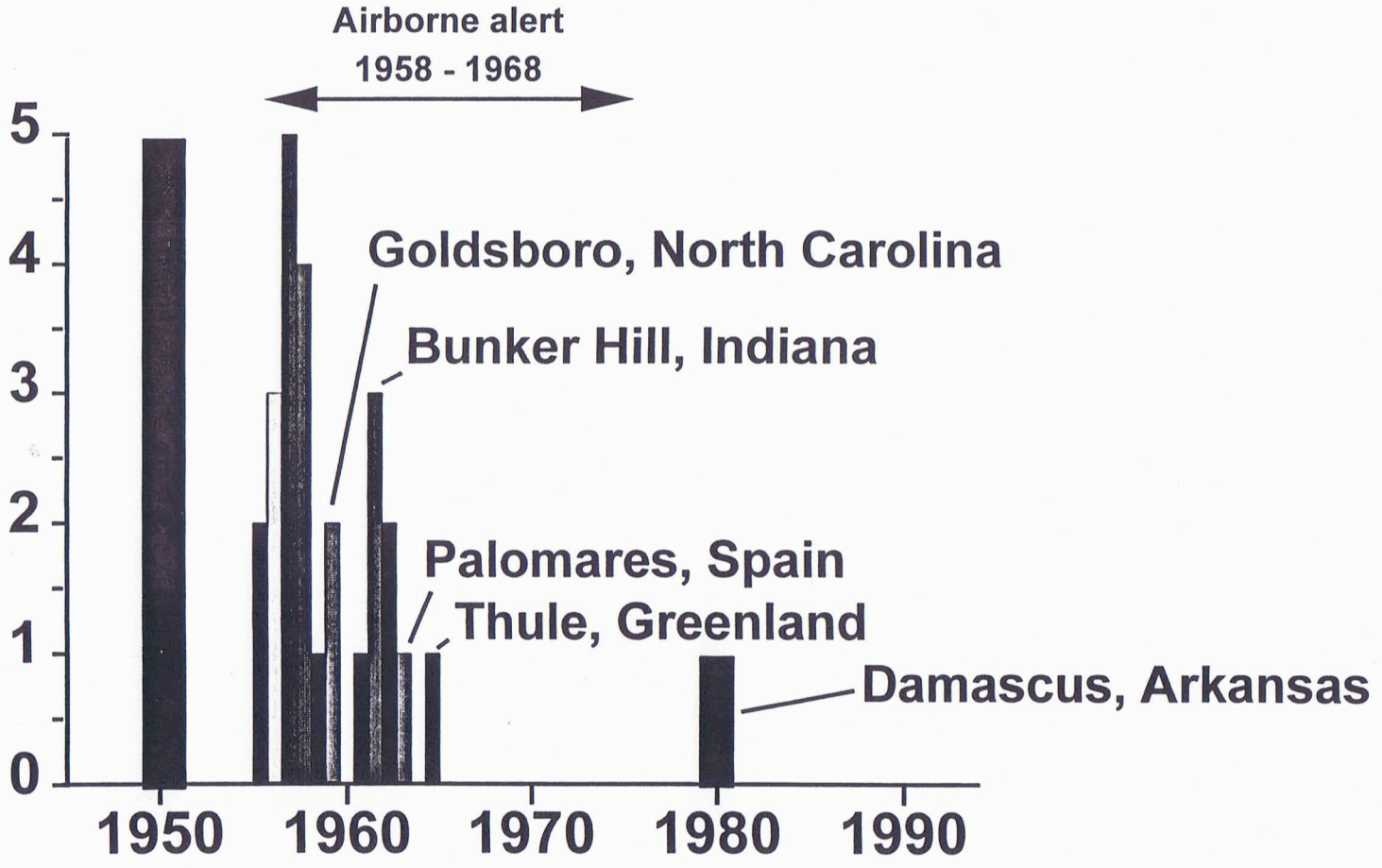
- Removable safing plugs
- Circuit board and cable isolation
- Removable or external power supplies
- Ready-safe switches
- Thermal fuses
- Environmental sensing devices

Environmental Sensing Devices (ESDs)

An open switch in the prearming circuits.

It is closed after sensing an environment experienced by the weapon system when enroute to the target.

US Nuclear Weapon Accidents



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B-52G INCIDENT
GRAND FORKS AFB
15 SEPTEMBER 1980

DURING A CARTRIDGE START FOR AN ALERT EXERCISE, AN ALERT CONFIGURED B-52G EXPERIENCED A FIRE IN THE NUMBER 5 ENGINE. 30 KNOT WIND WAS FORTUITOUSLY BLOWING FROM DIRECTION DIRECTLY AFT OF AIRCRAFT. FIRE WAS FOUGHT FOR THREE HOURS BEFORE FUEL FLOW TO ENGINE POD WAS SHUT OFF AND FLAMES EXTINGUISHED. ENGINE POD AND LEADING EDGE OF WING WERE DAMAGED, ALONG WITH SOME MINOR DAMAGE TO FUSELAGE SKIN.

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