2017 International
Perforating Safety Forum

PERFORATORS.ORG
INTERNATIONAL PERFORATING FORUM

A REVIEW OF SYSTEM SAFETY IN WIRELINE PERFORATING

IPSF 17-03

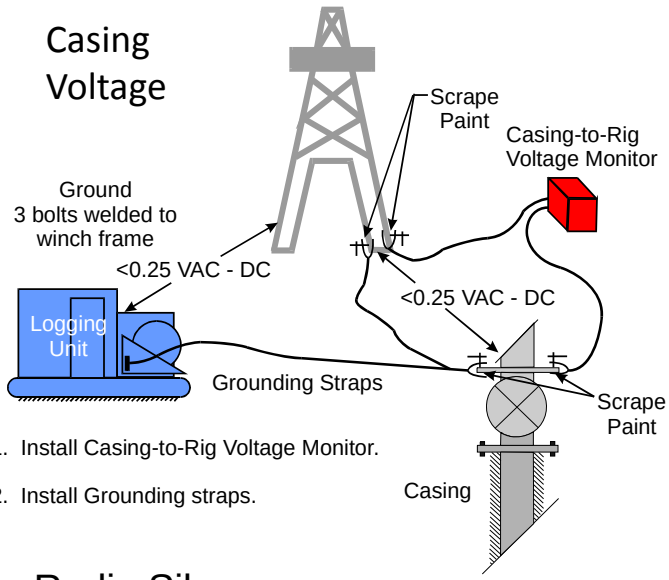
AUTHORS: Alfredo Fayard and Kenneth Goodman,
Schlumberger

AGENDA

- Wireline Perforating Safety
- Radio Frequency Safety
- Perforating Hazards and Incidents
- Definition of a Safe Initiation System
- API RP67 4th Edition
- Initiator’s Lifecycle
- Summary and Observations

Safety Basics

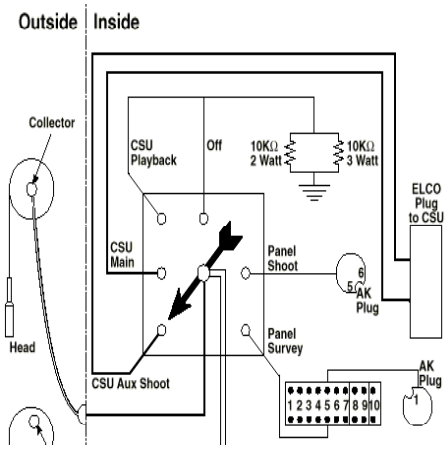
Casing Voltage



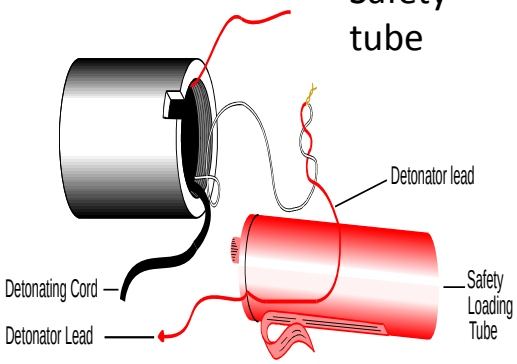
1. Install Casing-to-Rig Voltage Monitor.
2. Install Grounding straps.

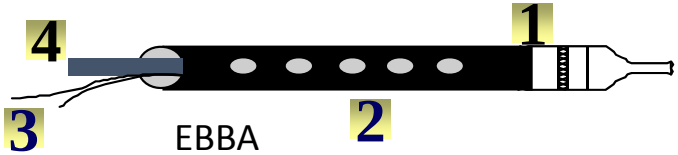
Radio Silence

CSS



Safety tube





Evolution

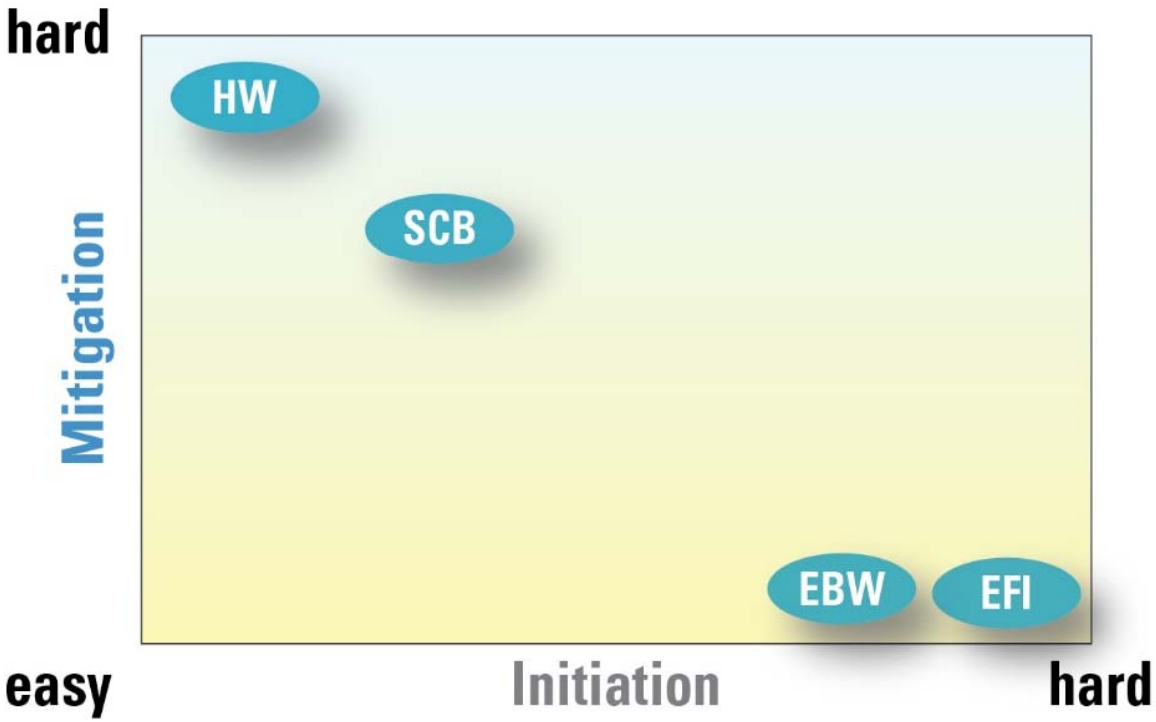
- New EFI based RF Safe detonator eliminated the need for radio silence offshore (Huber and Pease, 1990)
- Smaller radio-silence zones (100 ft) were adopted for resistorized detonators (Dickes, 2004)
- A new study by an ITPO further reduced the radio-silence distance from 100 ft to 30 ft (Franklin, 2009)

RF SAFETY

	Test Exposure Level	Safety Factor	Specific Consideration of wireline attachment
Military	200 V/m minimum	45	Yes
Automotive	200 V/m	1	No
Oil & Gas (API RP67 fourth edition draft)	200 Watt	20 / 100 (low power)	Yes
ITPO 1	3 Watt		Yes
ITPO 2	300 V/m	> 1 (measured)	No

- MIL-STD 331 is specific to detonators. It defines criteria for passing, procedures and data analysis to establish safety level
- Automotive Electromagnetic (EMC) compatibility is covered by ISO Standards 11451-XX and 11452-XX for vehicle and components
- Large variation on testing protocols

DESIGN TRADE OFFS



- Hot Wire (HW) based on sensitive primary explosives
- Semiconductor Bridge based on primary explosives or deflagration to detonation with secondary explosives
- Exploding bridge wire / exploding foil initiator with secondary explosives only

HAZARDS AND MITIGATION

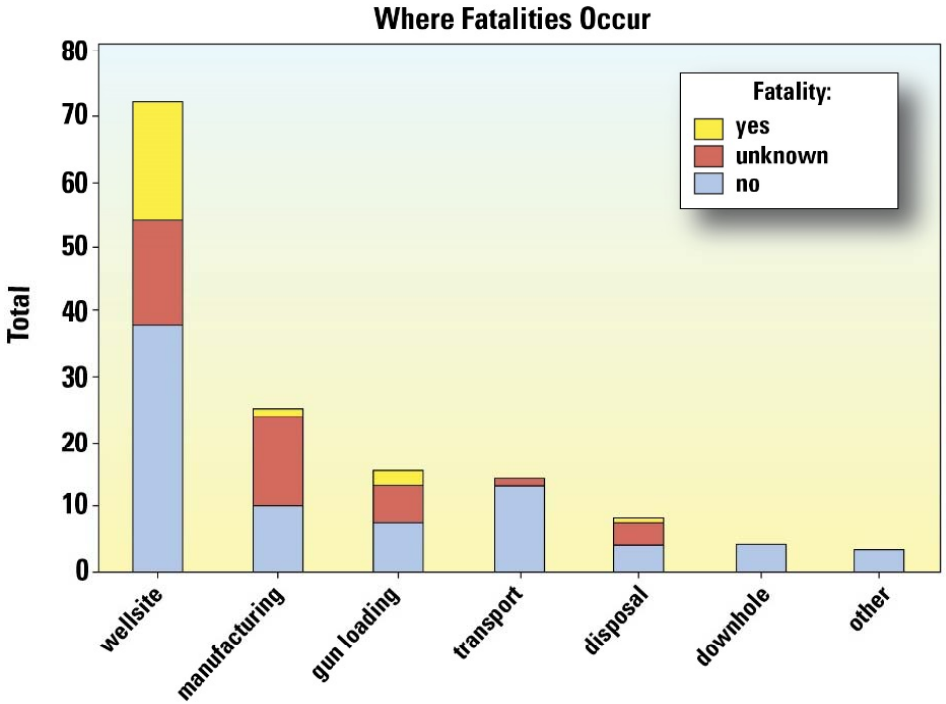
Hazard	Source	Mitigation
Human error	Not following procedures	Addressability
ESD	Environment	ESD protection, no primary explosives
Stray voltage	Welding, cathodic protection	High input voltage, addressability
RF	Cell phones, towers, offshore satalite systems, military, and navigation	RF filtering, high power requirement
Downhole sources	Wireline and tractor companies	Addressable safety barriers
Fire	Mainly transport	No primary explosives, out-of-line systems
Security	Theft or malicious use	Addressability, high power

- The development of addressable switches in early 2000's brought additional protection and security
  - It mitigates risks associated with downhole power sources, stray voltage and human errors
- EFI/EBW technology mitigated risks of Electrostatic Discharge, RF, Fire

PERFORATING INCIDENTS

IPSF 17-03

Analysis

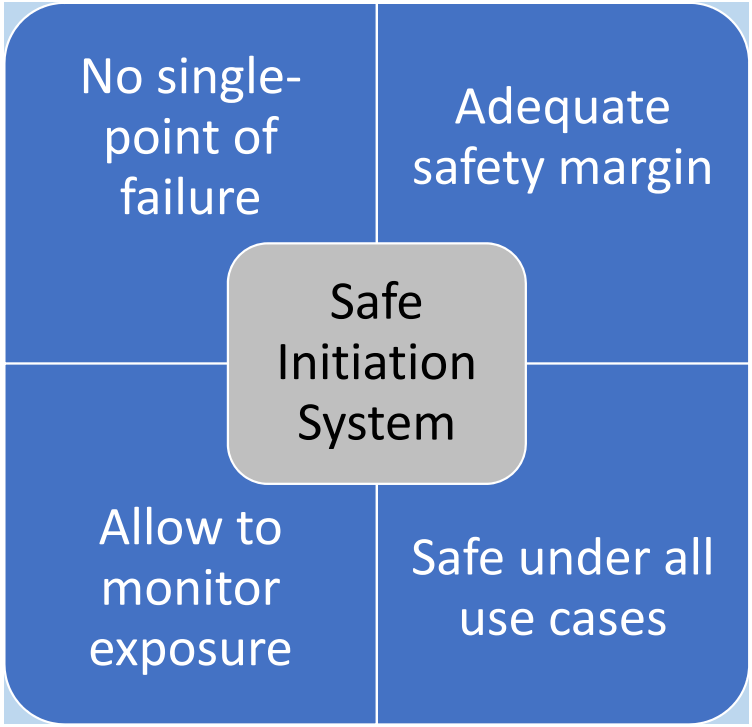


- Human mistakes are the biggest cause of perforating incidents
- If safety procedures were properly followed the risks are minimal
- Data for last decades shows engineered controls could offer step-change improvements in incident avoidance

SAFE INITIATION SYSTEM

IPSF 17-03

Definition



- No single-point of failure present in critical protection mechanisms
- Safe for unwanted exposure of hazards with adequate safety margin
- If hazards cannot be totally mitigated limit necessary procedural controls
- System is safe as used throughout its lifecycle

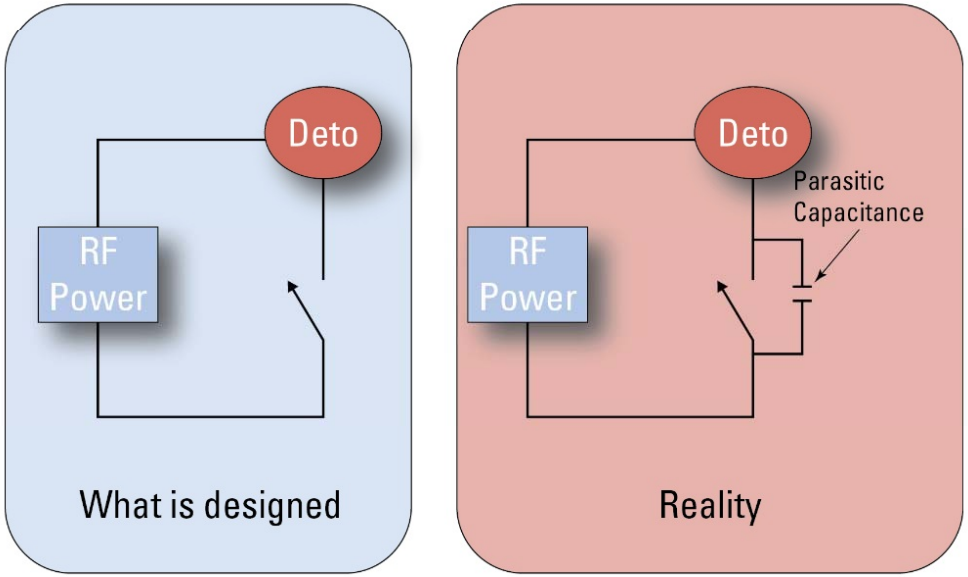
RADIO-FREQUENCY HAZARDS

IPSF 17-03

Transmitter Class	Transmitter ID	Lowest frequency (MHz)	Maximum Power (Watt)
Industrial, scientific, and medical (ISM)	Generic	868	0.05
WIFI	Generic	2400	0.1
Bluetooth	Generic	2400	0.2
Walkie-talkie	Generic	136	5
Mobile	Industrial	136	200
Mobile	CB	27	5
Satellite	Skycasters	14000	6

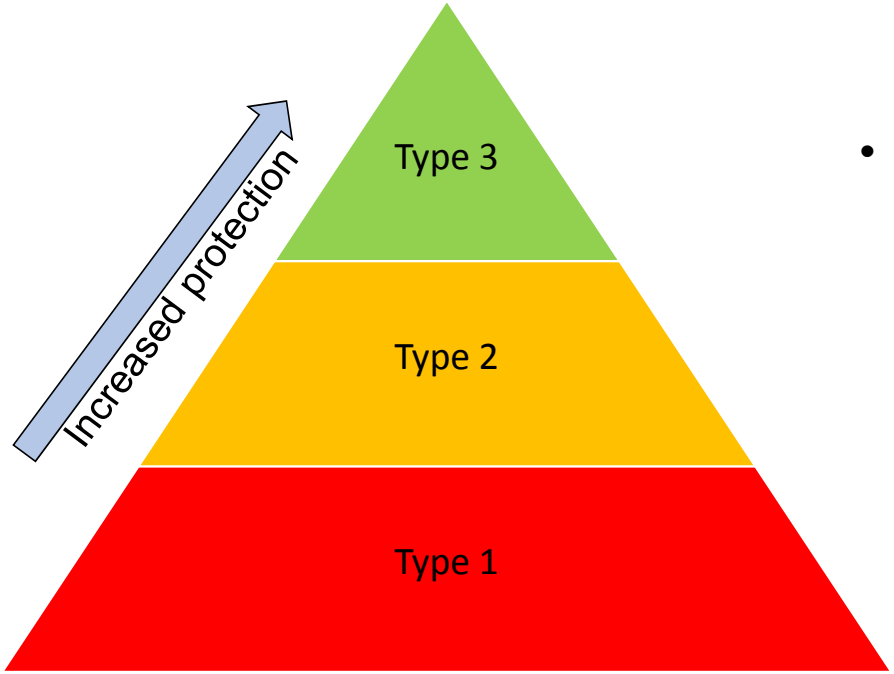
ADEQUATE SAFETY MARGINS

Parasitic Capacitance



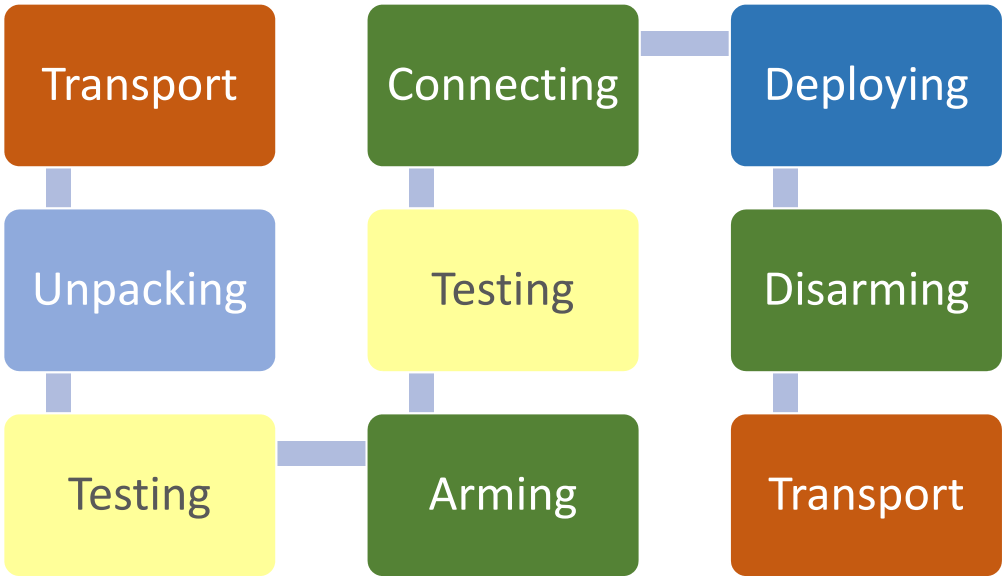
- Switches and detonators can be degraded due to manufacturing or operational defects (Leidel, IME)
- Multiple RF sources can be present at once
- Nearly all RF testing of detonators and switches have been using the leads as the product is packaged, and not with test equipment guns or logging cable attached

API RP67 4th EDITION



- API RP67 4th Edition defines new Type 2 detonators
  - They may contain some primary explosives
  - No-fire voltage of 25 V AC/DC
  - Exclusion distances must be calculated based on 20 mobile transmitters of 200W output at 144 MHz or higher frequency
  - No single-point failure should result in initiation; failure mode effect analysis (FMEA) performed by manufacturer.
  - Safety features tested and validated by independent third party (ITPO)

SAFE UNDER ALL USE CASES



- The amount of power a detonator can receive depends on the field strength and size of antenna
- Testing with a safety meter can add to antenna length
- Connecting the cable head may further increase the antenna size
- Worst case analysis must consider the whole process

SUMMARY AND OBSERVATIONS

- The industry is moving from well known procedures and technologies, to a more varied portfolio of engineered solutions
- We have proposed basic principles to define a safe initiation system
- We have also reviewed RF test data for new products and found significant variation
- API RP67 4th edition is a move in the right direction, and will allow monitoring

ACKNOWLEDGEMENTS

The authors wish to extend appreciation to the management of Schlumberger for support to conduct this work and prepare the manuscript.

2017 International Perforating Safety Forum

QUESTIONS? THANK YOU

IPSF 17-03

A REVIEW OF SYSTEM SAFETY IN WIRELINE PERFORATING

AUTHORS: Alfredo Fayard and Kenneth Goodman, Schlumberger