INSTITUTE OF MAKERS OF EXPLOSIVES

RF Hazards to Oilfield Electric Detonators – The New IME SLP-20

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The Institute of Makers of Explosives Safety Library Publications

- The Institute of Makers of Explosives was established ninety-nine years ago as a forum for safety information for the commercial explosives industry in the U.S. and Canada.
- The I.M.E.'s fourteen safety library publications, and their guidelines, videos and safety posters are periodically reviewed for accuracy and completeness as the technology advances and security and environmental impact become more significant issues.
- Safety Library Publication 20 was reviewed in 2001 and once again in 2011 to keep pace with the proliferation of fixed and portable RF sources and to expand on the application of hot-wire detonators to upstream oil and gas production.

Topics from the New June 2011 Version of SLP-20, "Safety Guide for the Prevention of Radio Frequency Hazards in the Use of Commercial Electric Detonators"

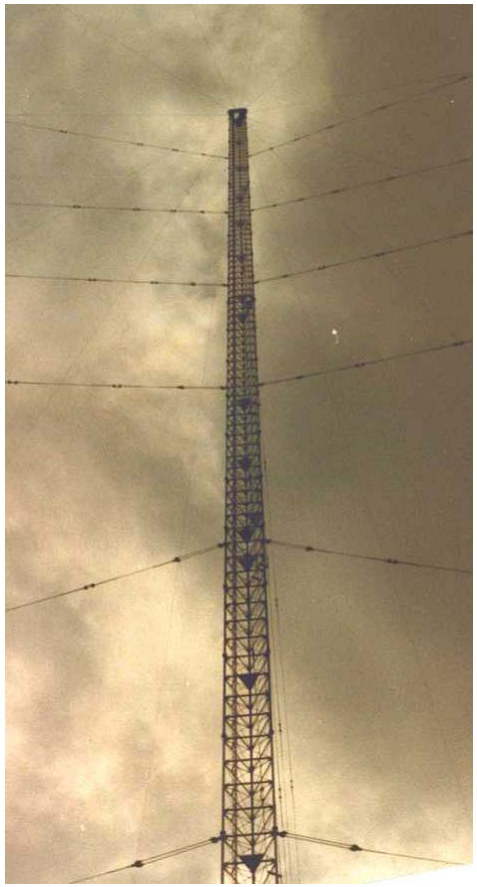
- Changes in U.S. frequency allocations
- Conversion from Analog to Digital TV
- Resistorized electric detonators used in the oilfield
- Comments on electronic detonators

U.S. Frequency Allocations

- In the U.S., the Federal Communications Commission allocates usage of the electromagnetic spectrum from 9 kilohertz to 275 Gigahertz, assigning bands of frequencies for use to approximately 30 types of radio services covering approximately 1350 individual bands.
- Use of the electromagnetic spectrum by various services is not fixed but varies with new types of communications technology or obsolescence of older types of technology.

The Demise of LORAN-C

- LORAN-C, (LOng RAnge Navigation System), was a series of fixed surface transmitters up to 4 megawatt in power and operating in the 90 to 110 kHz band to assist marine traffic in fixing their position.
- Since Global Positioning System technology using 24 satellites, (providing 4 are accessible and unobstructed), has supplanted more traditional means of radio-navigation, LORAN-C went off the air as of 3 August 2010.

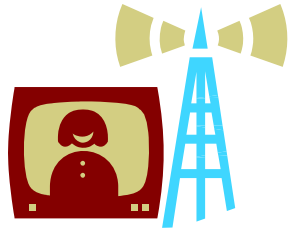


The Similar Demise of OMEGA

- OMEGA was a VLF navigational aid for aircraft that operated in the 10 to 14 KHz band with approximately a 10 kilowatt power. Some towers were as tall as 1200 feet
- OMEGA's primary function was to assist military and commercial aircraft with locating their position within a few miles.
- The advent of the GPS system rendered OMEGA redundant and it was shut down in 1997.
- There are those who suggest that a backup system to GPS is still necessary particularly in lieu of the recent solar "storms".

OMEGA Guyed Tower

Analog to Digital TV Conversion



- As of 12 June 2009, all full power TV transmitting stations were required to cease transmission in analog mode and commence transmitting in digital mode. All low power TV transmitters must cease analog transmission by 1 September 2015.
- The advantage of digital transmission is a much lower bandwidth requirement compared to analog transmission. For example, the old analog TV Channel 8 became digital Channels 8-1, 8-2, and 8-3.
- The downside of digital TV is that with the older analog transmission, poor weather conditions could result in “ghost” images but the reception was still intelligible. However, digital transmission can transition from good to non-existent depending on the weather.
- A substantial reduction in permitted maximum power accompanied the transition from analog to digital TV.

U.S. Analog and Digital TV Power Limits

TV Band and Channel	Maximum Effective Radiated Power ; Analog TV	Maximum Effective Radiated Power; Digital TV
VHF Channels 2 through 6	100,000 watts video 10,000 watts audio	45,000 watts video (audio ERP is 22% of video)
VHF Channels 7 through 13	316,000 watts video 31,600 watts audio	160,000 watts video (audio ERP is 22% of video)
UHF Channels 14 through 36 UHF Channels 38 through 51	5,000,000 watts video	1,000,000 watts video (audio ERP is 22% of video)

Minimum Safe Distances from VHF TV and FM Radio Transmission Towers for 50 Ohm Resistorized Oilfield Electric Detonators

Effective Radiated Power (Watts)	Minimum Distance (Feet)	Minimum Distance (Feet)	Minimum Distance (Feet)
	Channels 2 to 6	FM Radio	Channels 7 to 13
Up to 1,000	853	670	480
10,000	1,520	1,200	850
45,000	2,210*	NA	NA
100,000	2,700**	2,120	1,511
160,000	NA	NA	1,700*
316,000	3,600	2,850	2,014**
1,000,000	4,800	3,770	2,690
10,000,000	8,600	6,700	4,780

* Boxes shown in yellow pertain to new digital TV power limits

** Boxes shown in blue pertain to old analog TV power limits

Minimum Safe Distances from UHF TV Transmission Towers for 50 Ohm Resistorized Oilfield Electric Detonators

Effective Radiated Power (Watts)	Minimum Distance (Feet)
Up to 10,000	520
1,000,000	1640*
5,000,000	2500**

* Box shown in yellow pertains to new digital UHF TV power limit

** Box shown in blue pertains to the old analog UHF TV power limit

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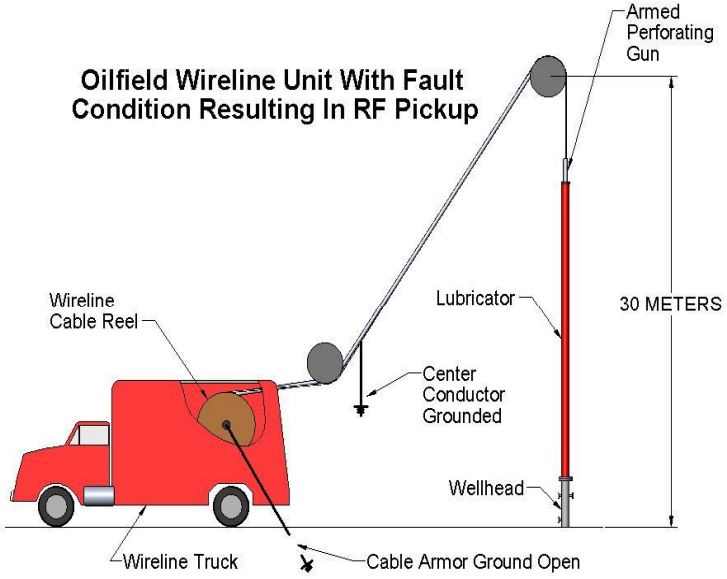
Special Considerations for the Case of Resistorized Oilfield Electric Detonators

- The upstream oil and gas industry use several types of downhole tools such as perforating guns, junk charges, backoff shots, casing and tubing cutters and drill collar cutters initiated by electric detonators.
- Special electric detonators are frequently used containing two 25 ohm resistors wired in series with the fuzehead increasing the “all-fire” current of the device, hence decreasing the detonator’s sensitivity to RF and stray current.
- Whereas the 1 ohm electric detonator, for computing safe distance purposes, is considered to be a 0.040 watt “no-fire” power device, the “no-fire” power of the 50 ohm oilfield electric detonator was not known.
- Following a series of tests on various samples of 50 ohm electric detonators, the “no-fire” power was established to be 0.10 watt.

Antenna Models for Oilfield Wireline Operations at the Wellsite

- Most “receiving antenna” models for the RF pickup configuration of the oilfield electric detonator are unchanged from the one ohm electric detonator with one major exception.
- If a fault condition exists in the wireline unit as described in the adjoining diagram, when the cable is in the vertical position a short dipole antenna or half-wave dipole antenna can be formed. This was the model used for RF pickup by the electric detonator in the AM broadcast and for AM transmitters up to 50 MHz.



Comparison of Safe Distances for AM Broadcast Transmitters between 1 ohm and 50 ohm Electric Detonators

Type of Electric Detonator	Type of "Antenna" Model Used to Compute Safe Distance For 50,000 Watt Source	Safe Distance to 50,000 watt AM Broadcast Transmitter Source (feet)
Conventional One Ohm Electric Detonator (40 milliwatt "no-fire")	Small loop pickup circuit raised 5 feet above ground level, (elevated shot line)	2500
50 ohm Oilfield Resistorized Electric Detonator (100 milliwatt "no-fire")	Short Dipole (vertically elevated wireline 90 feet above ground with fault condition)	3390

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Recommended Safe Distances for 50 ohm Oilfield Electric Detonators for High Frequency AM up to 50 MHz excluding AM Broadcast for ½ Wavelength Dipole Pickup

Transmitter Power (watts)	Minimum Distance (feet)
100	446
200	531
500	667
1000	794
1500	878
5000	1187
50000	2110
500000	3753

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Electronic Detonators

- A recent innovation in electric initiation systems is the electronic detonator
  - The electronic detonator contains a circuit ahead of the detonator's fuzehead that isolates, to a degree, the fuzehead from stray voltage or RF fields.
  - Some types of electronic detonators have been tested in RF fields of 200 volts/meter to 300 volts/meter with no ill effect.
  - However, recognizing that designs of these devices may vary, the manufacturer of the electronic detonator should be consulted for assistance on the device's limits to RF energy fields or stray voltage.
  - Electronic detonators and electric detonators should NEVER be used together in the same initiating circuit.

Summary

- The December 2011 version of the Institute of Makers of Explosives Safety Library Publication 20, “Safety Guide for the Prevention of Radio Frequency Radiation Hazards in the Use of Commercial Electric Detonators (Blasting Caps), was approved by the IME’s SLP-20 Subcommittee, the Technical Committee, the Legal Affairs Committee and the Board of Governors.
- SLP-20 is currently available for online download or purchase of a printed copy.