

2017 International Perforating Safety Forum



Experience with calculation of the RF Exclusion Zones
according to the new API RP67 safety distance
recommendations

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Agenda

- New API RP 67 – 7.3.6 Electric Detonators
- IME SLP 20 – Part III – Tables of Recommended Safe Distances from RF Sources for 50 Ohm Oilfield Resistorized Electric Detonators
- Test Setup for Radiated Electromagnetic Susceptibility
- Result Summary according HERO Specifications
- Result Comparison of Radiated Electromagnetic Susceptibility for a Safe Detonator
- Sample Calculation for Multiple Transmitters According new API RP 67
- Additional Testing
- Conclusions

New API RP 67 – 7.3.6 Electric Detonators

- New Detonator Classification
 - Group 1 (equivalent to 50 Ohm Resistorized Detonators)
 - May contain primary explosives
 - No fire current of min 200mA
 - Follow SLP 20 guidance on rf exclusion distances

 - Group 2 (Safe Detonators)
 - May contain primary explosives
 - No fire voltage of min 25 vac/vdc
 - Manufacturer to publish safe distances for all frequencies according to SLP 20 – the user will have to determine the safety distance dependent on the actual well site situation
 - Manufacturer to provide a sample calculation of rf exclusion distances for multiple transmitters
 - No single point of failure within the detonator may result in an unintended initiation

New API RP 67 – 7.3.6 Electric Detonators

- Group 3 (Immune Detonators)
 - No primary explosives
 - Immune to rf energies – no exclusion zone required
 - No single point of failure within the detonator may result in an unintended initiation

- Any detonator attachment that changes the characteristics of the assembly may change the group

IME SLP 20 – Part III

Tables of Recommended Safe Distances from RF Sources for 50 Ohm Oilfield Resistorized Electric Detonators

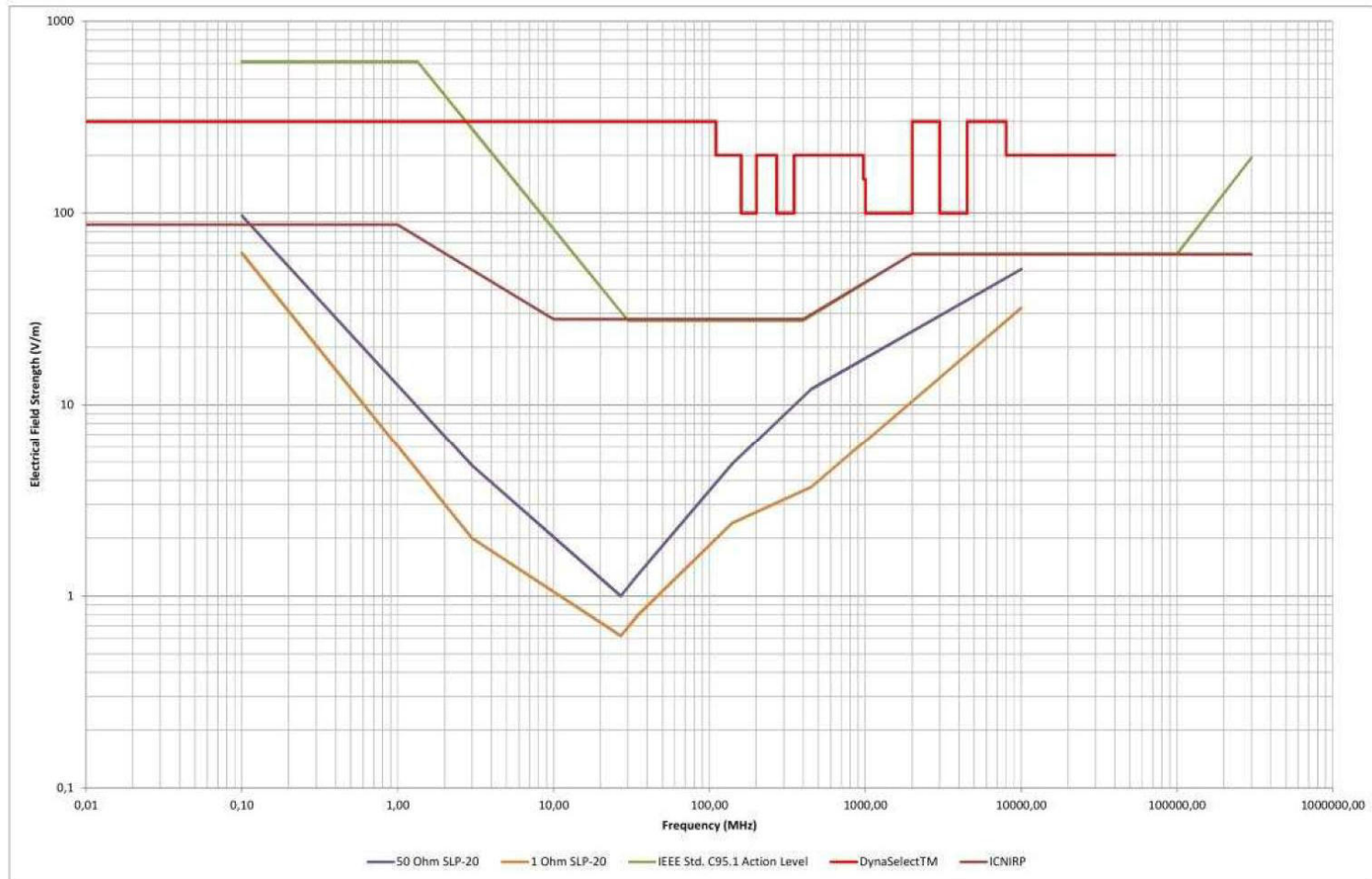
- Safety distances are based on minimum safety levels

- Examples for safely distances for 50 Ohm oilfield resistorized detonators
 - Standard AM Transmitter – 3,391 ft
 - FM Transmitter – 2,120 ft
 - Television Transmitter – 1,511 ft to 4,800 ft (dependent on Channel)
 - Amateur/Citizen's Band – 878 ft
 - Cellular Telephone – 5 ft
 - Cellular Telephone Transmitter – 54 ft
 - Maritime Radionavigation Radar (Commercial Shipping) – 190 ft

Test Setup for Radiated Electromagnetic Susceptibility

- Tests were done in accordance with the HERO SAFE ORDANANCE specification (MIL Standard HDBK-240 3.2.9) for RF immunity to tested levels
 - The devices under Test are assembled with a fusehead without primer
 - A temperature sensor measures the heat of the filament wire of the fuse head
 - The temperature is calibrated towards current flows
 - The devices are exposed to the RF-field in vertical and horizontal polarization and the temperature increase of the filament wire is measured
 - The test is done in two wire configurations, stretched and folded dipole
- Test pass criteria
 - The measured temperature is below the safety reference temperature
 - If the temperature is too high the field strength is reduced and the measurement repeated until a safe field strength is found

Result Summary according HERO Specifications



Result Comparison of Radiated Electromagnetic Susceptibility

Recommended Minimum Distance

	Transmitted Power [Watt]	50 Ω Detonator [FT]	Tested Group 2 Electronic Detonator [FT]
Standard AM Transmitter	50,000	3,391	17
FM Transmitter	100,000	2,120	24
Television Transmitter	100,000	1,511 to 4,800 (dependent on Channel)	73 to 77 (dependent on Channel)
CB Radio	4	42	0
Amateur/Citizen's Band	1,500	878	4
Cellular Telephone	3	5	0
Cellular Telephone Transmitter	500	54	3
Maritime Radionavigation Radar (Commercial Shipping)	50,000	190	17

Sample Calculation for Multiple Transmitters According new API RP 67

- 100 handheld transmitters of 5 Watt output at 144 MHz or higher (use most sensitive frequency) – all transmitters at same distance
- 20 mobile transmitters of 200 Watt output at 144 MHz or higher (use most sensitive frequency) – all transmitters at same distance

- Base data
 - Most sensitive Frequency for the Group 2 electronic detonator is 160 MHz at 100 V/m
 - All handheld transmitters are at a distance of 15 ft
 - All mobile transmitters are at a distance of 30 ft

- For one handheld transmitter the minimum distance is 14 ft for a 50 Ohm detonator and 1 ft for the Group 2 electronic detonator
- For one mobile transmitter the minimum distance is 84 ft for a 50 Ohm detonator and 4 ft for the Group 2 electronic detonator

Sample Calculation for Multiple Transmitters According new API RP 67

- According to SLP 20 the following equation has to be met to assure a very low likelihood of an inadvertent initiation

$$(E_1/E_{1\max})^2 + (E_2/E_{2\max})^2 + (E_3/E_{3\max})^2 + \dots + (E_n/E_{n\max})^2 < 1$$

E_n are the measured or computed electric field strengths at the detonator location with respect to the RF sources

$E_{n\max}$ are the maximum acceptable electric field strengths for that frequency from the above plot

$$E = \frac{7,02 \sqrt{ERP}}{D}$$

ERP is the power of the transmitter

D is the distance from the transmitter

Sample Calculation for Multiple Transmitters According new API RP 67

- Handheld Transmitter
 - ERP = 5 W
 - D = 5 m (approximately 15 ft)
- E_1 to E_{100} for the handheld transmitters at 15 ft is 3.14 V/m

- Mobile Transmitter
 - ERP = 200 W
 - D = 10 m (approximately 30 ft)
- E_{101} to E_{120} for the mobile transmitters at 30 ft is 9.93 V/m

Sample Calculation for Multiple Transmitters According new API RP 67

- E_{\max} for all handheld and mobile transmitters for the 50 Ohm detonator is 1 V/m at the most sensitive frequency of 28 MHz and 5 V/m at the frequency of 160 MHz (for comparison only)
- E_{\max} for all handheld and mobile transmitters for the Group 2 electronic detonator is 100 V/m at the most sensitive frequency of 160 MHz

$$(E_1/E_{1\max})^2 + (E_2/E_{2\max})^2 + (E_3/E_{3\max})^2 + \dots + (E_n/E_{n\max})^2 < 1$$

- The result for the 50 Ohm detonator is 2956.824 for 1 V/m and 118.273 for 5 V/m, both of which are bigger than 1 resulting in **unsafe** situations
- The result for the Group 2 electronic detonator is 0.295 which is smaller than 1 resulting in a **safe** situation

Sample Calculation for Multiple Transmitters According new API RP 67

- Optional scenario
 - Handheld Transmitter
 - ERP = 5 W
 - D = 33 m (approximately 100 ft)
 - E_1 to E_{100} for the handheld transmitters at 15 ft is 3.14 V/m
 - Mobile Transmitter
 - ERP = 200 W
 - D = 33 m (approximately 100 ft)
 - E_{101} to E_{120} for the mobile transmitters at 30 ft is 9.93 V/m
- The result for the 50 Ohm detonator is 203.638 for 1 V/m and 8.146 for 5 V/m, both of which are bigger than 1 resulting in **unsafe** situations
- The result for the Group 2 electronic detonator is 0.020 which is smaller than 1 resulting in a **safe** situation

Additional Testing

On the Group 2 electronic detonator the following additional tests were conducted

- Electromagnetic Susceptibility
 - Burst Test - Maximum test voltage 4.4 kV
 - Surge Test - Maximum test voltage 6.0 kV
 - 25 VAC/VDC input (according former API RP 67)
 - 120 VAC/VDC input (according former API RP 67)
 - 230 VAC/VDC input (company internal test)
- FMEA - Failure mode and effects analysis
 - Instead of a FMEA a FMECA (Failure mode, effects, and criticality analysis) was done on component level with single and double component failures

- All tests passed successfully

Conclusions

- The base electromagnetic susceptibility tests is cumbersome to conduct, but once done the measured safe field strength' at the individual frequencies are known and the safe operating environment can be calculated
- With the present well site environment a safety assessment is imperative
- Contact your detonator or system manufacturer in case you have any questions

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QUESTIONS?
THANK YOU!

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