Chapter Comm 7

APPENDIX C
SAFETY GUIDE FOR THE PREVENTION OF RADIO FREQUENCY RADIATION HAZARDS IN THE USE OF ELECTRIC BLASTING CAPS

These recommendations are from publication number 20, adopted September, 1981 by the Institute of Makers of Explosives.

Purpose and Scope

This guide is intended to provide a basis for assessing the hazards associated with initiation of commercial electric blasting caps by radio frequency (RF) energy by indicating safe distances from commercial RF sources.

The statements in this booklet apply solely to commercial electric blasting caps manufactured in the United States. They do not apply to military electric firing devices. They are based on competent analysis and research and are believed to be accurate. However, no guarantee of their applicability is made because we cannot cover every possible application nor anticipate every variation encountered in the use of electric blasting caps.

Occasionally, situations develop where adherence to the tables of safe distances as stipulated in this booklet becomes an operational handicap. Or, situations develop which are so unusual as not to be covered in this booklet. In these instances, we recommend that competent experts be consulted to evaluate each particular situation. These experts will have the ability to make field measurements at the blasting site so that the RF hazard can be evaluated.

Introduction

Radio–Frequency (RF) transmitters, which include AM and FM radio, television and radar, create powerful electromagnetic fields, decreasing in intensity with distance from the transmitter antenna. Tests have demonstrated that electric blasting cap wires, under certain circumstances, may pick up enough electric energy from such fields to cause caps to explode.

Magnitude of the RF Energy Hazard

From a practical standpoint, the possibility of a premature explosion of electrical blasting caps due to RF energy is extremely remote.

The annual consumption of electric blasting caps in the continental United States is approximately 100,000,000 and they are used in every section of the country. To date, there have been a few authenticated cases of a cap being fired accidentally by RF pickup on the wires. Investigation showed that even these cases would not have happened if tables of distances had been adhered to. This long–term experience and also numerous tests indicate that if proper precautions are taken, such as adherence to the tables of distances, the probability of an accidental firing is extremely remote.

RF Initiation

The usual method for firing an electric blasting cap is to apply electric energy from a blasting machine, power line or other source of electric power to the open ends of the cap wires or the blasting circuits. The electric current then flows through the wires to the cap and the very small resistance wire inside the cap heats the primary explosive to the burning–explosion temperature.

If the electric blasting cap wires are in a strong RF field (near a transmitter that is radiating RF power), the usual unshielded leg wires or circuit wires, whether connected to a blasting machine or not, or shunted (short–circuited ends) or not shunted (open ends), will act as an antenna similar to that on a radio or TV set. This antenna will absorb RF energy from the transmitter RF field and the electric current produced in the cap wires will flow into the cap.

In certain cases, depending on the strength of the RF field and the antenna configuration formed by the blasting cap wires and its orientation, sufficient RF energy may be induced in the wires to fire the electric blasting cap.

RF Sources Presenting Hazards to Blasting Operations

Commercial amplitude–modulated (AM) broadcast transmitters (0.535 to 1.605 Megahertz) are potentially the most hazardous. This is because they combine high power and low enough frequency so that there is little loss of RF energy in the lead wires.

Frequency–modulated (FM) and TV transmitters are unlikely to create a hazardous situation. Although their power is extremely high and antennas are horizontally polarized, the high–frequency currents are rapidly attenuated in cap or lead wires. These RF sources usually employ antennas on top of high towers. This has an additional effect of reducing the electromagnetic field at ground level.

Mobile radio must be rated as a potential hazard because, although its power is low, it can be brought directly into a blasting area.

Citizens Band (CB) radios are an unusual problem for several reasons:

(1) There are millions of units being used by the general public;

(2) Their operating frequency is in the range that is considered to be worst–case for typical electric blasting circuits; and

(3) Some irresponsible operators use illegal linear amplifiers to increase their transmission range.

Safe distances are recommended for the FCC approved, double sideband (4 watts maximum output power) and single sideband (12 watts peak envelope power) units in Table 7.33–3 in this chapter. It is not possible to specify safe distances for the illegal units because they do not operate within established FCC limits that can be used for making definitive worst–case assumptions.

Federal regulations require the posting of signs within 1,000 feet of construction sites warning that two–way radios should be turned off because of blasting. Observance of the posted signs will provide the necessary degree of safety if the units are a maximum of 200 watts peak power. It is recommended, therefore, that

all CB operators obey posted signs and turn off their units in observance of posted warnings or if they know that there are blasting operations in the area.

There may be instances where the use of two–way radios will increase the overall safety of a blasting operation by providing instantaneous voice communications between the shotfirer and personnel at remote locations guarding the approaches to the blast area. When two–way radios are used for this purpose, the minimum separations specified in Table 7.33–3 for a particular transceiver (frequency and power) should be maintained.

There is little possibility that sources of RF energy such as microwave relay will ever constitute a practical problem. They are all characterized by one or more of the following:

(1) Location in areas where blasting is unlikely;

(2) Very high frequency; and

(3) Restricted radiation patterns.

In the vicinity of high power radar installations, blasting should not be conducted within the beam because of the high effective radiated power of these units resulting from the use of high–gain antennas.

Radio–frequency transmitters used in underground mining operations could present a hazardous situation. Because of the uncertainties of RF absorption and scattering within mine tunnels, the potential hazard can only be evaluated with the aid of consultants.

RF Pickup Circuits

For the radio frequencies used in AM radio broadcasting and mobile operation, cap and lead–wire layouts can act as RF circuits (receiving antennas).

One sensitive RF pickup circuit that might be encountered in electric blasting operations is the dipole circuit. The most hazardous conditions exist when:

(1) The circuit wiring and/or electric blasting cap leg wires are elevated several feet off the ground;

(2) The length of this wiring is equal to one–half the wavelength of the radio wave or some multiple of it; and

(3) The electric cap is located at a point where the RF current in the circuit wiring is at a maximum. An example of this circuit is where the wiring is equal to a half wavelength and the electric blasting cap is located at the center.

Another hazardous situation, similar to the dipole antenna, occurs when the electric cap is at one end of wiring which:

(1) Is elevated in the air;

(2) Has a length equivalent to one–quarter the radio wavelength or an odd multiple of it; and

(3) Is grounded to earth through the electric cap.

Radio wavelengths in feet are approximately obtained by dividing 1,000 by the frequency in megahertz. Both of these circuits require that the lead or cap wires be suspended above the ground, a situation not usually found in blasting operations. Both antennas achieve their maximum current pickup when they are:

(1) Parallel to a horizontal transmitting antenna, FM, TV or amateur radio; or

(2) Pointed toward a vertical antenna, AM, mobile, etc.

Another sensitive RF pickup circuit and one commonly encountered in blasting operations is the loop circuit. The loop circuit is sensitive to the magnetic portion of the electromagnetic wave. In general, the larger the loop area, the greater the RF current pickup. The loop orientation for maximum pickup results when it is placed in the plane of the transmitting antenna. The loop configuration was selected for calculations deriving safe distance tables for AM broadcast transmitters and mobile transmitters, both employing vertical antennas.

In general, loop areas can be reduced by picking up both lead wires as in a duplex wire circuit and making wire splices as close to the ground as possible.

General Precautions to be Followed

The following list of precautions will further increase safety and reduce hazards associated with conducting electric blasting operations near RF energy sources.

1—When blasting electrically at a fixed location, such as a quarry, make sure that there are no radio transmitters located closer to the blasting site than the applicable separation recommended. Be on the lookout for the installation of new transmitters. Check them out before they go into service to insure that they will not pose a hazard to the blasting operation.

When planning to blast electrically at a new location, as in construction work, inspect the area for RF transmitters before blasting is started. This will permit securing technically qualified assistance, if necessary, in planning proper blasting procedures to minimize any RF hazard.

2—KEEP MOBILE TRANSMITTERS AWAY FROM BLAST SITES. Place adequate signs to remind operators to turn off transmitters when at the blast site. If two–way radios are used to provide instantaneous communication between the shotfirer and personnel guarding the approaches to the blast area, the minimum separation specified in Table 7.33–3, for the type transceiver used, should be maintained.

3—Use the higher frequency bands, 450–470 MHz, for mobile transmitters if there is a choice. RF pickup is less efficient at these frequencies than at the lower frequencies.

4—Avoid large loops in blasting wiring by running lead wires parallel to each other and close together (preferably twisted in pairs).

5—If loops are unavoidable, keep them small and orient them broadside towards the transmitting antenna.

6—Keep wires on the ground in blasting layouts. Bare connecting points should be elevated slightly to prevent current leakage.

7—Keep all lead lines out of the beam of directional devices such as radar or microwave relay stations.

Military RF Installations

Military transmitters are becoming very numerous, and they cover the frequency range from kilohertz to thousands of megahertz, often having extremely large power outputs.

Because of the nature of military work, much is classified for security reasons. Installations may vary from day to day, and multiple transmitters may cause the energy to be pyramided in a particular location. If blasting must be done in the vicinity of military areas, it is strongly recommended that the officer in charge of the military establishment be contacted and the blasting schedule explained. Such cooperation will be the best protection. Presenting IME publication No. 20 to the military authorities will enable them to assist in determining whether or not the blasting operation will be safe from RF hazards.

Transportation

All available evidence indicates that radio frequency is not a hazard in the transportation of electric blasting caps so long as they are in their original containers. This is because the wires are then coiled or folded in a manner which provides highly effective protection against current induction. Furthermore, almost all truck bodies and freight cars are made of metal and this virtually eliminates the penetration of RF energy.

If vehicles equipped with radio transmitters are used in transporting electric blasting caps to or from a job, it is recommended that:

(1) The caps be carried in a closed metal box; and

(2) The transmitter be turned off when the caps are either being put into or taken out of the box.

To protect against shock and friction, the metal box should be lined with a soft material such as wood or sponge rubber.

A practice which is considered to be a valuable backup to the above–noted procedures is for the radio to be disconnected from the power source whenever caps are being placed in or removed from the vehicle. This practice could also be carried out whenever the vehicle is in close proximity to a blast pattern using electrical caps. The physical disconnection will prevent those occurrences where a person uses the radio strictly out of habit, without thinking about the fact that one shouldn't be doing so at that particular moment.

Radio Frequency Sources and Definitions

A partial list of RF sources is given in Table C–1 and standard definitions related to radio frequency sources are given in Table C–2.

Table C–1
RADIO TRANSMITTING STATIONS (Partial List)

Type	Frequency (Megahertz)	Wavelength (Feet)	Maximum Transmitter Power (Watts)	Reference Table for Safe Distance
Commercial				
Standard Broadcast (AM)	0.535–1.605 (540–1,600 KHz)	1820–615	50,000	7.33–1
Frequency Modulation (FM)	88–108	11.2–9.1	550,000(1)	7.33–4
Television (Channels 2 to 6)	54–88	18.2–11.2	100,000(1)	7.33–4
Television (Channels 7 to 13)	174–216	5.6–4.5	316,000(1)	7.33–4
Television (Channels 14 to 83)	470–890	2.1–1.1	5,000,000(1)	7.33–5
Amateur				
160–Meter Band	1.8–2.0	545–490	1,000	7.33–2
80–Meter Band	3.5–4.0	280–246	1,000	7.33–2
40–Meter Band	7.0–7.3	140–135	1,000	7.33–2
20–Meter Band	14.0–14.4	70.0–68.2	1,000	7.33–2
15–Meter Band	21.10–21.25	46.3–46.0	1,000	7.33–2
Citizens' Band	26.96–27.23	36.6–36.0	5	7.33–3
10–Meter Band	28.0–29.7	35.1–33.0	1,000	7.33–3 Mobile only
10–Meter Band	28.0–29.7	35.1–33.0	1,000	7.33–2 Fixed
6–Meter Band	50.0–54.0	19.7–18.2	1,000	7.33–3
2–Meter Band	144–148	6.8–6.65	1,000	7.33–3
1¼–Meter Band	220–225	4.46–4.36	1,000	7.33–3 Use 150.8–161.6 MHz Column
(Also others scattered in the range 420 to 30,000 megahertz.)				
Two–Way Communications				
HF Range Central Station	25–50	39–20	500	7.33–2
Mobile Unit	25–50	39–20	500	7.33–3
VHF Range Central Station	148–174	6.6–5.6	600	7.33–3
Mobile Unit	148–174	6.6–5.6	180	7.33–3
UHF Range Central Station	450–470	2.2–2.1	180	7.33–3
Mobile Unit	450–470	2.2–2.1	180	7.33–3
LF Range (Aviation)	0.2–0.4	5,000–2,500	2,000	7.33–1
HF Range (Aviation)	4–23	250–44	50,000	7.33–2
VHF Range (Aviation)	118.0–135.9	8.3–7.2	50	(100 ft.)
UHF Range (Aviation)	225–500	4.4–2.0	100	(50 ft.)
Radio Telegraph	6–23	164–43	50,000	7.33–2
Microwave Relay	2,000–12,000	0.5–0.08	50	*
Navigational Aids				
Radio Range Beacon ("A"–"N")	0.200–0.415	5,000–2,400	600	7.33–1
Loran	1.8–2.0	545–490	1,000,000 peak; 3,000 avg.	*
VOR–ILS (Aviation)	108–118	9.0–8.3	200	*
Shoran	290–320	4.7–3.1	25,000 peak; 1,000 avg.	*
Long–Range Radar (Nonmilitary)	1,300–1,350	0.77–0.74	1,000,000 peak; 100,000 avg.	**
10–cm. Radar (Nonmilitary)	2,700–2,900	0.37–0.34	750,000 peak; 1,000 avg.	7.33–6
3–cm. Radar (Nonmilitary)	10,000	0.10	50,000 peak	7.33–6

(1) Maximum effective radiated power.
* See material under RF Sources Presenting Hazards to Blasting Operations.
** Hazardous within one mile—Consult local authority.

Table C–2

TABLE OF DEFINITIONS

A number of these definitions have been abstracted from FCC regulations.

(1) Broadcasting Service

"A radio communication service in which the transmissions are intended for direct reception by the general public."

(2) International Broadcast Service

A service "whose transmissions are intended to be received directly by the general public in foreign countries."

(3) Amateur Service

"A service of ... intercommunications and technical investigations carried on by .... duly authorized persons interested in radio technique."

(4) Citizens Band Radio

"A radio communication service of fixed, land, and mobile stations intended for personal or business radio communication, radio signaling, (and) control of remote objects or devices."

(5) Maritime Services

Services intended for maritime radio communication and including fixed stations, land stations, and mobile stations on land and on board ships.

(6) Aviation Services

Services of fixed and land stations, and mobile stations on land and on board aircraft "primarily for the safe expeditions, and economical operation of aircraft."

(7) Mobile Service

"A service of radio communication between mobile and land stations, or between mobile stations."

Mobile Station

"A station in the mobile service intended to be used while in motion or during halts at unspecified points."

Land Station

"A station in the mobile service not intended to be used while in motion."

(8) Fixed Service

"A service of radio communication between specified fixed points."

Fixed Station

A station in the fixed service.

(9) Standard Frequency Terms and Bands

1 Megahertz, MHz=1,000,000 cycles per second

Medium Frequency Band—MF	0.3–3 MHz
High Frequency Band—HF	3–30 MHz
Very High Frequency Band—VHF	30–300 MHz
Ultra High Frequency Bank—UHF	300–3,000 MHz