(continued)

FIRING SYSTEM AND TRANSMISSION CABLE PARAMETERS

The critical factor in the design of a firing system and transmission cable for an EBW detonator system is to ensure that the proper energy level and rate are applied to the bridgewire such that it will reliably explode at an energy level which is matched to the explosive train and other detonator parameters.

Figure 7 depicts examples of what would be marginal parameters for a detonator designed to be subjected to an energy pulse as shown in Figure 4. If the circuit inductance is high, as could be caused by too long a transmission cable or incorrect cable configuration, the current pulse is drawn out in time which can reduce the magnitude of the shock wave at bridgewire burst. This will result in a marginal firing condition. Transmission cables for EBW detonators are designed for low inductance and resistance. Most cables are coaxial in construction when long distances are required. However, flat cables with the flat surface set on top of each other are also used. It should be noted that if a system requires the simultaneous firing of two or more detonators, balanced transmission lines are necessary because the bridgewire burst time (t_b) can vary due to cable inductance.

The firing set must supply an adequate amount of energy. In normal firing of an EBW detonator, the current increases after burst as the resistance lowers due to ionization of the gases in the bridgewire area. This current flow, after burst, is all excess energy and has no direct influence on the explosion of the wire or detonation of the explosive. However, for reliable operation, this excess energy is required as a safety factor. The second current trace in Figure 7 depicts a marginal firing wherein there is no excess energy. This is the type of curve obtained when performing a voltage and current threshold test.

The firing system most commonly used for an EBW detonator is a capacitor discharge type; however, any type of system can be used which will supply the correct energy pulse. Other systems in use include piezoelectric transducers and induction coils.

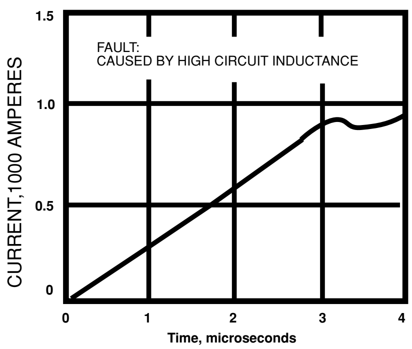
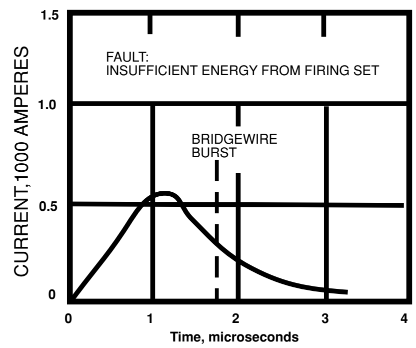


Figure 7
Marginal Firing Parameters due to Firing Set and Transmission Cable not Matched with EBW Detonator



BRIDGEWIRE PARAMETERS

A wide variety of bridgewire materials can be used for EBW detonators. Their efficiency is a function of their heat of vaporization; however, other factors may override this consideration. These other factors include: environmental stability, solderability or weldability for attachment, and uniformity. The most widely used wire material is gold, primarily due to its inertness. The diameter and length of the bridgewire must be matched to the firing system and characteristics of the explosive to result in the proper burst current and burst time.

In general, EBW detonators use wire diameters between 0.001 and 0.003 inch. The longer the bridgewire the more energy required to burst the wire even though the value of the burst current will be approximately the same. As wires become excessively short, end effects come into play and insufficient energy is transferred. Therefore, there exists an optimum wire length for each specific system.

EXPLOSIVE PARAMETERS

To match the explosive next to the bridgewire with the other characteristics of an EBW detonator system, the critical parameters include: powder crystal size and shape, powder surface area, and powder density. The objective is to obtain the lowest threshold current for a specific bridgewire and firing system.

In general, any secondary explosive can be used next to the bridgewire in an EBW detonator. PETN is used to the largest extent because it results in the lowest threshold values. Also its crystal size and shape can be easily changed by recrystallization. Standard MIL Spec PETN is manufactured in various classes which enhance its handling characteristics for specific uses such as detonating cord or pelletizing. None of the standard classes are ideal for EBW initiation; therefore, in general, the explosive should be recrystallized. The standard MIL Spec Powder has a relatively thick and short crystal. To initiate PETN in an EBW detonator in general requires a somewhat long and thin crystal with some fracturing. The specific surface area is related to particle size and shape and must be matched to the bridgewire parameters. In general, the smaller the bridgewire, the greater the required specific surface area. For any specific system, there is an optimum density of the explosive next to the bridgewire for a minimum threshold current. The value of this is dependent upon most of the parameters which have been discussed in this section.