An earlier version appeared in *American Fireworks News*, No. 83 (1988).

Reduction of Aerial Shell Ignition Failures

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A shell ignition failure means there will be a live dud in the fallout area after a display. If that dud is not retrieved, is found by a member of the public, and that person is subsequently injured as the result of mishandling the dud shell, an insurance claim against the shooter and manufacturer will almost certainly result. This article presents a discussion of one method which can result in a significant reduction of the number of shell ignition failures.

For the purposes of this article, an ignition failure is any cause or series of causes that results in fire failing to be passed from burning lift gases to the pyrotechnic contents of the shell via a fuse or similar device. This includes: the fuse failing to take fire from the burning lift gases, the fuse failing to burn continuously, and the fuse failing to successfully transfer fire to the shell's contents. Each of these general causes can be further broken down into a number of more specific causes. However, it is not the purpose of this short article to present a discussion of the relative merits of priming vs. cross-matching, cutting fuse perpendicular vs. cutting it at an angle, using fuse vs. using spolettes, etc. Those are important considerations, but, because of the many variations in technique, each of which can affect the results achieved, that discussion is beyond the scope of this article. This article discusses a simple technique that is routinely utilized in many fields of endeavor when it is necessary to reduce failure rates. The technique is redundancy, in this case the use of two time fuses on an aerial shell. This is not a new idea; it has been used in this country and abroad for many years, but is not commonly done. With manufacturers under increased products liability pressure and with many amateurs seeking short-cuts to priming and cross matching, perhaps this approach is worth further consideration. This is because the reduction in the rate of ignition failures may be considerably greater than might be expected. To understand why this can be the case, it is first necessary to delve a little into Probability Theory.

Probabilities are expressed as numbers ranging from zero (0) to one (1). If the probability of something happening is zero, then it will never happen, ever. On the other hand, if the probability is one, then it will happen every time, always. Obviously, for most things, the probability is some where in between. A probability of 0.5 (or 1/2) means it will happen one-half of the time (one out of two times). A probability of 0.75 (or 3/4) means it will happen three quarters of the time (three times out of four).

If the probability of something happening is P, then the probability of it not happening is (1 – P). In the last case above, when the probability of an event happening was 0.75, the probability of it not happening is (1.00 – 0.75), which is 0.25.

If the probability of one thing happening is P1 and the probability of a second thing happening is P2, then the probability of both things happening is (P1 × P2). Take as example coin a flipping. When flipping single coin, the probability of getting "heads" is 0.50. When flipping two coins, the probability that both will be heads is (0.50 × 0.50), which is 0.25.

In order to apply probability theory to the problem of aerial shell ignition failure, it is first necessary to establish the probability of experiencing an ignition failure when using a single time fuse under a fixed set of conditions. A mediocre performance might be considered to be one in which 1 out of 100 shells is a dud, which corresponds to a probability of 0.01. A good performance might be considered to be one in which 1 out of 1000 shells is a dud, a probability of 0.001. Perhaps the very best that is achievable is when 1 out of 10000 shells is a dud, a probability of 0.0001. Now consider the case where the same technique is employed that resulted in a mediocre probability of ignition failure of 0.01 for a single time fuse, except that a second identically prepared fuse is used in addition. In this case, the probability of both fuses failing to ignite the shell is (0.01 × 0.01) which equals 0.0001, and that is a 100 fold reduction in the probability of ignition failure, and is the same as had been defined above as the very lowest failure rate achievable.

In addition to the little extra time and the very little extra expense associated with using two time fuses, are there any other costs? The answer is yes; there is an increased probability of shell failure due to fire leaks from the presence of the second fuse. Again, in order to determine the increased probability of fire leaks resulting from the use of a second time fuse, it is first necessary to establish the probability of a fire leak occurring around a single fuse. A mediocre performance in this area also probably corresponds to a failure rate of 1 out of 100, a probability of 0.01. If this if the probability of a fire leak occurring around a fuse, then the probability of no fire leak occurring is (1.00 – 0.01), which is 0.99. If two fuses are used, the probability that there will be no fire leak around either fuse is (0.99 × 0.99), which is 0.98; which corresponds to a failure rate of (1.00 – 0.98), which is 0.02, a 2 fold increase in the rate of rate of failure.

At this point, the question is whether it is an effective trade-off to achieve a 100 fold reduction of ignition failures at the expense of a 2 fold increase in fire leaks around fuses. However, before considering this, it is appropriate to point out that there are other ways besides leaks around time fuses that fire can leak into the contents of an aerial shell. Thus it should not be assumed that, because there is a 2 fold increase in the number of fire leaks around the time fuses, there will also be a 2 fold increase in the number of fire leaks from other sources. That is to say, there will not be a 2-fold increase in the number of "flowerpots" experienced as a result of using two time fuses. Further, if chlorate based stars are not used, if the shell is not a salute, and proper firing safety practices are followed, the consequences of the fire leak is likely to be a rather harmless flowerpot. All things considered, a number of manufacturers seem to have concluded that it is an effective trade off, particularly for larger shells. The authors have seen oriental shells with 3 time fuses and have heard of shells with 4 fuses.

(Note: Kosanke Services, Inc. has offered two-hole end disks for aerial shells for about 8 years. From time to time, the question has been asked as to why. In part, this article is in response to those questions.)