# Vibration measurements at the National Defence building site

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# TECHNICAL NOTE

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PREPARED FOR Record Purposes

SUBJECT IGNITION OF MAGNESIUM ALLOY COMPONENTS FOLLOWING AIRCRAFT ACCIDENTS

In crashes of aircraft that incorporate components of magnesium alloy, these components may be ignited by fuel burning on the ground, or by other means. The Accident Investigation Division of the Department of Transport has requested information on the time-scale of this process. It was hoped to throw light on the sequence of events leading to or following a helicopter accident, where magnesium oxide was stated to have been drawn into a gas turbine that would be expected to run down in at most several seconds after impact.

To ignite bulk magnesium it is not necessary to heat it until ignition occurs. It is sufficient to raise it to a critical temperature estimated at 585°C[1]. From that point, oxygen diffuses to the metal and surface combustion takes place sufficiently to cause its temperature to continue to rise, eventually reaching ignition at around 630°C. This ignition point is slightly below the melting point 650°C, so that ignition is rapidly followed by melting. Time lags from critical temperature to ignition up to over three hours have been recorded[2].

The present problem, however, is not how slowly, but rather how quickly magnesium can be ignited from the sources envisaged. Thus the problem is one of heat transfer, where the temperature of the object under consideration is determined by the balance between rate of access of heat from the flames, and rate of loss, primarily by conduction, to other components in direct contact with the object.

It was thought that simple experiments would be both quicker and more convincing than heat transfer calculations. For the heat source, it seems plausible to assume that no diffusion flame of spilt fuel would be hotter than a premixed propane-air flame from a Meker burner. The object was a piece cut from 3/8 inch magnesium alloy plate to various sizes from 1/4 in. square to 1 in. square. It was supported by a pair of leads from a thermocouple in the piece of plate, so that the heat sink was minimal..

In several trials the minimum time to ignite a 1-in. square from room temperature was 1 min. 10 sec., and for a 1/4-in. square, 25 sec. Addition of an inert heat sink would obviously lengthen these times, if it did not prevent ignition.

The material used was Alloy AZ31B[3] which consists of:

| | |
|---|---|
| Aluminum | 2.5 to 3.5% |
| Manganese | 0.20% |
| Zinc | 0.6 to 1.4% |

Impurities subject to limits in the specification

| | |
|---|---|
| Magnesium | Balance to 100% |

Alloys with these metals are stated[4] to have oxidation rates higher than pure magnesium at temperatures (420 to 460°C) below the critical. This may make little difference if the minimum ignition time is governed by heat transfer from flame to metal as suggested above.

References

1 Mellor, A.M. and Glassman, I. A physical criterion for metal ignition. Pyrodynamics, 3, 43-64 (1965).

2 Ibid, p. 59.

3 American Society for Testing and Materials: Specification B90-66.

4 Kubaschewski, O. and Hopkins, B.E. Oxidation of Metals and Alloys. Butterworth, London 1962, page 210.