# MUZZLE FLOW FIELD STUDIES

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**Abstract: Recent experimental studies on muzzle blast overpressure histories of an 81mm mortar system have revealed a number of reproducible features following the main blast front. Some of these features are shock fronted, with pressure rises of similar magnitude to that in the main blast front. The time lapse indicates that these may be associated with the precise geometry of the projectile. A study was therefore undertaken, using our previously validated CFD code, to examine the evolution of the flowfield behind the blast front. The primary concern is to achieve an improved understanding of the changing flowfield, and how this determines the features of the experimentally measured pressure history.**

## INTRODUCTION

Recent advances in computational fluid dynamics (CFD) techniques have led to the development of a number of codes, [1–3], for computation of intermediate ballistics flowfields during projectile launch. These have been applied to several different studies, to follow the flow through muzzle brakes, to clarify heat transfer and patterns of particulate damage in muzzle brakes, and to examine the separation of sabots in this flow regime. Such codes are increasingly being employed to assist the understanding of these highly transient complex flowfields, where only limited experimental data is available. In this paper such a study of a muzzle flowfield, employing both experimental measurements and CFD analysis to provide greater understanding of experimental measurements, is described. The paper describes the work in the form of a case study.

## 81MM MORTAR FIRINGS

An experimental study of overpressure histories in the muzzle flowfield of an 81mm mortar system was undertaken recently as part of an ongoing study of gun-break signatures. Twenty rounds were fired on full charge, and the pressure histories were recorded at six different positions in the resulting flowfield, at distances between 10 and 30 calibres (D) from the muzzle, on rays at angles of $5^o$, $30^o$ and $60^o$ from the forward extended barrel axis. Kistler type 603B gauges mounted side-on to the radial flow in a pancake configuration, connected to charge amplifiers, were used to measure the static pressure. The gauge positions were selected to give a reasonable spread of locations in the forward sector of the near field, without the risk of the gauges being damaged by close encounters with the projectile.

When the recorded pressure histories were examined two features of interest were noted. The first was a number of shock-fronted features behind the main blast front, see Figure 1, which appeared on several traces from some, but not all the rounds. In some cases these shock-fronted features were, if anything, more conspicuous at greater distances from the muzzle. It is of particular interest to determine whether these features are directly related to the projectile geometry. The second feature was that when the traces recorded at the same location for different rounds were overlaid, with the blast arrival times matched, the first part of the signals showed broad agreement, but there was significant divergence of the traces a fraction of a millisecond after the blast arrival, although there was overall similarity—see Figure 2 for example. This was noted at several different gauge locations, but the cause was not clear. Hence this study was initiated.

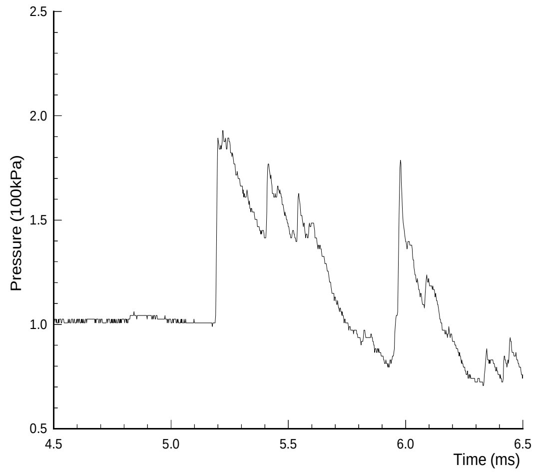


**Figure 1. Experimental pressure-time history at $60^o$,10D gauge.**

## MBIB2 CODE

The MBIB2 code [1] is a two-phase flow code developed originally for the study of particulate impact on the muzzle brake during the intermediate ballistics phase of projectile launch. It is assumed that the highly transient compressible, but inviscid, flow is symmetric about the barrel axis. Turbulence is not included in the current code. A moving projectile may be included in the simulation if required, and has been included in this study.

The code solves the finite volume form of the equations of conservation of mass, momentum and energy for the gas phase using a cell-centred Eulerian approach. If a particulate phase is present, mass and momentum equations for this phase are added. Zalesak's multi-dimensional flux corrected transport algorithm [4] is employed to limit the overshoots and undershoots commonly associated with the numerical computation of shock waves. The low-order flux is calculated using a first order exact 1D Riemann solver, and the higher order flux is predicted using a second-order central difference scheme based on a predictor-corrector method.

It is assumed that both gases, that is the propellant gas efflux and air, satisfy the ideal gas law with the appropriate gas constant, and that the mixture properties are given by appropriate weighted averages.

A number of calculations have been undertaken to validate this code against published results in [3,5], and have demonstrated that the results from this code are in good agreement with experimental data.