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Solution of the 1D Riemann Problem with a General EOS in *ExactPack*

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Compressible flow algorithms rest at the foundation of many multi-physics hydrocodes. The 1D Cartesian Riemann problem provides an essential test of nonlinear wave interaction for these algorithms. Consequently, 1D Riemann problems constitute an essential element in the core set of code verification test problems for many computational mechanics software packages.

Several 1D Riemann problems are often exercised in code verification studies for these codes. The workhorse in this stable of problems is the well-known Sod shock tube problem; accurate performance on this problem is now widely considered to be the minimal acceptance test for compressible flow algorithms. The set of problems catalogued in the monograph of Toro provides notably more discriminating code verification tests; others have proposed additional tests that further broaden the scope of solution features. Almost all of these tests, however, share one key, limiting feature: they are predicated upon the simple polytropic ("gamma-law") equation of state (EOS) for the compressible medium. This aspect of the problem description allows a straightforward solution procedure, as described by several authors.

There is no need for this assumption on the EOS. In this talk, we describe in detail a numerical algorithm for the solution of the 1D Cartesian Riemann problem with an arbitrary, convex EOS. While overviews of algorithms for this problem appear in the literature, this talk offers a unified description, bringing together key details from various sources and providing necessary information for software implementation. The algorithm described has been instantiated in software that is part of the *ExactPack* package.

We begin with a short review of the 1D Cartesian Riemann problem, discuss the implications of the EOS on the solution, describe how the nature of the various waves present naturally suggests the numerical solution approach, and provide results for different equations of state. We verify our general EOS implementation by quantitative comparison with established gamma-law gas cases. We show results for 1D Riemann problems with the highly nonlinear Jones-Wilkins-Lee (JWL) EOS, used to describe detonation products of high explosives. We describe how the *ExactPack* software can be extended to an arbitrary EOS, including tabular EOSs.