

## **Explosion Bulge Performance of High Strength Steel Undermatched Weldments**

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In an effort to reduce shipbuilding costs, the U.S. Navy is considering the use of higher strength steels as a means of reducing plate thickness, and thus weight, in ship construction. One such possibility is to replace existing 100 ksi yield strength steels with HY-130 steel in certain ship applications. It is further desired to use an undermatched weld metal in the HY-130 steel to help reduce the costs of HY-130 fabrication. One of the initial steps in establishing the feasibility of this concept is the evaluation of the response of the steel system (plate and weld metal) to explosive loading.

Three series of flat position weldments were produced in two-inch thick HY-130 steel plate by the gas metal arc welding process. Navy-approved welding consumables and welding procedures were carefully selected to achieve three conditions of undermatched weld metals ranging from 0% to 35% undermatching. The consumables were 100-type, 120-type, and 140-type welding wires. Welding heat inputs ranged from 55 to 85 kJ/in. Preheat and interpass temperatures were coordinated with the welding consumable and heat input combination to attain the cooling rate necessary to get the appropriate weld metal yield strength.

Standard weld metal mechanical property testing was conducted on the welds. Remaining materials were shipped to Puget Sound Naval Shipyard for preparation and testing using the Navy's explosion bulge test series. Each of the three conditions was represented by four 30 by 30 inch specimens. For each condition, brittle "crack starter" beads were applied to two specimens, while the remaining two were tested in the as received state as "bulge" specimens. All specimens were cooled to a holding temperature of 30° F for testing. Each specimen was subjected to a number of explosive shots, each consisting of a 42-pound charge detonated approximately 17 inches from the specimen surface. The number of explosive shots ranged from one to five, depending on the type of specimen and the progression of its performance. The condition of each specimen was documented and evaluated after each shot.

The bulge specimens representing the 0% and 20% undermatched conditions exhibited similar performance. Both sets met the performance criteria for 100-ksi and 130-ksi Navy steels. The 35% undermatched specimens did not meet any acceptance criteria for Navy high strength steels. These results, in addition to results from other test programs, will be used to establish a maximum undermatch criterion for welding HY-130 steel. Development of improved welding consumables to cost effectively fabricate HY-130 steel is planned.