Evaluation of Advanced GMAW and Distortion Mitigation Techniques for Thin Panel Aluminum and Steel Structures

NSRP TIA 2007-374

Project Lead

BMT Fleet Technology Limited

Project Team

Marinette Marine Corp

ESAB

Hobart Brothers

SP7 Welding Technology Panel Meeting
Fort Collins, Colorado

March 27, 2007

Background

- The Lockheed Martin Littoral Combat Ship (LCS) monohull consists of a combination of thin high strength and low strength steel.
  - Plates and stiffeners that arrive onsite are blasted and primed (primer thickness between 0.5 and 1.0mm)
  - Isn't cost effective to remove primer prior to welding
  - FCAW process typically used with slow travel speeds to allow the gases to escape to prevent porosity. Results in high heat inputs and distortion
  - Welding alternatives?
  - Distortion reduction?
- Aluminum Superstructure
  - Higher productivity methods?
  - Distortion reduction on thin sections?

Objectives

- Investigate Tandem Gas Metal Arc Welding (TGMAW)
  - Higher deposition rates and productivity
  - Elongated weld pool may provide longer degasification period, allowing for higher speeds when welding over primers
- Investigate ESAB Superpulse Technologies for Welding Aluminum
  - Reduce heat input without compromising productivity
- Investigate Mechanical Tensioning to Reduce Distortion in Thin Aluminum and Steel Structures

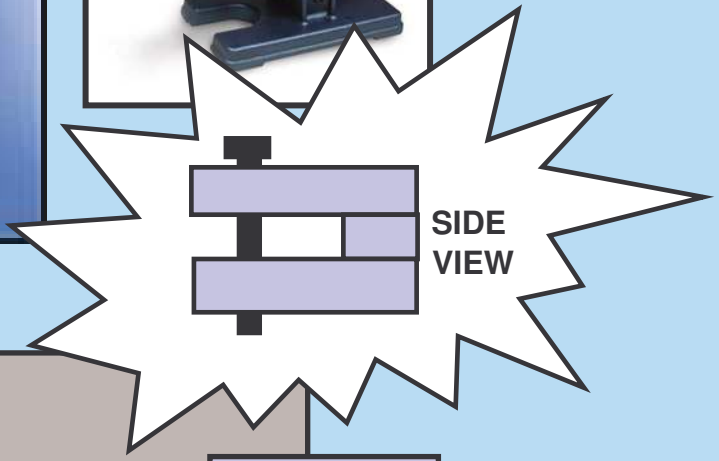
Project Outline

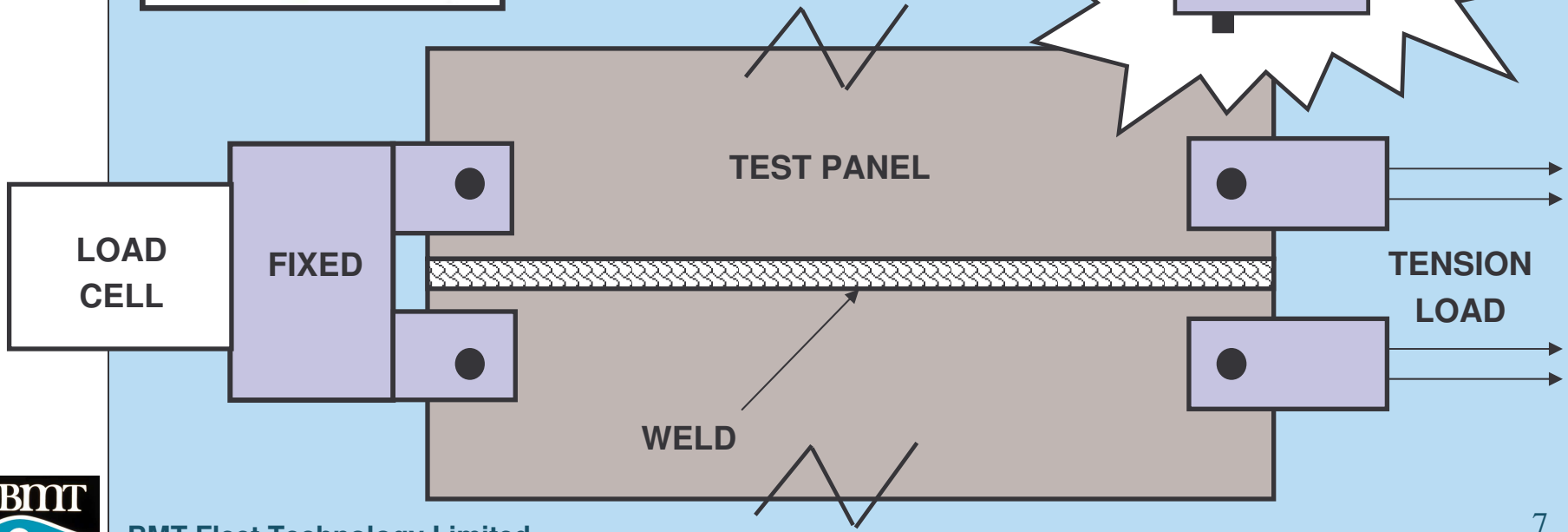
- **Task 1:** Collection and analysis of current welding practice from project sponsor (MMC) for benchmarking;
- **Task 2:** Define tension load profiles that achieve significant distortion reductions for each type and thickness of material evaluated;
- **Task 3:** Develop optimized welding procedures and guidelines for controlled dip transfer welding (STT and RMD) of thin steel structures;
- **Task 4:** Develop optimized welding procedures and guidelines for ESAB's Aristo Super Pulse technologies for aluminum; and
- **Task 5:** Develop optimized welding procedures and guidelines for TGMAW of aluminum and steel structures, including welding over primers using metal cored type of electrodes.

- **Task 1:** Collection and analysis of current welding practice from project sponsor (MMC) for benchmarking
  - Productivity benchmarking for welding of aluminum and primed steel structures (square groove and fillet welds), thicknesses of 3/16”, ¼”, and 5/16”
    - AA5083 extruded stiffened panels
    - HSLA-80
  - Reproduce sample fillet and groove weld benchmark procedures for subsequent productivity and distortion comparisons

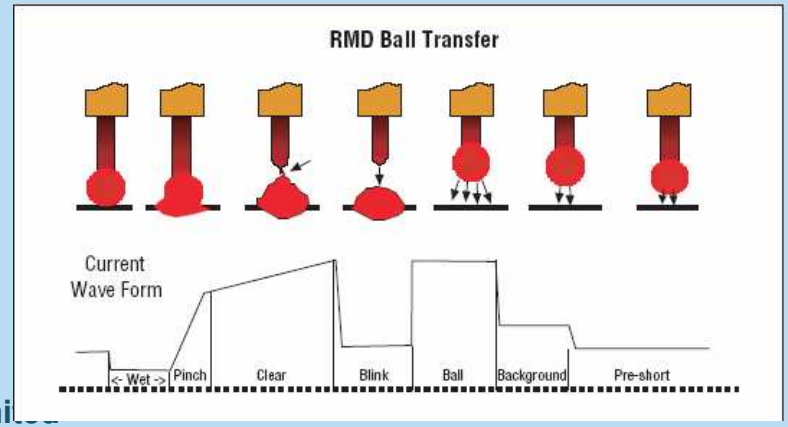
- **<u>Task 2:</u>** Define tension load profiles that achieve significant distortion reductions for each type and thickness of material evaluated using benchmark welding procedures
  - Other than reducing heat input, restraint is one of the most effective methods of reducing distortion
    - Kawasaki Heavy developed the perfect panel production method, where plates were stretched and held under tension load during welding to minimize buckling distortion in thin plate. The tension load forces the weld and thermally upset zone alongside to stretch longitudinally and transverse to the weld to conform to the geometry of the balance of the sheet
  - Build Tension Load Apparatus
  - Produce welds and measure distortion with each load applied
    - Incrementally increase load until minimal distortion is achieved for each groove and fillet weld scenario

- **Task 2: Cont.**

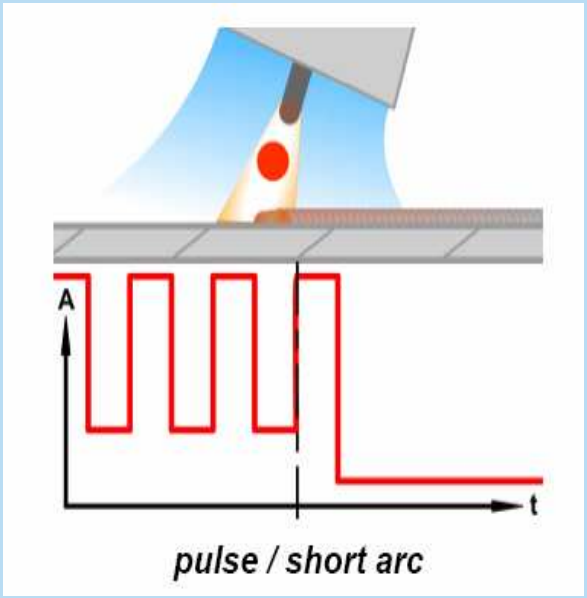




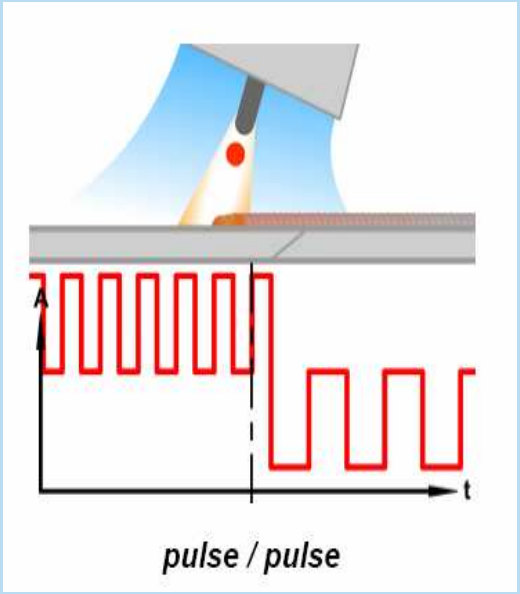
- **<u>Task 3:</u>** Develop welding procedures and guidelines for controlled dip transfer welding (STT and RMD) of thin steel structures – research area recommended by PEO Ships
  - Define usability limits of controlled dip transfer processes for fillet welding of steel structures
  - Lower limit avoids flaws (LOF) and upper limit produces highest productivity while still demonstrating minimal distortion
    - Extract samples along the weld to examine for subsurface defects and weld penetration profiles
      - Fillet weld fractures
    - Perform global distortion measurements
      - Compare back to benchmarks and those achieved under tension loads



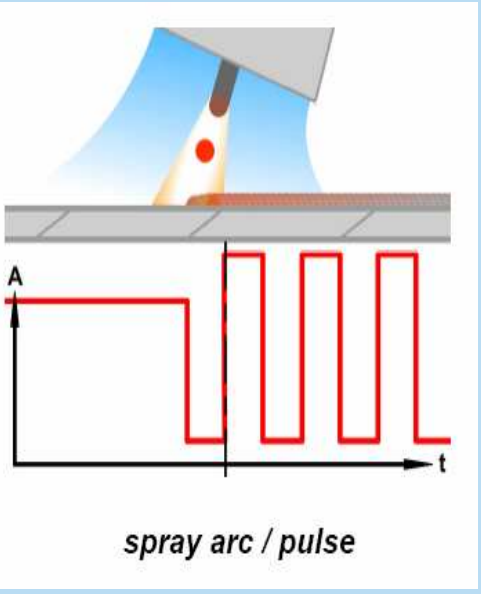
- **<u>Task 4:</u>** Develop welding procedures and guidelines for pulse/pulse, pulse/short arc, and spray arc/pulse welding of aluminum
  - ESAB Aristo Power Source with SuperPulse Technology
  - Focus on Groove Welds in Stiffened Aluminum Extrusions



pulse / short arc

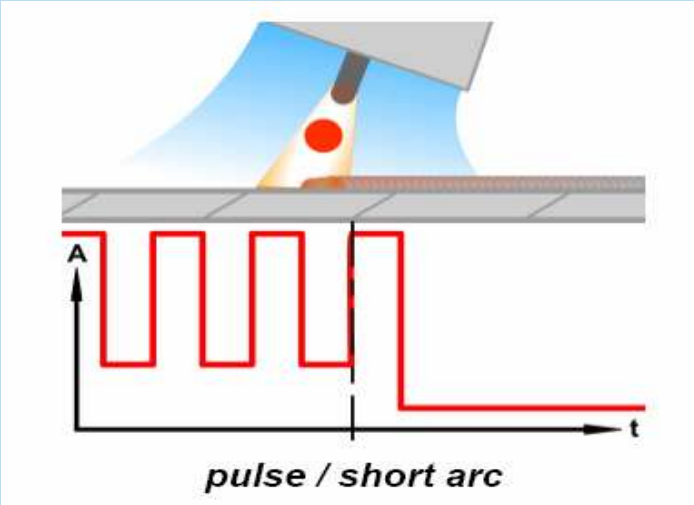


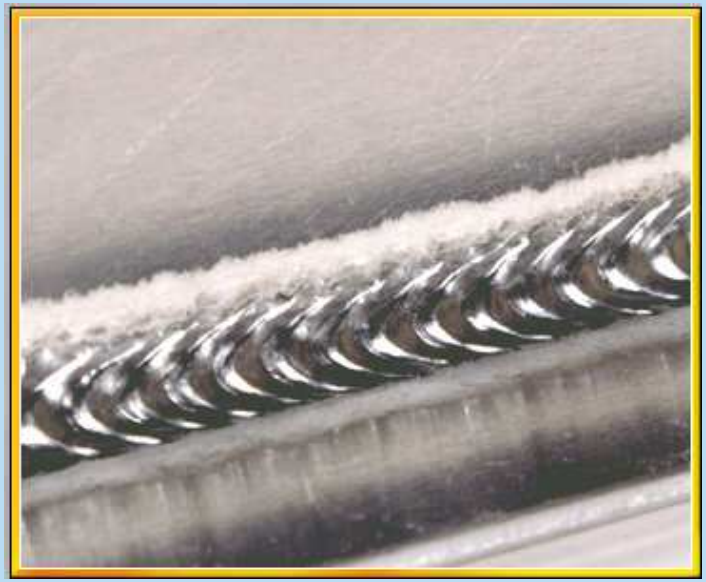
pulse / pulse

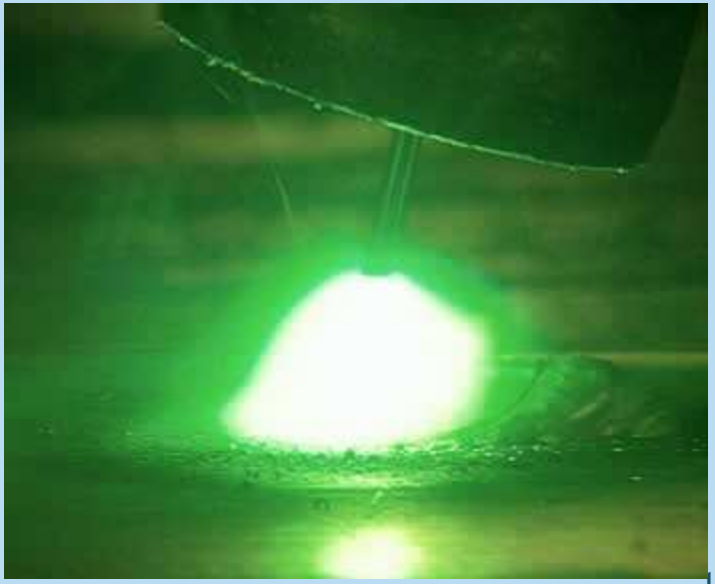


spray arc / pulse

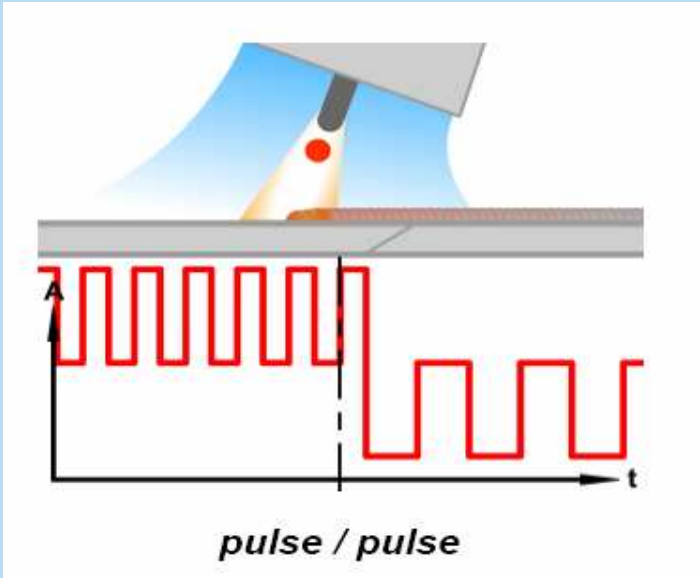
- **Pulse Short Arc:**
  - Shifts between pulse and conventional CV short arc
  - Lower average heat input without compromising deposition rate
  - Typically for gauge to 3/16” materials
  - GTAW bead appearance





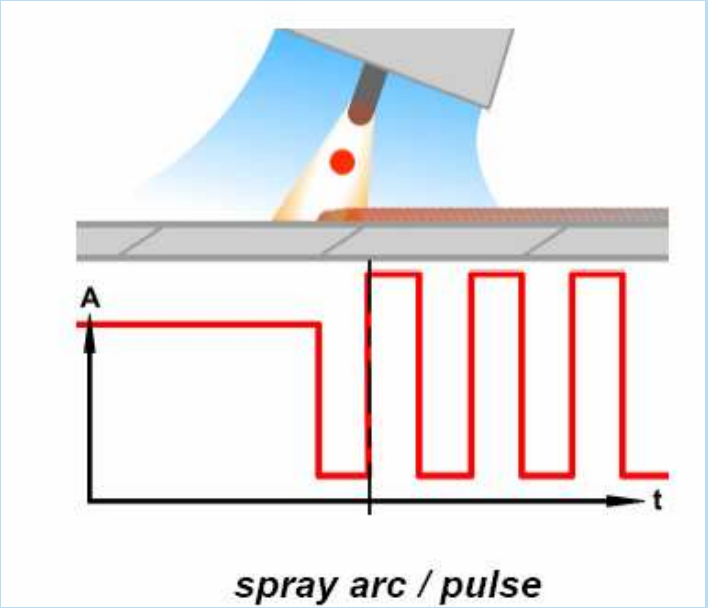


- **Pulse / Pulse:**
  - Uses wire feed speed shifting between a peak and background value to control maximum and minimum average current levels
    - Maximum value to enhance penetration
    - Minimum value to reduce heat input
  - Typically for 3/16” to 3/8” thickness range of materials

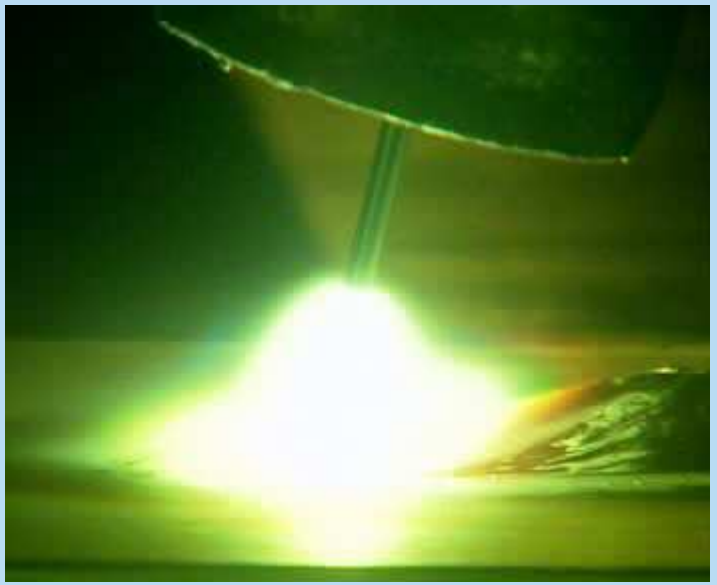


pulse / pulse

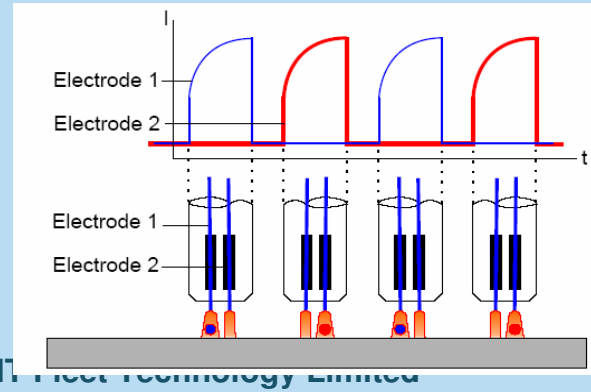
- **Spray Arc / Pulse:**
  - Shifts between conventional CV spray transfer and pulse
    - Positional welding of thicker aluminum, 5/16” and above
    - Spray Transfer for enhanced penetration
    - Pulse arc for lower heat input

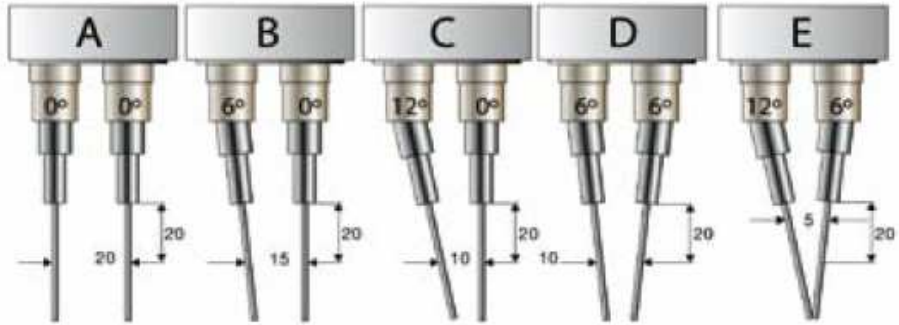


spray arc / pulse

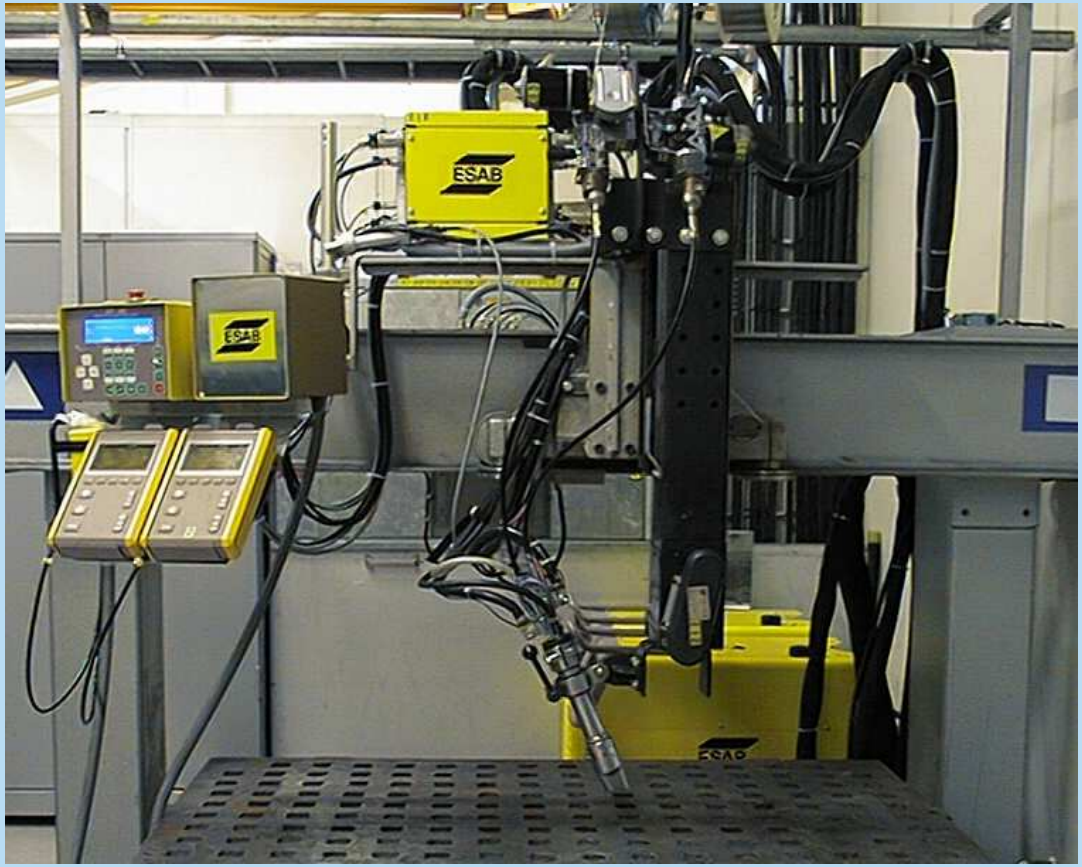


- **<u>Task 5:</u>** Develop optimized welding procedures and guidelines for TGMAW of aluminum and steel structures, including welding over primers using metal cored type of electrodes.
  - Wide electrode spacing (standard CV) for welding over primers to elongate weld pool and provide longer degasification period
    - Allows for independent procedures on lead and trail electrodes
      - Synchronized pulse requires same parameters for each electrode
    - Use Trimark Metalloy Vantage Metal Cored Electrodes
    - Focus on Fillet Welds – predominantly second side
    - Compare with results achieved by TODD Pacific
  - Narrow electrode spacing (synchronized pulse) for aluminum
    - Groove Welds





Tandem GMAW Set-up



Project Progress

- Kick-off meeting at Marinette Marine Corp in Marinette WI, on March 19, 2007
- Defined materials to be evaluated and finalized delivery arrangements (approx 4 to 5 weeks)
- Finalized delivery arrangements of ESAB equipment and aluminum GMAW electrodes to BMT (approx 3 weeks)
  - Capacity 100 ipm Travel Speed
- Started to fabricate base working surface and mechanical tensioning apparatus for simulated panel line at BMT (capacity 40 tons of combined tensioning load, 2 x 20 ton cylinder capacity)
  - Groove Welds Joining 2 x 4'W x 8'L panels together

QUESTIONS?