Evaluation of Commercial SMAW Electrodes in Fresh Water

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Introduction

Shielded metal arc welding (SMAW) is frequently employed for underwater wet welding in the repair of aging offshore platforms and in components of power plants. For aging offshore structures, typical steels are: API 5L grade B, ASTM A-36 and A-572. This paper discusses their weldability using three commercial electrodes (AWS E6013, E7018 and E7024) at two water pressures, referred here as water depths of 50 m and 100 m.

Procedures

The wet welds were fabricated using a hyperbaric chamber capable of simulating water depths as low as 200 m. Wet welds were fabricated using a gravity welder that was placed inside the chamber. Both bead-on-plate (BOP) and V-groove welds were produced on plates with the following dimensions: BOP (1/2" thick x 4" width x 10" length), and V-groove (1/2" thick x 3" width x 10" length, 45º V preparation, 1/4" root opening and 5/8" thick backing plate).

While different currents were applied for the BOP wet welds, the V-groove welds were deposited with the best BOP welding current. Defects, bead morphologies and porosity were examined both visually and using X-ray radiography.

Results and Discussion

Visual examination of the BOP welds showed irregularities (including porosity) at bead surfaces, which increased at high water depths. When pores were observed at bead surfaces, small holes were left and surface was rough (Fig. 1). Table 1 summarizes results for the BOP welds made with the three electrodes. Electrodes were compared using criteria such as visual appearance, pore sizing and counting.

Table 1 – Performance of each electrode in various welding conditions.

Bead appearance	**E 6013**		**E 7018**		**E 7024**	
	50 m	**100m**	**50 m**	**100m**	**50 m**	**100m**
Good	250-290 A	270-310 A			29-330 A	310 A
Acceptable	310–330 A	330 A	230-290 A		350-370 A	330-350 A
Bad		350 A	310-390 A	250-310 A		370-390 A

Fig. 3 shows, from the left to the right, macrographs of the best welds made at 50 meters using the E6013, E7018 and E7024 electrodes respectively. The E6013 electrode presented the best results. Amount and size of pores were smaller and surface appearance was excellent. Additionally, arc stability with both the E7024 and the E6013 electrodes was best.

Wet welds with the E7018 electrode had good bead appearance. However, more pores were encountered. Fig. 2 shows a macrograph of a BOP weld produced at 100 m water depth with the E7018 electrode. Pores at the weld root could not be removed even after multiple passes (V-groove weld). The predominant microstructure was invariably: ferrite with aligned second phase, grain boundary ferrite, martensite and bainite, Fig. 4 shows a micrograph of a BOP weld made with the E7024 electrode at 100 m and 330 amps. Hardness indentations

across the BOP welds revealed that the electrodes at 50 m and 100 m comply with the AWS D3.6:1999 specification. Radiographic examinations showed that all wet welds (including V-groove multi-pass welds) exhibit homogeneous pore distributions (Fig. 5).

Conclusions

The three steels of this study could be welded with the E6013 and E7024 electrodes (at 50 and 100m) and with the E7018 electrode (only at 50 m). The best BOP welds were found with the E6013 electrode. With the E7018 electrode, porosity became a major problem, particularly at high currents. The wet welds made with the electrodes complied with the AWS D3.6M:1999 specification.

Acknowledgments

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Figure 1 – BOP welds with electrode E7024 at 100 m water depth.

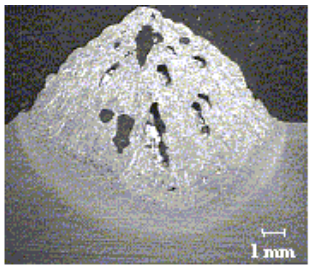

Figure 2 –BOP weld at 100 m with the E7018 electrode.

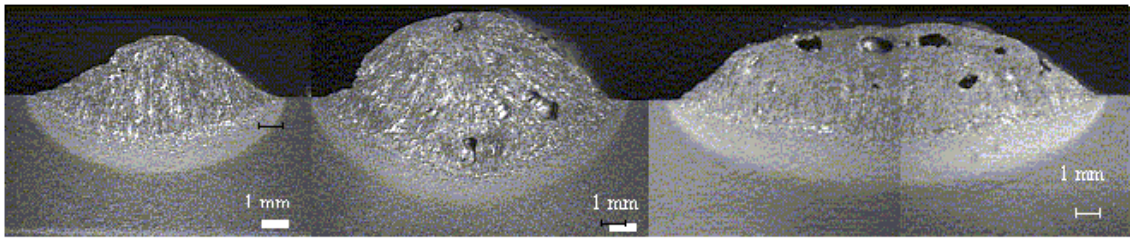

Figure3 – Macrographs of the best welds created at 50 m using the three electrodes.

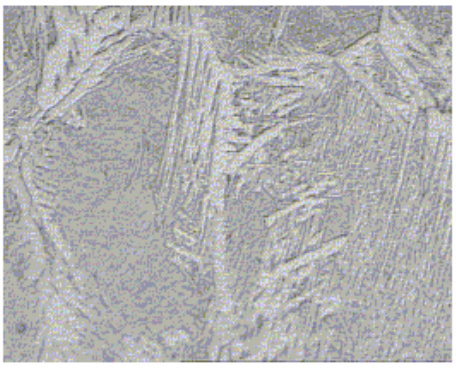

Figure 4 – Micrograph of a BOP weld made with the E7024 electrode at 100 m and 330 amps, 500x.

Figure 5 – V-groove weld with uniform pore distribution.