# Field Welding Repair of Heavy Equipment


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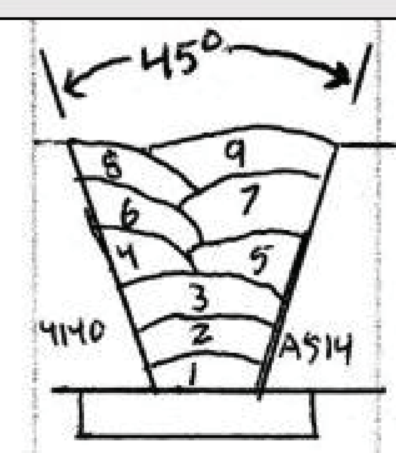
## Methodology

Using AWS D1.1 as a guide, 3 different weld procedures were tested for their mechanical performance. The first procedure had no heat treatment performed and was used as a control. The second procedure used a small amount of preheat that could be applied with a oxy-fuel torch. The third procedure has an altered weld bead progression intended to temper the Heat Affected Zone with no other heat treatment. This third procedure was performed twice with only different root openings. All procedures were tested by guided bend tests, tensile tests, and Charpy V-notch impact testing. To represent a bucket tooth AISI 4140 chromoly steel was used and to represent the bucket walls ASTM 514A steel was used.

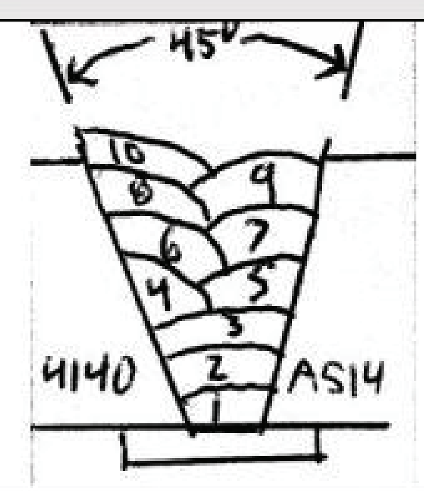
**XA**

| Pass | Process | Filler Metals class | Filler Metals Diam | Current Polarity | Current amps |
|---|---|---|---|---|---|
| 1-3 | SMAW | E11018M H4R | 1/8" | DECP | 118 |
| 4-9 | SMAW | E11018M H4R | 1/8" | DCEP | 116 |



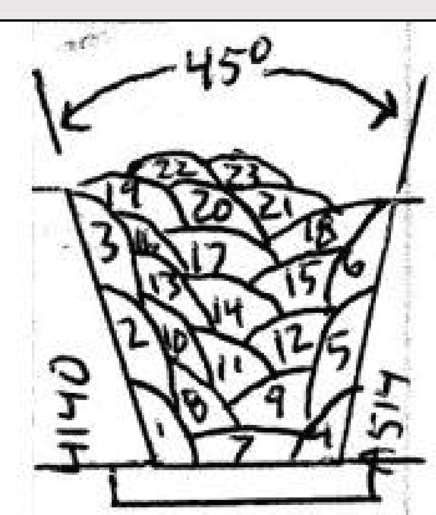

**XB**

| Pass | Process | Filler Metals class | Filler Metals Diam | Current Polarity | Current amps |
|---|---|---|---|---|---|
| 1 | SMAW | E11018M H4R | 1/8" | DECP | 118 |
| 2-4 | SMAW | E11018M H4R | 1/8" | DCEP | 116 |
| 5-10 | SMAW | E11018M H4R | 1/8" | DCEP | 114 |



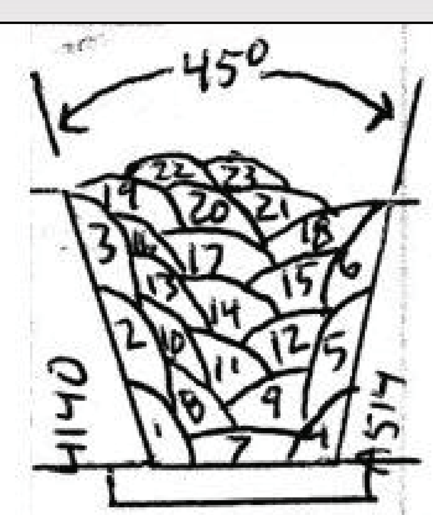

**XC**

| Pass | Process | Filler Metals class | Filler Metals Diam | Current Polarity | Current amps |
|---|---|---|---|---|---|
| 1-4 | SMAW | E11018M H4R | 1/8" | DECP | 116 |
| 5-23 | SMAW | E11018M H4R | 1/8" | DCEP | 114 |



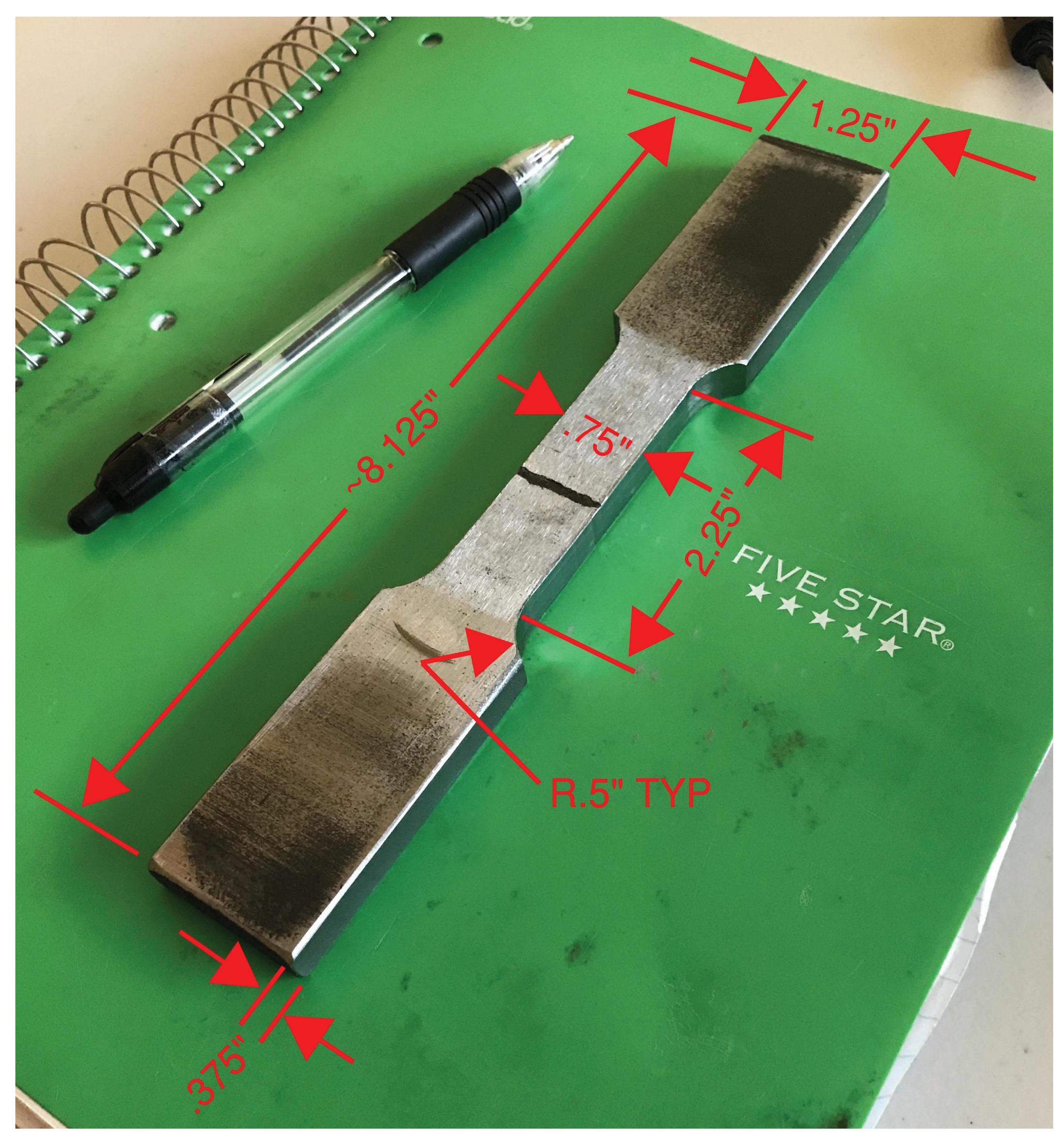

**XC**

| Pass | Process | Filler Metals class | Filler Metals Diam | Current Polarity | Current amps |
|---|---|---|---|---|---|
| 1-4 | SMAW | E11018M H4R | 1/8" | DECP | 116 |
| 5-23 | SMAW | E11018M H4R | 1/8" | DCEP | 114 |

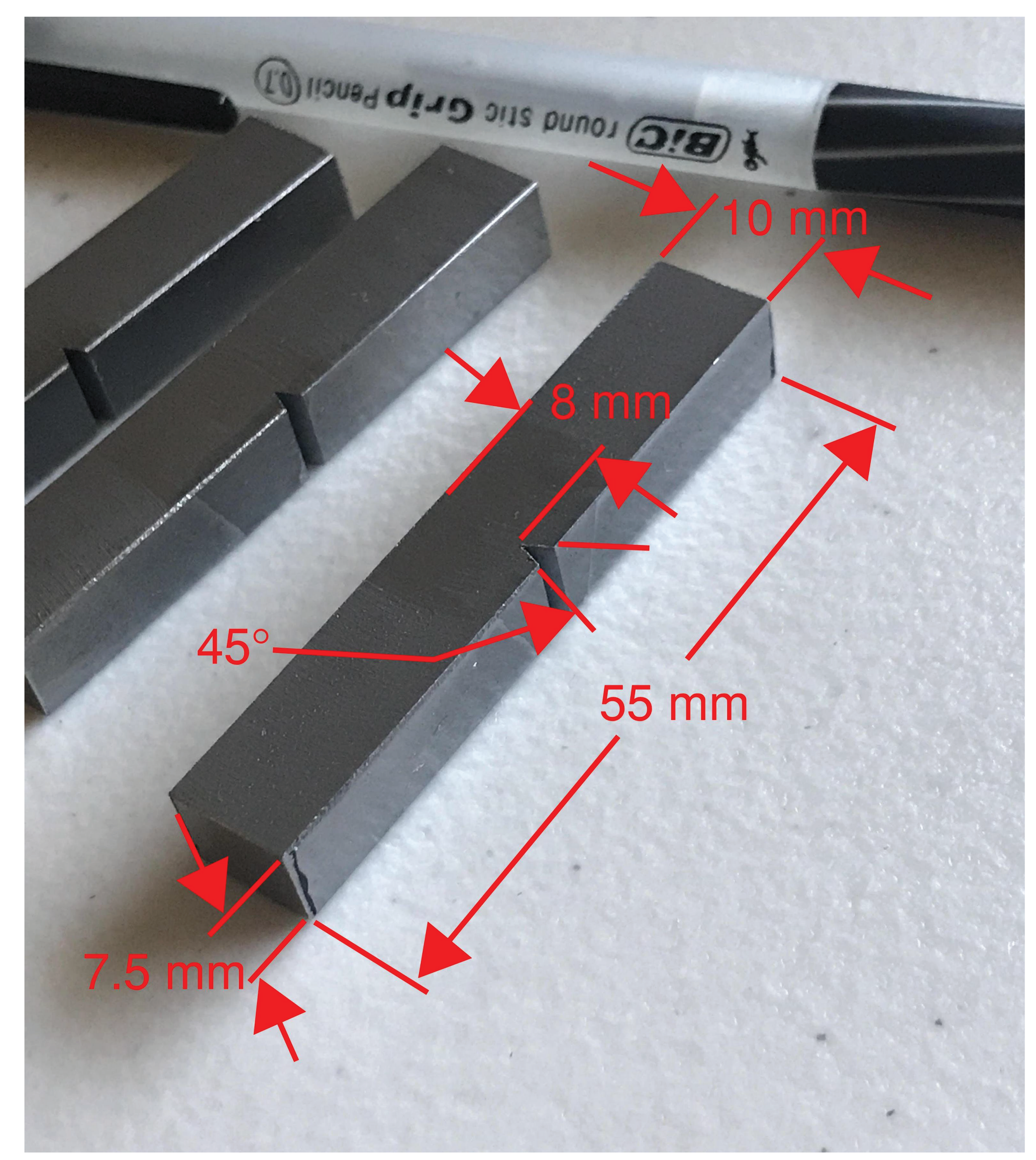



Welding repairs of heavy equipment in the field can vary in levels of success. This can be due to the high strength steels used in the manufacture of heavy equipment implements that require special metallurgical considerations. Martensite formation within the Heat Affected Zone being of particular concern. Repair difficulties can be further compounded by the limitations of tooling typically found on a construction site and schedule commitments. A successful repair of these items done out in the field can reduce downtime and improve productivity. This project will attempt to develop a welding procedure that can be done in the field to successfully repair damaged equipment. Considerations will be given for tooling that can typically be found on the construction site and skills familiar to a contractor or operating engineer. Different welding procedures will be compared for their ability to successfully weld high strength steels like that found on heavy equipment. Equipped with this welding recipe, anyone who can weld would be able to make a successful repair.


**Key Words:** Heavy Equipment repair, welding repair, ASTM A514, AISI 4140, weld procedure


Typical reduced section specimen for tensile test




Substandard sized Charpy V-notch bar

## Results

### Tensile Testing

| | Sample | UTS (psi) | % elongation | % reduction in area | Failure observation |
|---|---|---|---|---|---|
| XA | XA1 | 121606.55 | 8.18% | 21.82% | ~.5" from weld area, 4140 side |
| | XA6 | 119038.68 | 11.64% | 39.63% | along weld boundary of A514 |
| | average | 120322.62 | 9.91% | 30.72% | |
| XB | XB1 | 121606.55 | 6.58% | 20.75% | ~.5" from weld area, 4140 side |
| | XB6 | 116201.12 | 4.84% | 6.20% | adjacent weld boundary of 4140 |
| | average | 118903.84 | 5.71% | 13.48% | |
| XC | XC1 | 121481.48 | 6.89% | 19.15% | ~.5" from weld area, 4140 side |
| | XC6 | 110903.66 | 4.67% | 22.61% | within weld area |
| | average | 116192.57 | 5.78% | 20.88% | |
| XD | XD1 | 117388.11 | 10.80% | 26.66% | within weld area |
| | XD6 | 118034.06 | 16.62% | 41.88% | within weld area |
| | average | 117711.085 | 13.71% | 34.27% | |

### Charpy V-notch Testing

| | Sample | Notch location | Results (Ft-lbs) | Average |
|---|---|---|---|---|
| XA | XA7 | 4140 | 7 | 7 |
| | XA8 | 4140 | 7 | |
| | XA9 | A514 | 70 | 65 |
| | XA10 | A514 | 60 | |
| XC | XC7 | 4140 | 10 | 11 |
| | XC8 | 4140 | 12 | |
| | XC9 | A514 | 90 | 80 |
| | XC10 | A514 | 70 | |

## Conclusion

Guided bend tests and tensile tests were overall inconclusive for determine the variations between the different procedures. However, they did show the filler rod used provides a ductile weld that matches the the strength of the base metals even when no heat treatment was used. Those test also exposed a possible grain growth problem in the 4140 steel that was occurring far outside the Heat Affected Zone. The greatest change can be seen with the Charpy V-notch testing. The altered weld bead progression shows an increase in energy adsorbed over the sample with no heat treatment. This could suggest a tempering affect is taking place with an altered weld bead progression. More testing would be needed to confirm this and further refine the procedure.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