Flux Cored Arc Welding CrMo Steel

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METRODE WELDING CONSUMABLES

Introduction

- Materials and national specifications.
- Currently available wires.
- Shielding gases.
- Typical properties and applications.
- The future.

Consumable specifications

Base Material	AWS A5.29	BS EN 12071
P2	B1/B1L	-
P11/P12	B2/B2L/B2H	CrMo1/CrMo1L
P21/P22	B3/B3L/B3H	CrMo2/CrMo2L
0.5Cr-0.6Mo-0.3V	-	MoV
P5	B6/B6L	CrMo5
P9	B8/B8L	-
P91	B9 proposed	-

Carbon content: L = 0.05% maximum
H = 0.10-0.15%
Standard levels typically 0.05-0.12%

Specifications continued

- Analysis on its own does not give the full picture.
- Flux type:
  - Metal cored wires (AWS, ERXX*C*-XX / EN, *M*).
  - Rutile all-positional (AWS, EX*1T1*-X / EN, *P*).
  - Rutile downhand wires (AWS, EX*0T1*-XX / EN, *R*).
  - Basic wires (AWS, EXXT*5*-XX / EN, *B*).
- Mechanical properties:
  - AWS – tensile only (for CrMo alloys).
  - BS EN – tensile and Charpy.

Available wires

- Most readily available CrMo wires:
  - 1¼%Cr-½%Mo
    - E81T1 B2
    - E80T5 B2 / E81T5 B2
  - 2¼%Cr-1%Mo
    - E91T1 B3
    - E90T5 B3 / E91T5 B3

Target wires

- Emphasis today will be on rutile flux cored wires.
- All-positional wires suitable for ASME 5G/6G welding.
- Primary aim being to achieve optimum operability and productivity.
- AWS, EX*1T1*-XX (EN, T CrMoX *P*).

Wires covered

- E81T1-B2 M
- E91T1-B3 M
- E91T1-B3L M
- E81T1-B6 M (based on AWS terminology)
- E81T1-B8 M (based on AWS terminology)
- E91T1-B9 M (proposed specification)

Note: M designates mixed gas.

Shielding gas

- Primarily designed for use with mixed gas:
  - Ar/15-25%CO_2.
  - AWS, EXXTX-XX *M* (EN, T CrMoX X *M*).
- 100%CO_2 also acceptable:
  - AWS, EXXTX-XX (EN, T CrMoX X *C*).
- No benefit in using Ar/He/CO_2 mixtures.
- Generally need >15%CO_2 to achieve designed operating characteristics.

Effect of shielding gas (E91T1-B3)

- Example of weld metal composition for an E91T1 B3 wire with different shielding gases.
- Gases with higher oxidising potential result in lower Mn and Si.

	C	Mn	Si
Ar/5%CO_2	0.049	1.14	0.37
Ar/20%CO_2	0.049	1.02	0.29
100%CO_2	0.041	0.90	0.19

Effect of shielding gas (E91T1-B9)

- A similar trend in composition is seen for E91T1 B9 type wires.
- The different shielding gas, and weld metal composition, does not have a drastic effect on properties:
  - Toughness 18-26 ft-lb (25-35J) at room temperature using Ar-5%CO_2, Ar20%CO_2 and 100%CO_2.
  - Room temperature strength is also similar with all the shielding gases used.

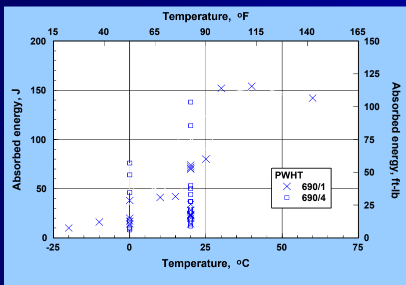
E81T1-B2

	AWS	BS EN	Typical
PWHT, °F/hours	1275/1	1255/1	1275/1
0.2% proof, ksi	68	51.5	80
UTS, ksi	80/1000	74	95
Elongation, %	19	20	24
Hardness, HV	-	-	220
Charpy at 68°F, ft-lb	-	35	35

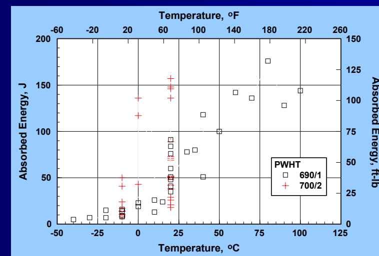
E91T1-B3

	AWS	BS EN	Typical
PWHT, °F/hours	1275/1	1330/1	1290/2
0.2% proof, ksi	78	58	90
UTS, ksi	90/110	72.5	105
Elongation, %	17	18	22
Hardness, HV	-	-	235
Charpy at 68°F, ft-lb	-	35	50

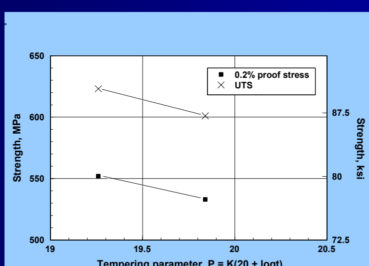
Toughness of E81T1-B2



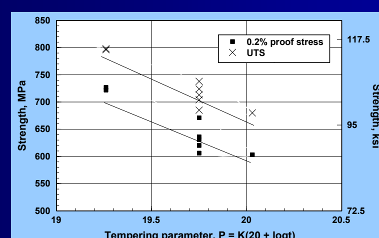
Toughness of E91T1-B3



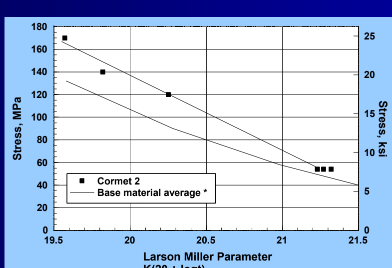
Tempering response E81T1-B2



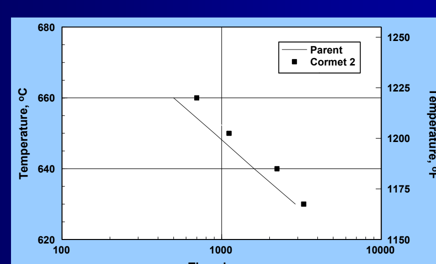
Tempering response E91T1-B3



Stress rupture data E91T1-B3



Stress rupture data E91T1-B3



E81T1-B2 & E91T1-B3 Applications

- Used extensively by UK power generation industry.
- Ideal for in-situ repairs during shut-downs.
- Also now being used for shop fabrication.
- Time savings of 25-45% compared to SMAW.
- Used for welding CrMoV and 2¼%Cr-1%Mo.

E91T1-B3L

	AWS	BS EN	Typical
PWHT, °F/hours	1275/1	1330/1	AW
0.2% proof, ksi	78	58	-
UTS, ksi	90/110	72.5	-
Elongation, %	17	18	-
Hardness, HV	-	-	280
Charpy at 68°F, ft-lb	-	35	35

E91T1-B3L Applications

- Only application to date has been for as-welded temper bead repairs.
- Repairs on CrMo piping during a scheduled shut-down.

E81T1-B6

	AWS	BS EN	Typical
PWHT, °F/hours	1375/2	1375/1	1275/2
0.2% proof, ksi	68	58	75
UTS, ksi	80/100	85.5	90
Elongation, %	19	17	22
Hardness, HV	-	-	230
Charpy at 68°F, ft-lb	-	35	35

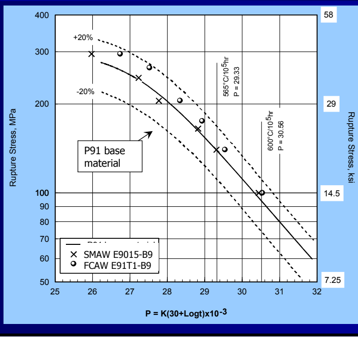
E81T1-B8

	AWS	BS EN	Typical
PWHT, °F/hours	1375/2	-	1375/2
0.2% proof, ksi	68	-	70
UTS, ksi	80/100	-	90
Elongation, %	19	-	24
Hardness, HV	-	-	220
Charpy at 68°F, ft-lb	-	-	35

'E91T1-B9'

	ASME code case 2297	Typical
PWHT, °F/hours	-	1400/2
0.2% proof, ksi	-	105
UTS, ksi	90	120
Elongation, %	17	19
Hardness, HV	-	270
Charpy at 68°F, ft-lb	-	20

Stress rupture data E91T1-B9



E91T1-B9 Applications

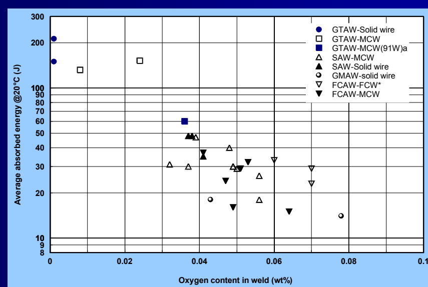
- Use to date has been in the power generation industry.
- Headers, steam piping etc.
- Time savings of up to 50% have been reported compared to SMAW.

Toughness

- There are limitations as to the toughness which can be achieved with a rutile flux system.
- Pick-up of Ti and Nb.
- Oxygen content (~600ppm).

Effect of oxygen on toughness

Using P91 as an example



High temperature properties

- For materials designed for service at high temperature it could be argued that toughness is not the most critical property.
- Hot tensile, creep and stress rupture properties are of more importance.

Summary

- The data I have presented, and experience I have, has been in the use of all positional rutile flux cored wires.
- They will not achieve the highest possible toughness but will achieve the required tensile and high temperature properties.
- Excellent all-positional operability.
- Significant productivity improvements compared to GTAW, SMAW & solid wire GMAW processes.

The future

- As the pressures for the most economic production methods increases more companies are considering flux cored wires.
- Most likely developments at present will be in the use of flux cored wires on new materials.
- The future is likely to see flux cored wires for new generation CrMo materials:
  - T23/T24.
  - P92.