Technical Paper

By P C J Anderson at
The Welding Institute
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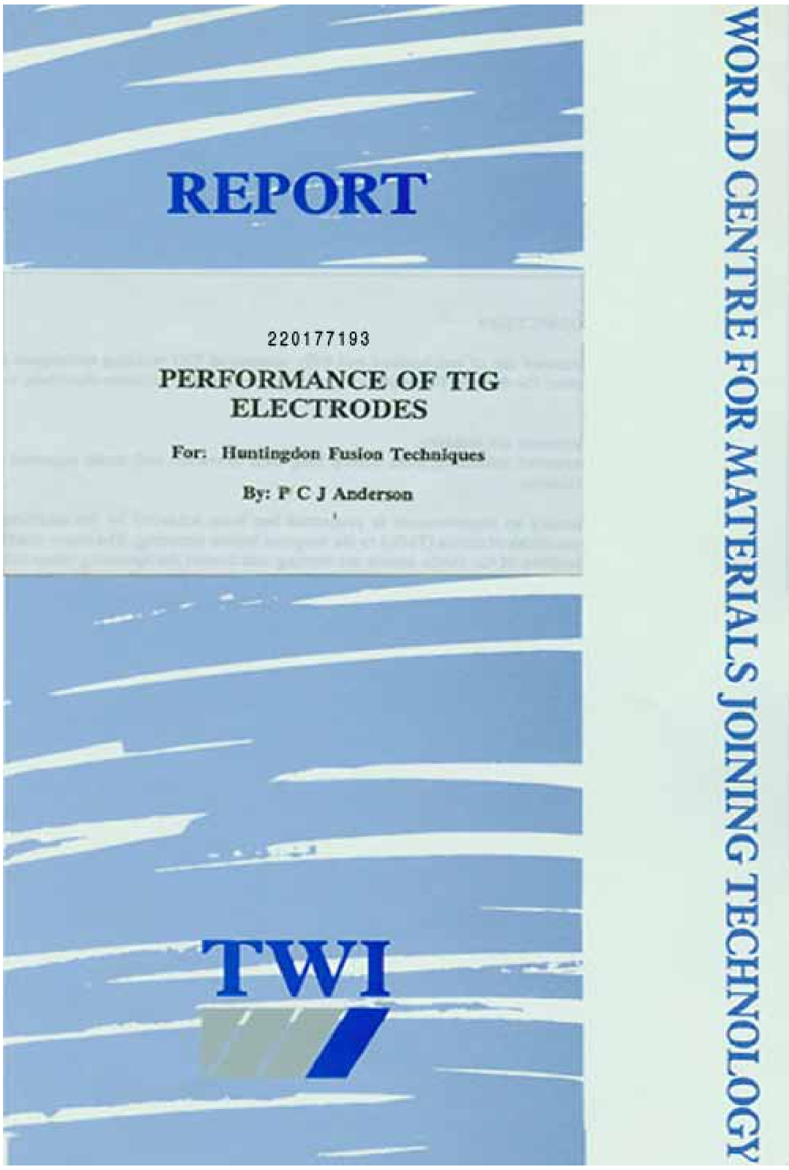

Incorporating
MultiStrike™ Tungstens
Comparison

PERFORMANCE OF TIG ELECTRODES

For: **Huntingdon Fusion Techniques (HFT)**

By: **P C J Anderson at The Welding Institute - Technical Paper Report N° 220177/1/93**
(Incorporating MULTI STRIKE™ Tungsten comparison)

1. INTRODUCTION

The increased use of mechanised and fully automated TIG welding techniques has highlighted the demand for improved performance from the tungsten electrode, such as:

- Increased arc stability.
- Improved reliability, both during long term operation and under repeated arc initiation.

Traditionally an improvement in properties has been achieved by the addition of small quantities of thoria (ThO_2) to the tungsten before sintering. The lower electron work function of the thoria assists arc starting and lowers the operating temperature of the tungsten electrode. However, thoriated tungsten electrodes suffer from two major drawbacks:

- Repeated arc initiation or operation at high currents soon leads to the evaporation of the thoria from the surface of the electrode, resulting in failure to restart the arc, excessive wear of the electrode tip or loss of arc stability. The usual solution is to regrind the electrode on a regular basis.

- Thorium is a radioactive element. Whilst its use in this application is essentially non-hazardous because of its low concentration and the excellent radiation absorbing properties of the tungsten matrix, there is increasing concern over the use of even weakly radioactive substances. The British Health and Safety Executive (HSE) have issued an information document to provide guidance for the storage and use of thoriated tungsten electrodes (1). This states that local exhaust ventilation should be provided during the grinding operation, and that the dust from the grinding equipment and the spent tips are disposed off in a sealed contained to a landfill disposal site. Further restrictive legislation on the use of thoria may be possible. The HSE has recommended to factory inspectors that, where thoriated tungsten electrodes are not necessary for the quality of the weld, users should be encouraged to look for alternatives (2).

Alternative, non-radioactive additions to tungsten electrodes are available, for example lanthana (La_2O_3) or ceria (CeO). Relative to thoriated tungsten electrodes, these electrodes are reported to exhibit improved arc starting characteristics and lower electrode consumption under heavy loading (3-9). A doped tungsten electrode which does not contain thoria is commercially available under the trade name "MULTI-STRIKE™" tungsten.

2. OBJECTIVE

To compare the performance of MULTI-STRIKE™ and conventional thoriated tungsten electrodes for TIG welding.

3. PROCEDURE

3.1 Materials

MULTI-STRIKE and 2% thoriated tungsten electrodes of 2.4 mm diameter were evaluated. The MULTI-STRIKE™ electrodes were selected at random from a typical batch. The electrode tips were ground to provide a 45° angle.

Argon was used as the shielding gas. The substrate material was a stainless steel.

3.2 Equipment

The power source used was a Miller SYNCROWAVE 300 power source. This power source uses four silicon controlled rectifiers (SCR) in a single phase, full wave bridge configuration. The characteristics of this power source are:

- Maximum open circuit voltage: 80 volts.
- Response time: approximately 35 milliseconds.
- Welding current ranges: low 5-75 amps, high 15-375 amps.
- Rated welding current: 300 amps @ 32 volts, 60% duty cycle.

The welding current is accurate to ±1% for line voltage variations of ±10%. This power source has good arc starting characteristics.

Additional arc starting tests were carried out using an OTC ACCUTIG 300P inverter power source. The characteristics of this power source are:

- Maximum open circuit voltage: 60 volts.
- Maximum pulse frequency: 500 Hz.
- Welding current ranges: 4-300 amps.
- Rated welding current: 300 amps @ 20 volts, 40% duty cycle.

This power source has excellent arc starting characteristics.

3.3 Programme of Work

The programme of work consisted of two phases:

- Arc starting characteristics.
- Electrode performance under heavy loading.

3.3.1 Phase 1: Arc starting characteristics

The arc starting characteristics of each electrode material was assessed over twenty welding cycles. Each cycle consisted of thirty seconds welding, followed by thirty seconds cooling.

The welding parameters used for the tests are shown in Table 1.

With the Miller Syncrowave 300 power source, arc lengths of 1.5 mm and 3 mm were assessed.

With the ACCUTIG 300P power source, arc lengths of 2 mm and 6 mm were assessed.

The outcome of each test was categorised as a self-sustaining arc, where the arc is initiated by HF and continues after HF ceases, or failure, where no arc is initiated.

Table One: Welding Parameters for the Arc Starting Characteristic Tests

Power source:	Arc length (mm)	Welding current (A)	Initial arc voltage: (V)	
			2% thoriated tungsten	MULTI-STRIKE
Miller Syncrowave 300	*1.5*	80	7.0	6.1
	3.0	80	7.3	6.5
ACCUTIG 300P	2.0	80	7.4	7.3
	6.0	80	8.9	8.7

3.3.2 Phase II: Electrode performance under heavy loading

The ability of each electrode material to withstand heavy (current) loading conditions was assessed by a continuous operation test.

The welding parameters used for the tests are shown in Table 2. The arc length was maintained at a constant 3 mm.

The weight of the electrodes was measured before and after the test.

Table Two: Welding Parameters for the Heavy Loading Tests

Electrode:	Arc length (mm)	Welding current: (A)	Arc voltage: (V)
2% thoriated3.0 tungsten	180	9.2	
MULTI-STRIKE	3.0	180	8.4

4. RESULTS

It was noted that the arc voltage required to maintain the same arc length was lower for the MULTI-STRIKE™ electrodes than for the 2% thoriated tungsten electrodes. This may be due to the lower electron work function of the MULTI-STRIKE™ electrodes, and is consistent with claims of a reduction in electrode temperature when moving from 2% thoriated tungsten to electrodes containing alternative additions (5). However, it should be noted that if the arc voltage changes outside the range specified in the welding procedure, it will be necessary to qualify a new welding procedure.

4.1 Phase I: Are Starting Characteristics

Table 3 shows the results of the tests to determine arc starting characteristics.

With the Miller Syncrowave 300 power source, it was necessary to slightly abrade the electrode tip between each test to facilitate arc initiation. Without tip abrasion, it was not possible to reignite the arc for either electrode material, even if the arc length was reduced to 1 mm. With tip abrasion, an arc was initiated at every attempt.

With the ACCUTIG 300P power source, an arc was initiated at every attempt without abrasion of the tip.

Table Three: Results of Arc Starting Characteristic

Power source:	Arc length (mm)	Number of tests:	Success: (self-sustaining arc)	Failure: (no arc initiation)
Miller Syncrowave 300	1.5	20	20	0
	3.0	20	20	0
ACCUTIG 300P	2.0	20	20	0
	6.0	20	20	0

4.2 Phase H: Electrode Performance Under Heavy Loading

Table 4 shows the change in weight of the electrodes over the test. There was no observable change in the weight of the MULTI-STRIKE electrode, and only a slight reduction in the weight of the 2% thoriated tungsten electrode.

Figures 1 and 2 show the 2% thoriated tungsten and MULTI-STRIKE electrodes respectively, before and after the test. It can be seen that the MULTI-STRIKE electrode maintained the shape of the electrode better than the 2% thoriated tungsten electrode.

The welder observed that the the arc was stable with the MULTI-STRIKE electrode for the full duration of the test, but that towards the end of the test with the 2% thoriated tungsten electrode there was some arc instability.

Table Four: Change in Electrode Weight over the Heavy Loading Test

Electrode:	Initial weight: (G)	Final weight: (G)	Change in weight: (G)
2% thoriated tungsten	12.20	12.19	-0.01
MULTI-STRIKE	12.09	12.09	0

5 DISCUSSION

5.1 Arc Starting Characteristics

Under the selected operating conditions, the performances of MULTI-STRIKE™ and 2% thoriated tungsten electrode were similar. This is in agreement with published work (3,4).

5.2 Electrode Performance Under Heavy Loading

Under heavy loading, the MULTI-STRIKE™ electrode maintained the shape of the electrode better than the 2% thoriated tungsten electrode. This indicates that there was significantly less melting of the electrode tip of the MULTI-STRIKE™ electrode relative to the 2% thoriated tungsten electrode. This is in agreement with published work (3,4,9). The change in shape of the electrode was probably responsible for the observed arc instability with the 2% thoriated tungsten electrode.

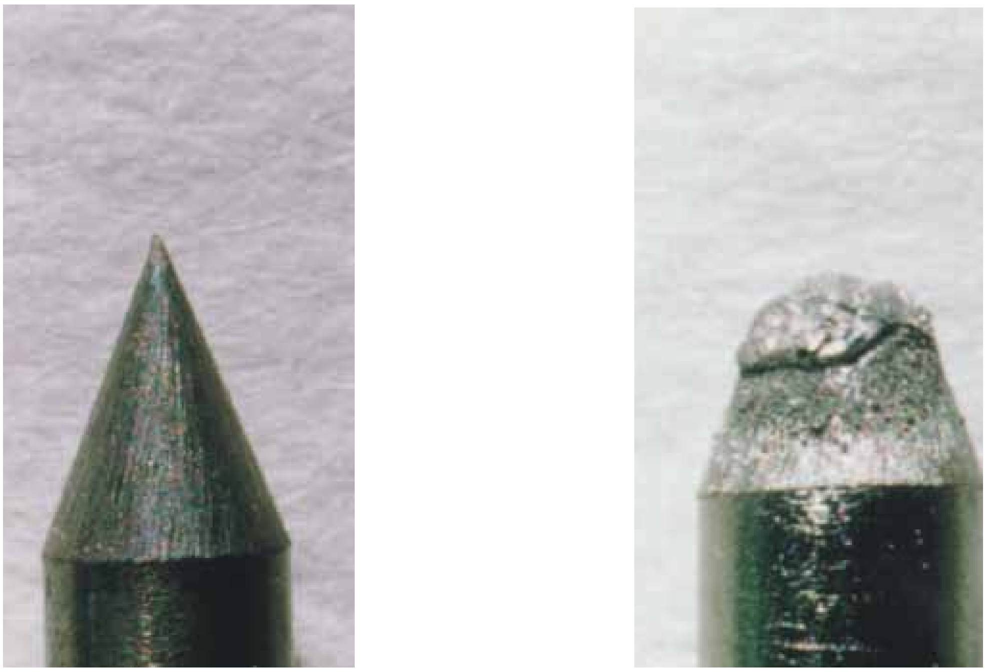

Fig 1 Appearence of 2.4 mm diameter, 2% Thoriated Tungsten Electrodes, (a) before and (b) after 1 hour continuous operation at 180 amps

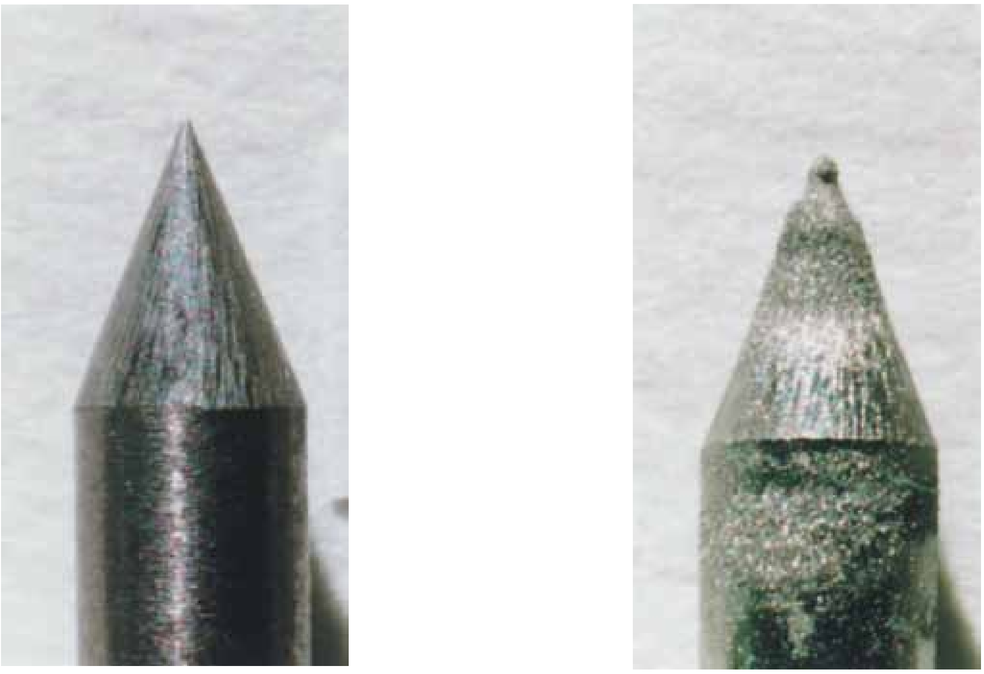

Fig 2 Appearence of 2.4 mm diameter, MULTI-STRIKE™ Electrodes, (a) before and (b) after 1 hour continuous operation at 180 amps.

6. CONCLUSIONS

A comparison was made of the arc starting characteristics and electrode consumption under heavy loading for 2% thoriated and MULTI-STRIKE™ tungsten electrodes. It was concluded that:

At an open circuit voltage of 80 volts, which is typical of power sources in the U& the arc starting characteristics of 2% thoriated and MULTI-STRIKE™ tungsten electrodes were similar.

Under heavy loading conditions, with a continuous arc of 180 amps for one hour, the MULTI-STRIKE™ tungsten electrode exhibited less melting than the 2% thoriated tungsten electrode, and maintained the electrode shape better.

7. RECOMMENDATIONS

MULTI-STRIKE™ electrodes should be considered as a valid alternative to 2% thoriated tungsten electrodes.

8. CONDITIONS OF CONTRACT

Please note that it is TWI policy that TWI's name cannot be used to endorse commercial products.

If the results of this project are distributed outside Huntingdon Fusion Techniques, the conditions under which the tests were carried out should be specified.

9. ACKNOWLEDGEMENTS

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