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**A PROTOCOL TO PERFORM REPAIR JOINTS INSIDE ATLAS BARREL TOROID CONDUCTORS**

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**Abstract**

In case substantial difficulties are met to extrude sufficiently long lengths of the conductor for the ATLAS Barrel Toroid, it could be necessary to join shorter pieces. We have shown elsewhere [1,4,6] that these joints, when properly performed, have a resistance sufficiently low to allow their use inside the ATLAS windings. The details of the protocol suggested to perform these joints is herein described.

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## 1 INTRODUCTION

Resistive joints inside the windings of the Barrel Toroid /End Caps are presently foreseen between the two layers of each pancake, as well as between pancakes and coils. A thorough analysis of the requirements and limits of such joints is presented in [1,4,6]. In those papers we have shown that a solution where the joint is performed by TIG-welding the aluminium matrices is feasible and compatible with a safe magnet operation. The experimental specific resistance value of these joints is about $4 \cdot 10^{-10}\,\Omega\cdot\mathrm{m}$, with an applied magnetic field of 2.62 T, the field experienced by the joint when the magnet is at its maximum. With such a value a joint length of 2.5 m is sufficient to maintain the Joule power dissipation at the joint sufficiently low.

A similar problem would arise in the event of cable breaks during winding or due to the failure to produce sufficiently long cable unit lengths (1730 m for BT). In a previous report [1] we have investigated a possible solution in which the two Rutherfords are soldered, and the Aluminium matrix reconstructed afterwards. Although such a joint could allow a specific resistance lower than $10^{-10}\,\Omega\cdot\mathrm{m}$, its mechanical properties are doubtful. We have therefore devised [2,3] a scheme where the two cable extremities are connected by TIG-welding; the specific resistance of these joints should be similar to the above-mentioned case since in this case only the geometry differs slightly while all the main parameters are unchanged. We have shown experimentally that these values of specific resistance are actually met in test joints [5]. In this note we present the protocol to perform these joints, with all the details. The References report the complete list of the papers we have published on this subject so far.

## 2 JOINT PREPARATION

This design aims to give a final joint whose geometrical characteristics are identical to the rest of the conductor, having at the same time a sufficiently low resistance. The different steps of the joint preparation are shown in Fig. 1. In A, the two ends of the conductors to be connected are machined as shown, with the two ends tapered. A photograph of the end of the two pieces of a test joint is shown in Fig. 2. The aluminum has been partly removed, taking care not to damage the Rutherford cable. Later (Fig. 1B) these two ends are bent in such a way that, after matching the two joints (Fig. 1C), the two conductors are properly aligned (Fig. 3). The conductors are TIG-welded on both sides (Fig. 4), but not along the broad faces, in order not to approach too much the Rutherford cable (Fig. 1D), possibly spoiling its superconducting properties. The chamfer size was 5 mm x 45°, and it was done by hand by means of a file. We have used a pure aluminum wire as filler, obtained by drawing a rod coming from an extruded conductor. Since it is mandatory to exploit a filler whose purity is similar to that of the matrix, we measured its RRR, whose value was 980±50. The section of the wire was a square with a side of 2 mm; there was no special motivation for the square section apart from the tooling exploited for the drawing process, a groove rolling mill. The temperature in the welding zone was monitored and recorded by means of a set of four thermocouples; when it exceeded 350 °C at any location, the welding was interrupted and resumed only when the sample was sufficiently cooled down. The current during the TIG-welding was 250 A, and the argon gas-flow was set at 10 l/min. After the completion of the welding, the excess aluminum in the joint zone is machined away (Fig. 5), so as to reconstruct exactly the outer dimensions of the conductor. The final result can be seen in Fig. 6, where it is shown about half of the whole joint. The transverse groove corresponds to the extreme of one piece, where no welding was performed. The length of the welded joint must be selected properly, in order to get a suitable resistance.

## 3 REFERENCES


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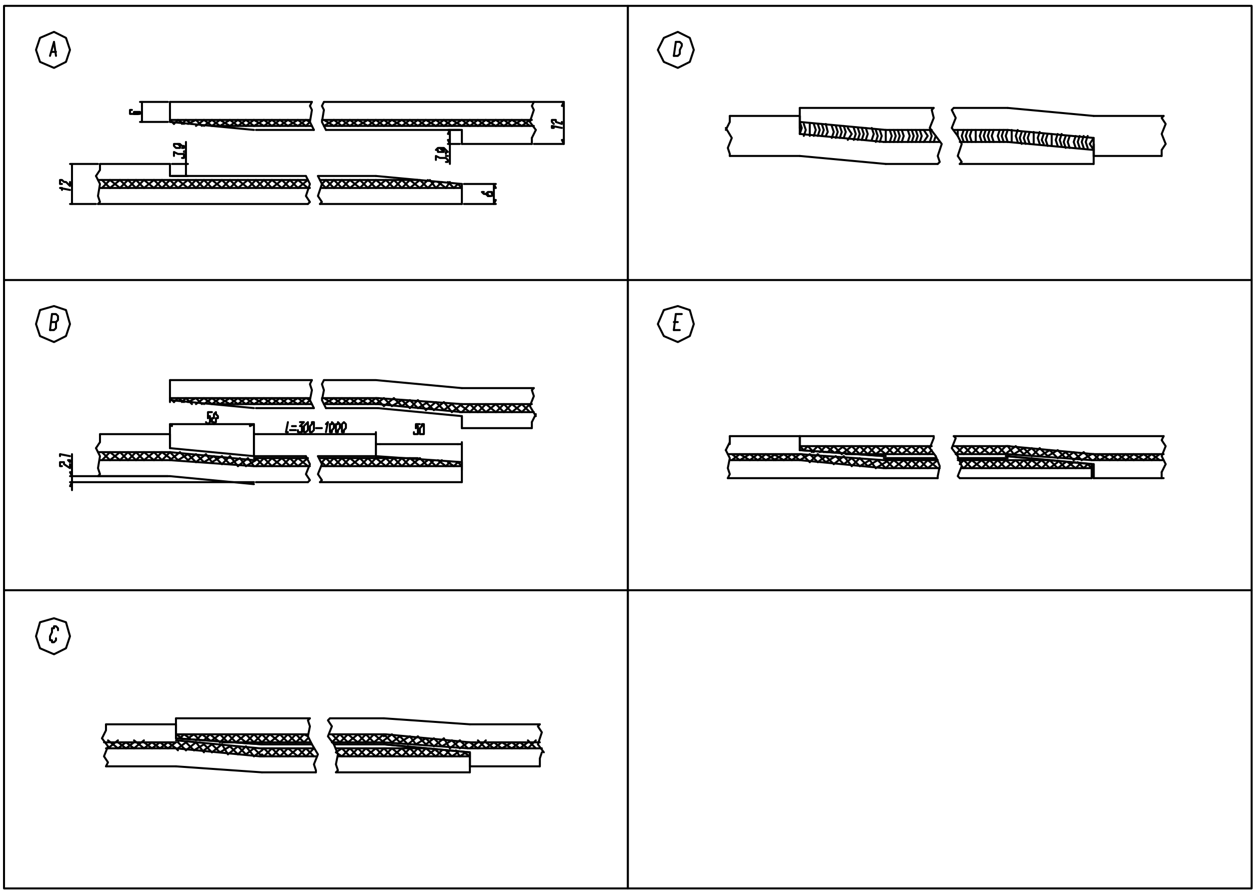


**FIG. 1:** The steps of the joint preparation.

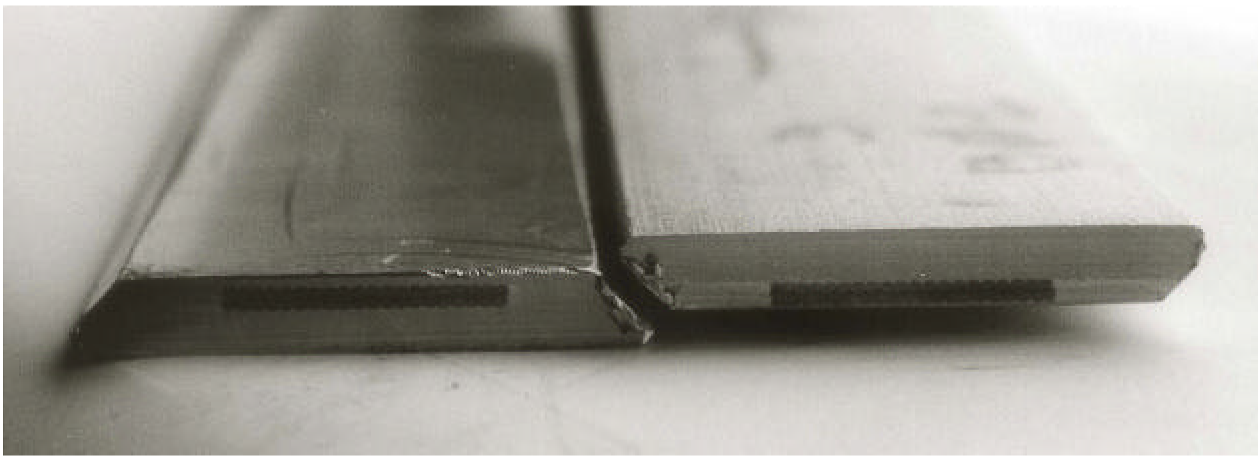

**FIG. 2:** The extremes of the two pieces to be used. The two pieces are not in the final position for the assembly.

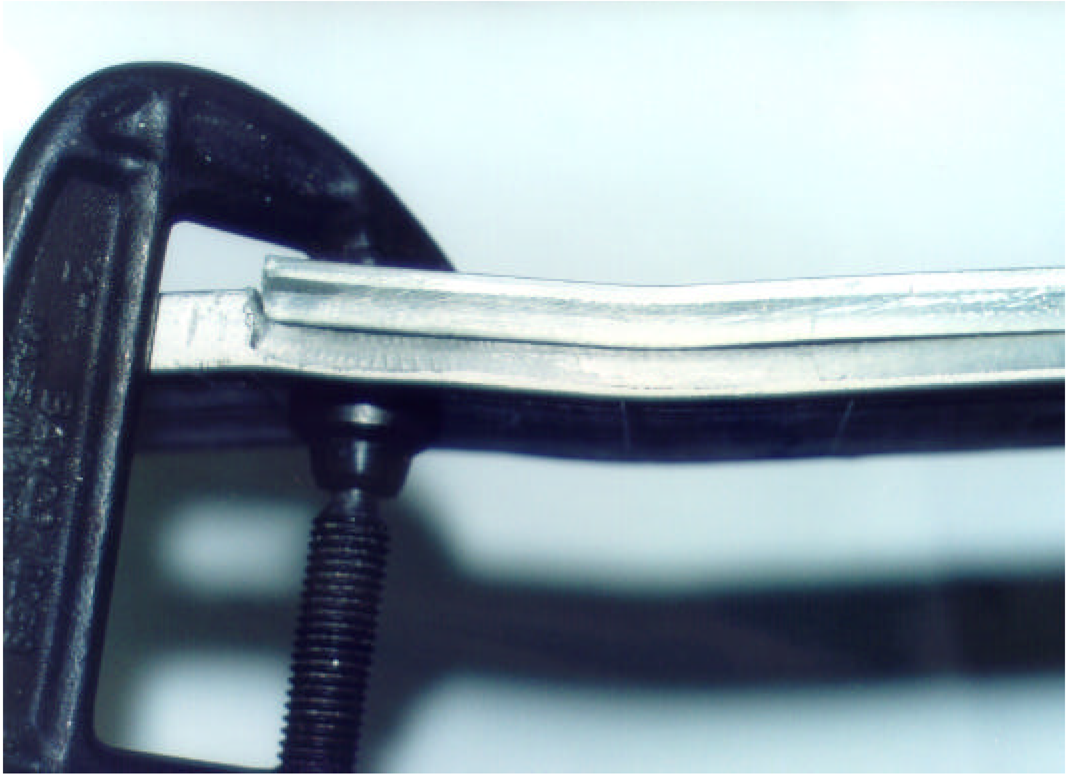

**FIG. 3:** The two pieces clamped in their final position, ready for welding.

**FIG. 4:** TIG welding of the test joint.

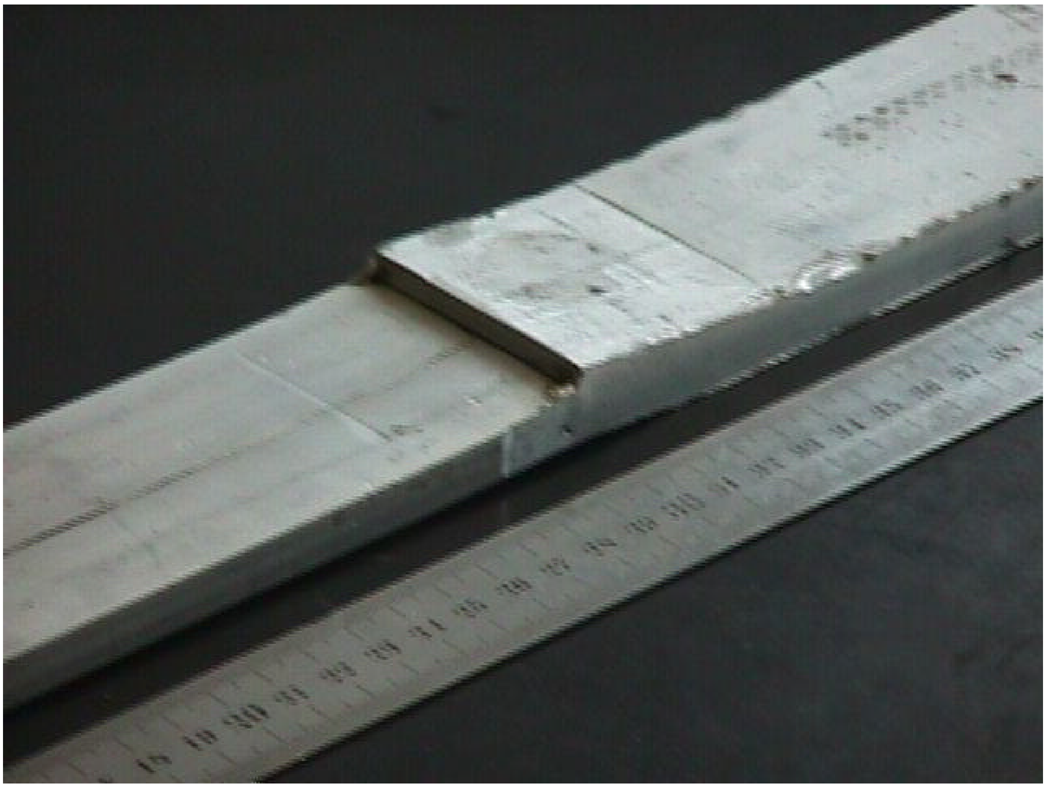

**FIG. 5:** After the welding, the test joint is machined so as to reach its final dimensions.

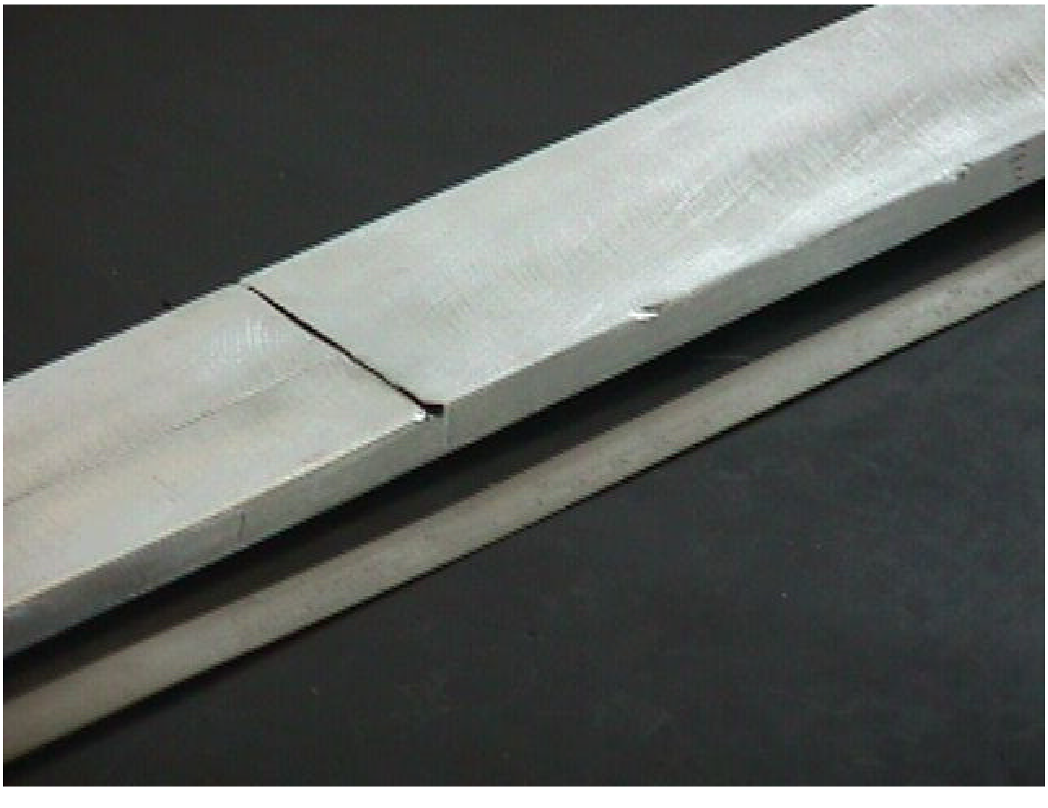

**FIG.6:** The test joint after the final machining.