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ABSTRACT.

During 2003 the UKAEA designed a novel low loss tri-axial and magnetics feedthrough to be installed during the 2004/2005 shutdown. The new low loss tri-axial and magnetics feedthrough incorporates two interacting systems -Toroidal Alfvén Eigenmodes (TAE) antennae and Magnetic pick-up sensors - in one assembly. These two systems put conflicting constraints on the feedthrough design, most notably RF interference from the high power and high frequency (500kHz, 600V and 30A maximum) TAE system onto the magnetic system. RF interference from the TAE was required not to affect the signals from the magnetic pick-up sensors to the extent that the signal-to-noise ratio is degraded significantly, particularly those used for MHD measurements. Other design considerations were UHV (at 450°C), gamma and neutron radiation, Remote Handling and double tritium boundary compatibility. For this purpose a new flexible tri-axial cable feeding the TAE diagnostic had to bedesigned, prototyped, developed, manufactured and tested. This cable was integrated into the overall feedthrough design.

INTRODUCTION

The Joint European Torus (JET) at Culham, UK is undergoing a major upgrade and refurbishment in 2004/2005 with the installation of a large number of improved diagnostics, heating systems (ICRH) and a new divertor configuration [1]. This JET Enhanced Performed (EP) programme is needed to prepare the Tokamak to run ITERrelevant plasma configurations and to validate design choices made for ITER. A number of these systems, in particular the bolometry and all the temperature and density measurements, will be accessible in real-time, allowing the control of plasma shape, current and pressure profile in view of ITER scenarios. Signals from in-vessel diagnostic and control systems are taken through conduits to vacuum feedthroughs that interface the in-vessel environment to the outside world. These vacuum feedthroughs are placed in a limited number of ports on the vacuum vessel. The combination of a limited number of available ports with the proximity of various systems has meant that some systems need to share a port and vacuum feedthrough. Two such systems are the Toroidal Alfvén Eigenmodes [TAE] antennae [2] and Magnetic pick-up sensors [3]. The feedthrough for these systems will be located in Octants 4 and 8. Unfortunately the requirements for the two systems are such that RF interference from the moderate to high-power and high frequency TAE system might render the signals from the magnetic pick-up sensors useless unless shielding is applied. This paper describes the integrated design of the two-system feedthrough including the requirements for remote installation of components. The latter has relevance for ITER related systems where Remote Handling will play an even greater role than at JET [4].

1. DESIGN

1.1. MAGNETICS FEEDTHROUGH

The feedthrough concept for the magnetic pick-up sensors is based on a typical feedthrough design adopted by JET (Figure 1). Mineral Insulated (MI) cable is brazed to two bulkheads. The space between the 2 bulkheads is enveloped by a chamber to form a pumped inter-space. The orientation of MI cables at the bulkhead has been set so that the RF interference from the TAE is minimised.

The MI cables at the ex-vessel end will be sealed by an epoxy resin (Stycast) and terminated (via standard electrical cable) into a Lemo socket. The MI cables at the in-vessel end will be hermetically sealed by a special termination (Figure 2) which is routed into the connection matrix. At the connection matrix the MI cable is connected to a flexible braided cable which terminates at the 20 way RH socket located on the (in-vessel) shoebox attached to the outer wall.

1.2 TAE FEEDTHROUGH

The feedthrough concept for the TAE is based on an existing coaxial feedthrough design used by Commissariat a L'Énergie Atomique (CEA) with slight modifications to suit JET requirements (Figure 3, 4) [5]. A tri-axial cable will be used to minimise interference between the two systems in the feedthrough. The central conductor and the screen conductor are isolated by a ceramic break. The screen conductor is in turn isolated from the main feedthrough housing by a second ceramic break. All joints between the conductors and the feedthrough isolators will be vacuum brazed, leak tested and thermally cycled at the appropriate stages. The inner bulkhead and outer bulkhead are similar in construction but are assembled together to form a pumped interspace. The design of the slotted sliding contacts between the 2 bulkheads allows for thermal expansion and vertical movement during disruptions. The inner and outer bulkheads are connected to the main housing by a small seal weld.

1.3 REMOTE HANDLING FEATURES

Although the bulk of the feedthrough will be installed ex-vessel by pushing it into the Limiter Guide Tube from outside the vacuum vessel, a number of in-vessel components will be installed by Remote Handling (Figure 5). With regard to the invessel arrangements for the TAE cabling 4 x ϕ14mm flexible coaxial braided cables will be installed. There will be a connection at the feedthrough and a connection at the TAE antenna via a 4 way RH TAE fixed socket. The intention is to install remotely the TAE socket, cabling and conduit. The 4 screen conductors in the RH TAE plug (Figure 6) and socket will be isolated from each other using a ceramic block (not shown). Both in-vessel ends of the TAE connections (point of RF leakage) are displaced from all magnetic connections to limit potential interference. The 4 way RH TAE socket will be situated on the near side of the TAE antenna. The TAE antenna assembly will be terminated with the 4 way RH TAE plug. The plug will be remotely connected to the socket.

Four RH Support Rails will be placed in a nominal position and welded in situ by Remote Handling. The RH support rails may be substituted by higher load capacity RH supports that are currently being developed by the Remote Handling Group. This will not affect or interfere with the LGT feedthrough design. A photogrammetry survey will be carried out on the installed RH support rails and the survey results will be translated on to a setting jig. The machineable blocks on the socket box will be machined to suit the setting jig thereby giving confidence that the remote installation in-vessel will be achievable.

SUMMARY

A novel space-saving feedthrough assembly has been designed, incorporating two diagnostic systems. The use of a new tri-axial cable and careful choice of geometries and materials has meant that the very different signal requirements for the two systems can be shared by one feedthrough.

ACKNOWLEDGEMENTS

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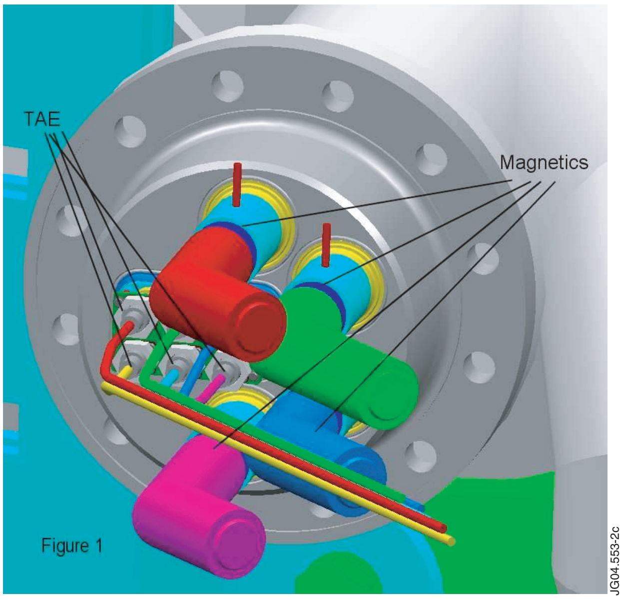

Figure 1: Details of the TAE antennae, highlighting the connection matrix.

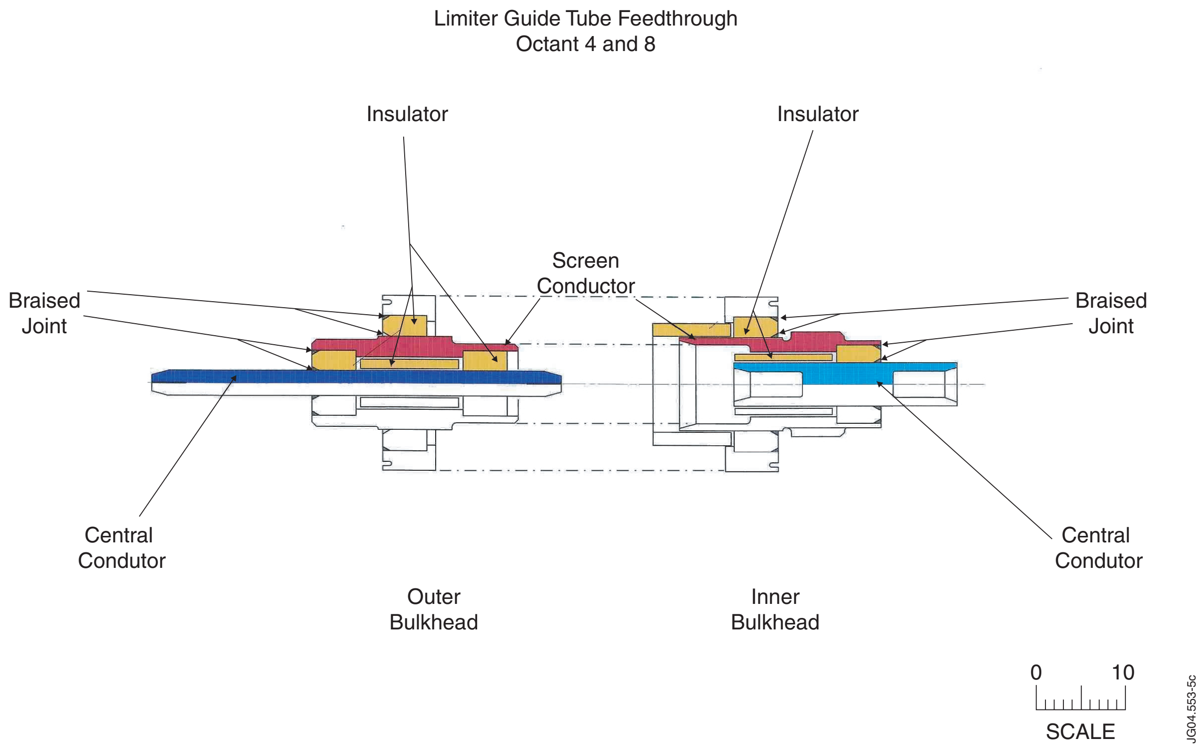

Figure 2: The ex-vessel configuration of the feedthrough.

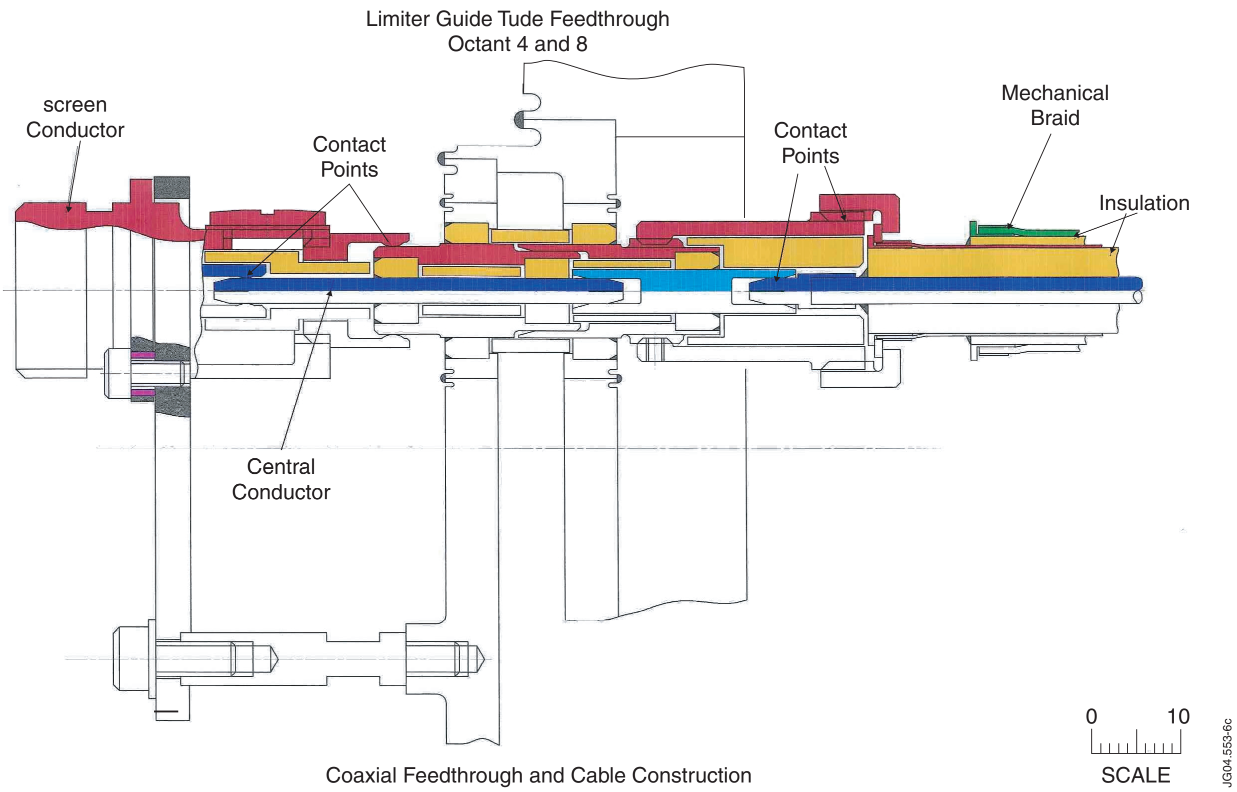

Figure 3: In-vessel RH plug for TAE antennae.

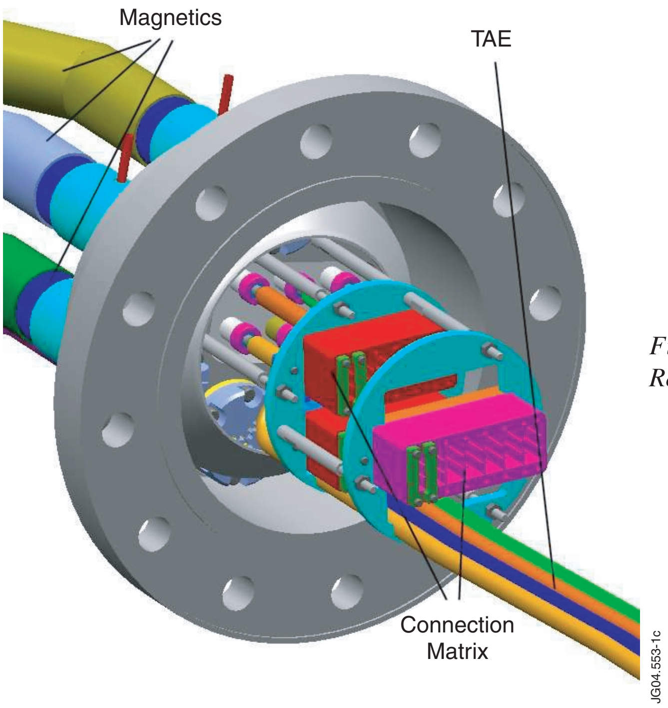

Figure 4: In-vessel components mostly installed by Remote handling.

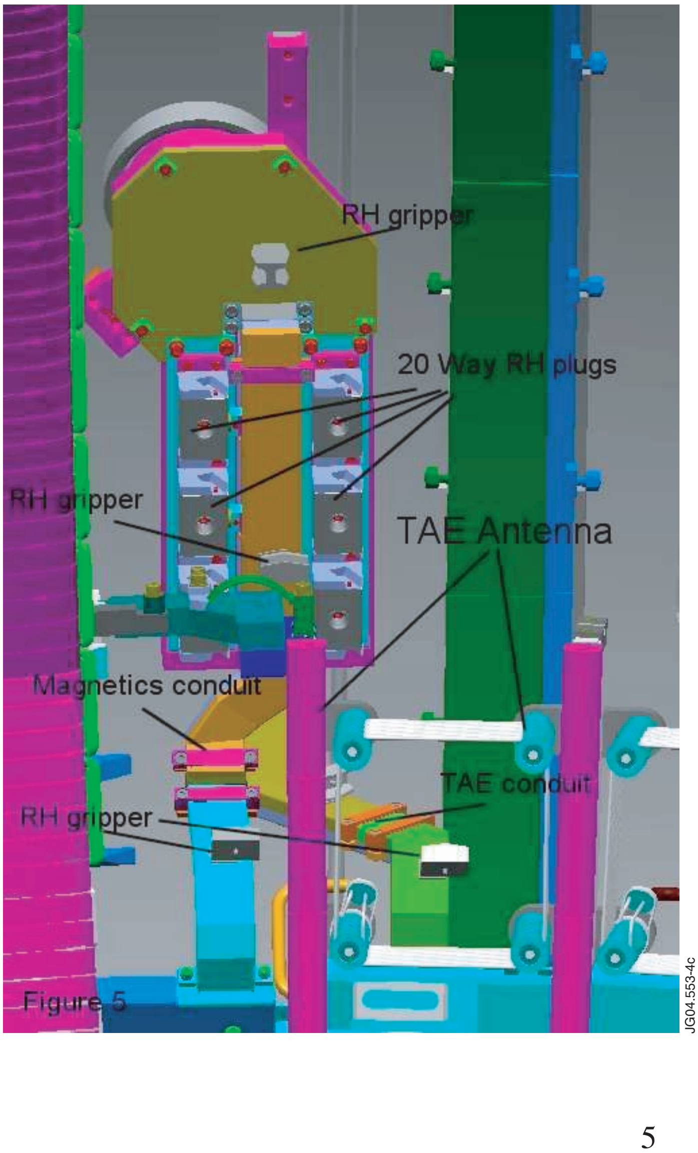

Figure 5: The TAE antennae feedthrough.

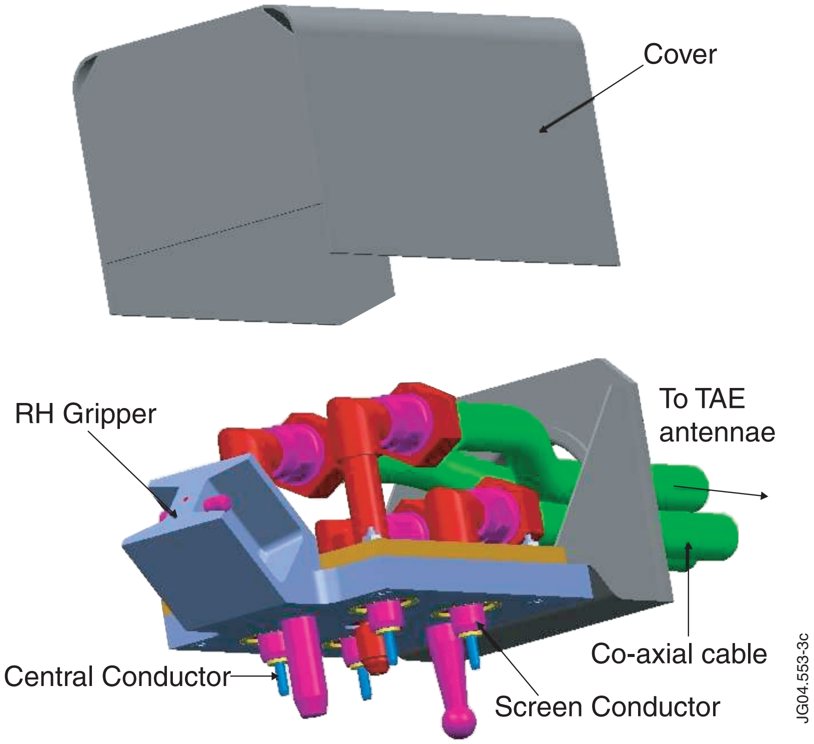

Figure 6: Hermetically sealed MI cable termination