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** See annex of J. Pamela et al, "Overview of Recent JET Results and Future Perspectives", Fusion Energy 2000 (Proc. 18th Int. Conf. Sorrento, 2000), IAEA, Vienna (2001).*

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ABSTRACT

The JET-EP Antenna is designed to verify the design principles of that proposed for ITER, in relevant plasma conditions. It is intended to launch 7.2 MW of RF power to the plasma of the JET machine during its 'Enhanced Performance' program, at a power density of around 8 MW/m 2 . The antenna comprises two poloidal current straps, each subdivided into four electrically short straps complete with in-vessel capacitors. The antenna is supported via a cantilever support box to the external support structure. This plug-in, through-port type assembly is clamped to the vacuum vessel externally. The antenna itself is fitted remotely. External rails and bellows allow radial positioning of the assembly. Eight capacitors are situated just behind the short antenna current straps. Plug-in replacement of the capacitors is performed through the vacuum vessel port.

1. INTRODUCTION

The antenna is positioned between two narrow Poloidal Limiters. It is supported via the rectangular section support box (pink) to the external support structure. The assembly is clamped to the Main Horizontal Port with swing bolts (green). External rails and bellows allow radial movement of the assembly. RF transmission lines are at the rear.

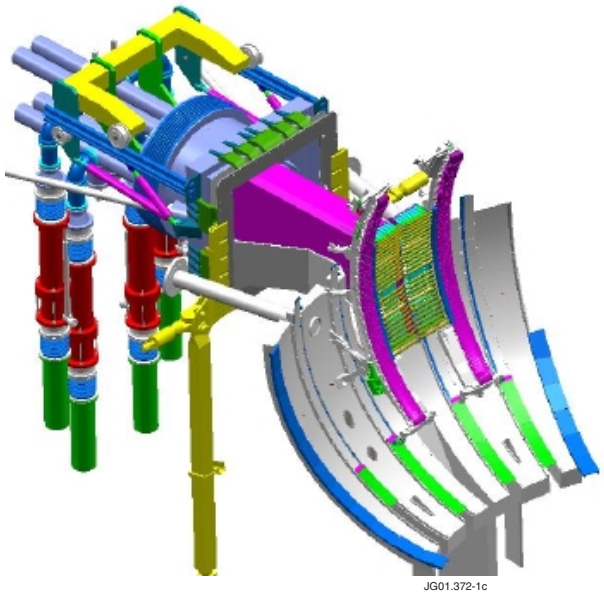


Figure 1: Overview of Antenna installed in Main Horizontal Port

Features:

- All metal antenna, with no resistors and no ceramics
- Continuous corona ring close to plasma and 'private limiter' protection tiles
- Continuous Inconel 718 flexible pivot to allow differential thermal expansion of beryllium screen bars.
- Continuous horizontal conductive path across the antenna/limiter assembly to earth
- RF Window as per that developed and successfully tested at JET 96/99
- New narrow Poloidal Limiters fitted remotely re-using existing in-vessel weldments
- No new in-vessel structural welding Remote assembly, and tile and screen bar maintenance

2. DESIGN CRITERIA USED IN THE EVALUATION OF STRESS

Electromagnetic disruption loads:

Radial dB_r/dt = 80 T/s

Poloidal dB_P/dt = 120 T/s

Toroidal field: 4T

Vertical field: 1T

Radial Field: 0.6T

Moment about vertical axis:
12 tonne.m

Moment about radial axis:
5 tonne.m

Machine loop voltage: 800V

Halo Current:

42kA applied to antenna screen
developing 6 tonne radial force in the antenna.

125kA applied to the limiter
developing a radial force of up to 50 tonne/metre length.

Vacuum: 16 tonnes

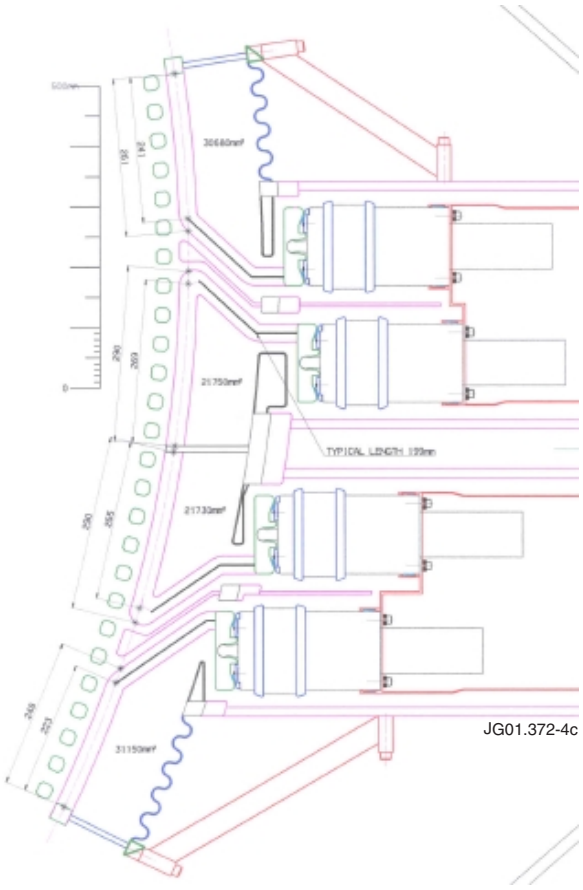
Vessel Port Acceleration/displacement:
7g, 16mm radial, 3.5g, 8mm toroidal, 2g vertical

Heat flux: 300 kW/m^2 for 10s i.e. $3MJ/m^2$

Housing dimensions:
Height 1400mm, Width 800mm,
Depth 200mm

NB Some of these figures are conservative (i.e. pessimistic)

3. DESIGN DETAILS



(a) VERTICAL SECTION

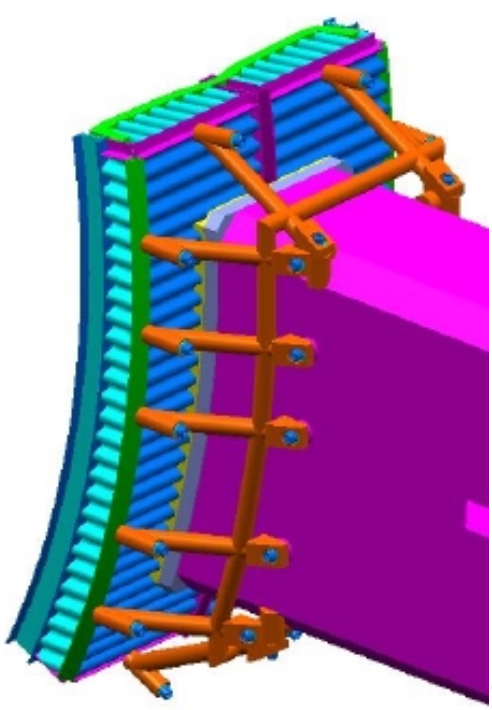
All metal design

- No ceramics (except capacitor)
- No resistors on the antenna

No massive in-vessel structural weldments

Configuration of current straps requires close liaison with low power
testing

Horizontal screen bars



(b) 3D HOUSING VIEW

Support box (purple) and frame (orange) support the antenna housing. 32 off M16 housing bolts providing distributed support to the distributed load.

Main flange, septa and housing side walls, support the corrugated 2mm inconel panels.

The support structure is independent of distortion of the vacuum vessel during a disruption.

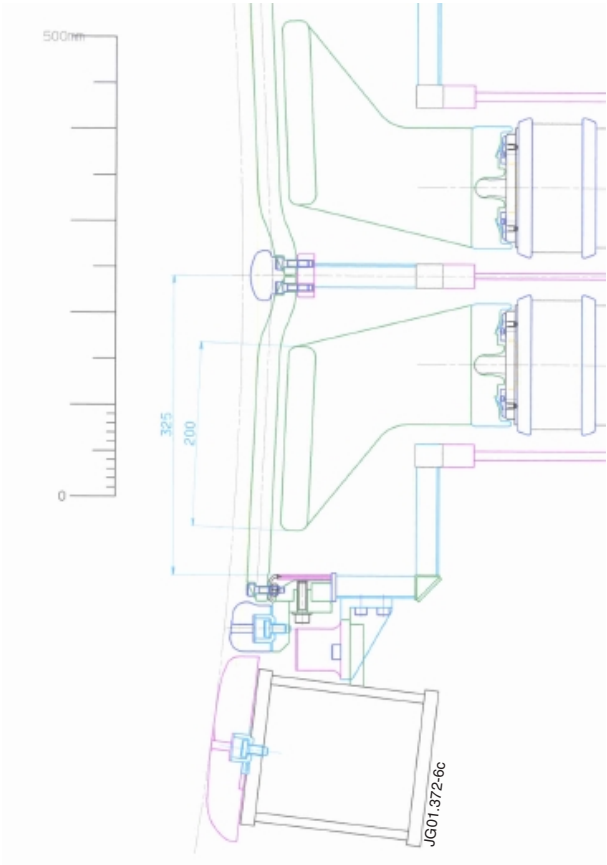
(c) HORIZONTAL SECTION

Continuous inconel 718 flexipivot to allow differential thermal expansion of screen bars

Continuous corona ring close to plasma and 'private limiter' tiles

RH tile and screen bar removal

Earth straps will be fitted between the Antenna and Poloidal Limiters, and to the torus wall (not shown)



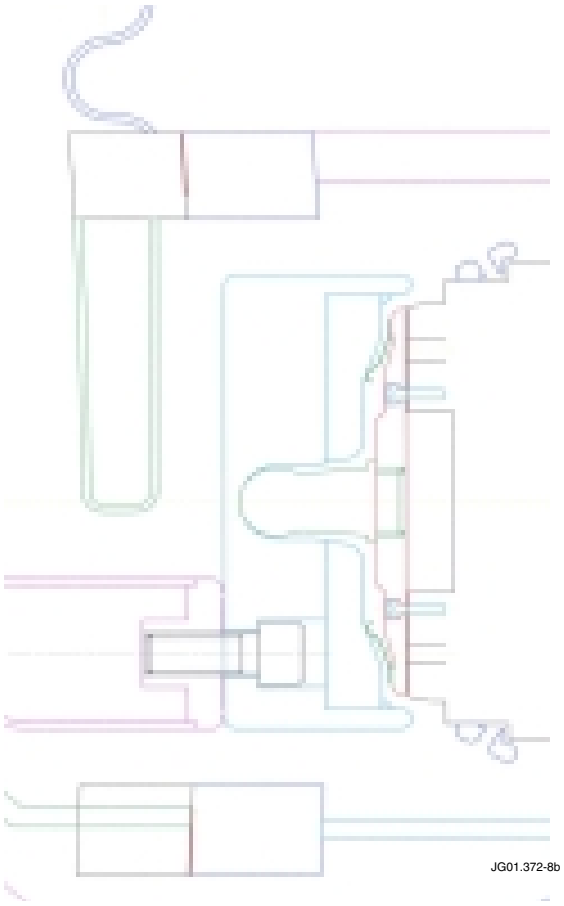
(d) CAPACITOR

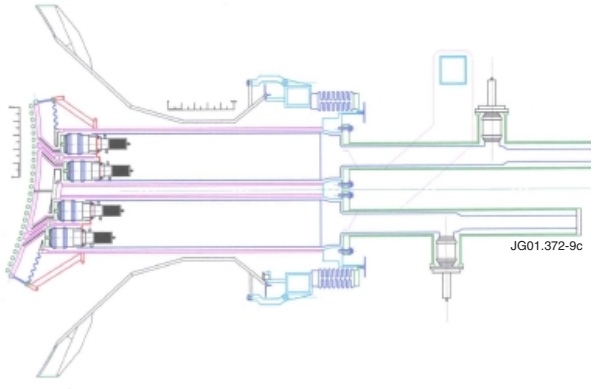
Spring contacts, self-centring boss

The spring contacts are arranged so that angular misalignment of the antenna current strap due to thermal expansion is accommodated by flexing of the spring fingers. The advantage over conventional axially orientated contacts, is that they are not required to slide at operating temperatures in vacuum.

The above arrangement is to be tested prior to installation.

The capacitor is cooled from the rear by water cooling, and is also cooled by radiation to its enclosure, which is also water cooled. The antenna flange may be water cooled if necessary, requiring the welding of the water cooling pipes from ex-vessel using a welding tool, which is capable of welding from inside the pipe.





(e) VERTICAL SECTION OF ASSEMBLY

'Plug-in' through-port type assembly

'Plug-in' type capacitor replacement complete with inner VTL through port.

Capacitor actuators and water-cooling feeds through stub.Bellows allows radial adjustability for:

- repositioning of the antenna if a hot spot develops.
- repositioning for screenless operation
- accommodating dimensional variation of ports such as angular misalignment
- reduction of stresses in ex-vessel cantilever supports – elimination of 'over- constraint' coupling, which depends on radial positioning

(f) JET WINDOW

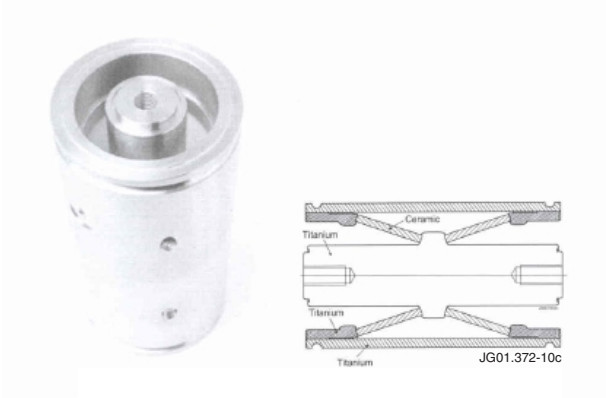
Window geometry exactly like the RF window developed at JET 96/99

Titanium housing

Alumina window - shrunk fit during brazing to produce axial and radial compressive stress field ***throughout*** the ceramic

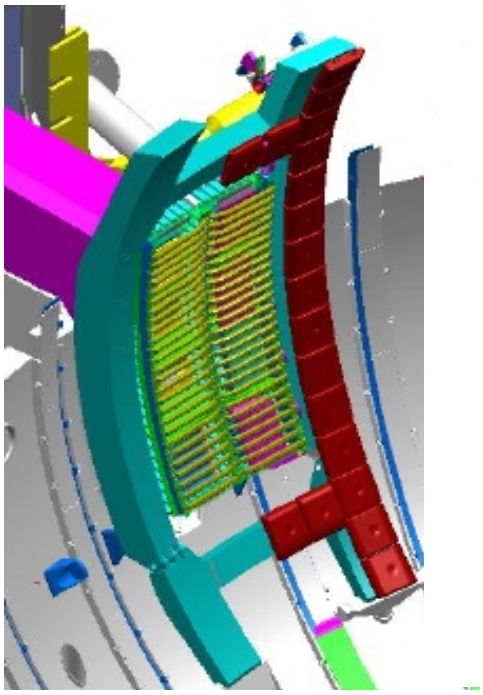
Ceramic is much weaker in tension than compression. The compressive residual stress therefore protects the ceramic when RF heat loads and other loads are applied.

The prototype was tested at JET to 48 kV for 20 seconds without arcing.



(g) POLOIDAL LIMITER

New narrow limiters are used with Remote Handling capability, re-using existing in-vessel weldments.



(h) REAR QUARTER 3D VIEW