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Diversification of the position sensing instrumentation for the JET neutral beam calorimeters

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The JET neutral beam injection system incorporates a calorimeter in each beamline, comprising 2 large cooled copper panels (about 2.5m x 1m) instrumented with thermocouples to provide diagnosis of the beam shape and alignment. The panels are rotated out of the beam path to allow the beam to enter the torus; they are inertially cooled and can only sustain full beam power for a fraction of a second, hence it is essential they are fully withdrawn during plasma operation.

Calorimeter position is monitored with in-vacuum micro-switches close to the limits of travel, but these have proved unreliable in the past; furthermore the panels are known to twist due to a combination of bearing friction, water bellows reaction torque and actuation from the top and as a result may not always reach the switches. This has led to periods of operation where the bottom of the panel has unknowingly scraped the edge of the beam and in 2013 this resulted in melting of the edge of one panel and a large water leak.

A procedure has been implemented to check the calorimeter position and thus avoid a repeat of the melting incident; however in 2015 an independent review panel examined NBI reliability and recommended that a diversity of methods should be used to detect the positions of the calorimeters. This paper summarises the methods considered and details the option selected for installation during the 2017 shutdown.

Key constraints on the technology choice were:

- Compatibility with ultra-high vacuum
- Presence of sputtered copper
- High neutron level (particularly during the planned D-T operation) meaning no active electronics close to the sensor
- Magnetic fields during pulsing
- High levels of vibration
- Measurement accuracy better than 5mm

Many technologies were considered, the most promising being:

- Rows of mechanical or magnetically actuated reed switches, to indicate a series of discrete positions
- Bespoke inductive proximity sensor
- A spring element deflected by the calorimeter movement, instrumented with strain gauges

The latter 2 were investigated in more detail through laboratory experiments and both considered suitable, however the spring element was finally selected on the basis of being considered lower risk.

The detailed design of the final sensor is described, along with the laboratory work on an inductive sensor; this technique was only rejected on the basis of requiring more development work and hence presented a higher risk given the limited time available to design and manufacture a sensor. It may have applicability to other in-vacuum position sensing requirements where more development time and resources are available.

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Eligible for student paper award?

No

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