Deposition of impurity metals in JET ITER-like Wall campaigns

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There have been three operational periods of JET with the ITER-like Wall – 2011-2 (ILW1), 2013-4 (ILW2) and 2015-6 (ILW3). Post-mortem analysis of divertor and wall tiles removed after each period by Ion Beam Analysis show that the principle plasma impurity that was deposited in the divertor was beryllium (Be) that had been eroded from the main chamber tiles (which are mostly made of solid Be, or coated with Be); Be was also re-deposited in areas of the main chamber. However, within the deposits were also quantities of the metals Ni, Fe and Cr in approximately the same ratios as found in Inconel, and small amounts of tungsten (W).

Much greater levels of Ni, Fe and Cr were found on Tile 6 (outer divertor corner) after ILW2 than ILW1, with a similar level after ILW3 to that after ILW2. This is attributed to the failure of some tie-rods in Tile 7 which then slipped down so that their ends were resting on Tile 6, exposing a few centimetres of their length to power load. To determine if this contamination was merely local, tiles from the main area of plasma impurity deposition from each period (Tile 1 at the top of the inner divertor leg) have been analysed. Similar peak Ni, Fe and Cr concentrations were found on the apron of Tile 1 after both ILW1 and ILW2 ($10x10^{17}$, $4x10^{17}$ and $3x10^{17}$ atoms cm^{-2}, respectively), but the average over the whole Tile 1 was greater after ILW2 than ILW1 ($4.92x10^{17}$ compared to $2.87x10^{17}$ atoms cm^{-2} for Ni, for example); the level was found to have returned to a lower level after ILW3. These results are in qualitative agreement with spectroscopic data. Ni, Fe and Cr have always been found at low levels within deposits in JET, probably due to erosion of the vessel wall and fittings (made of Inconel) by charge-exchange neutrals, but these ILW results indicate that impurities generated in the very corner of the outer divertor at Tile 6 are able to reach the main plasma and be re-deposited elsewhere in the vessel.

All divertor surfaces are of W – either as ~25 μm coatings on CFC or in the case of Tile 5 as solid W. There are also some W-coated CFC tiles in the main chamber, but well recessed from confined plasmas. Small concentrations of W are found within deposits at all parts of the vessel: Data are only reported for deposits on components that do not originally contain W. W levels on the stainless steel inner and outer deposition monitor covers after ILW1 were $72\text{-}104x10^{15}$ and $29\text{-}50x10^{15}$ atoms cm^{-2}, respectively: levels on inner louvres after ILW1 and ILW2 were $25\text{-}48x10^{15}$ and $5\text{-}32x10^{15}$, respectively, and on outer louvres $80\text{-}107x10^{15}$ and $17\text{-}42x10^{15}$ atoms cm^{-2}, respectively: levels on a Be Inner Wall Guard Limiter (2XR10) were also about a factor of two greater after ILW1 than after ILW2 (e.g. peak values of $500x10^{15}$and $250x10^{15}$ atoms cm^{-2}, respectively. The decrease in W concentrations with time may be due to the decrease in the numbers of W particles dislodged by plasma interaction with coated artifacts, or by the coverage of W-coated surfaces with Be thus protecting against W erosion.

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