IMPURITY CONTENT OF REDUCED-ACTIVATION FERRITIC STEELS AND THE EFFECT ON THE REDUCED-ACTIVATION CHARACTERISTICS—R. L. Klueh (Oak Ridge National Laboratory), E. T. Cheng (TSI Research, Inc.), M. L. Grossbeck, and E. E. Bloom (Oak Ridge National Laboratory)

Extended Abstract*

Development of low- or reduced-activation materials for fusion has focused on the issue of radioactive waste disposal or recycling of materials from fusion power plant components after they have reached the end of their service lifetime. The objective has been to eliminate or minimize those elements from an alloy that would produce long-lived radioactive isotopes during irradiation in a fusion neutron spectrum. Emphasis in the development process has generally centered on eliminating Nb, Cu, Ni, Mo, and N, widely used alloying elements, with niobium usually receiving the most attention, because of the very low levels (<1 wppm) that niobium cannot exceed if the steel is to meet low-activation criteria.

Besides the elements listed above, various other elements that could appear in the materials as tramp impurities must be restricted to extremely low levels. These elements include Ag, Ho, Bi, Co, Sm, Lu, Dy, Gd, and Cd. To determine the levels of these elements in steels, three heats of reduced-activation martensitic steel were analyzed by inductively coupled plasma mass spectrometry, which is capable of detecting very small levels of impurities. The steels analyzed were: a 5-ton heat of modified F82H for which an effort was made during production to reduce detrimental impurities, a 1-ton heat of JLF-1, and an 18-kg heat of ORNL 9Cr-2WVTa. Specimens from commercial heats of modified 9Cr-1Mo and Sandvik HT9 were also analyzed. The objective was to determine the difference in the impurity levels in the F82H and steels for which less effort was used to insure purity.

The results for the steels indicated that progress has been made in reducing the level of detrimental impurities for the two large heats of reduced-activation steel. The F82H produced with present technology had the lowest levels of the restricted elements, but in some cases the levels were not much different from the other heats. Silver, niobium, and molybdenum proved to be the most important of the restricted elements, and the steels that have been made up to now do not meet the criteria for low activation for shallow land burial of nuclear waste made up of these steels after an integrated wall loading of 20 MW y/m^2 after a 100 y cooling off period. However, it appears that reduced-activation steels could be produced with these detrimental impurity elements at levels low enough to meet the present criteria for shallow land burial. If instead of shallow land burial, it is desired to recycle the steel, with a "hands-on" dose rate limit of 25 μSvh^{-1} after a 100 y cooling time, then considerable research and expense will be required to develop processes that will allow the production of steel that will meet these criteria.

There has probably never been a requirement for a structural material to be processed to have specified impurity levels as low as those required to meet the reduced-activation criteria. Even though the materials will not be needed for some time, it would appear that an effort should be mounted to determine the means to achieve the desired purity levels, especially if recycling is to be pursued. Such an effort should enlist support from industrial materials processors to examine techniques used in the past to produce high-purity materials and determine ways that these techniques might be combined with the latest technology for future application. The effort should not be delayed if reduced-activation materials are to be available when fusion power production is ready to begin operation.

* Extended abstract of paper submitted for publication in the *Journal of Nuclear Materials* (Proceedings of the Ninth International Conference on Fusion Reactor Materials).