EXECUTIVE SUMMARY

As the nuclear industry attempts to increase the reliability and economic viability of nuclear plants, future safety analysis will rely even more on iodine behaviour codes. Attempts to reduce the exclusion boundary area, to extend the life of existing nuclear power plants, and to develop new safety concepts for advanced reactor designs have resulted in new requirements for safety analyses. There is increasing demand for the safety analyses of reactor accident consequences to move from bounding conservative estimates towards best estimates that are supported with uncertainty analyses. These changes require regulatory approval, and methodologies based on out-dated knowledge and bounding estimates are expected to be inadequate.

To meet current and future demands, it is necessary that iodine codes demonstrate their ability to provide accurate estimates of iodine volatility for a large range of reactor accident scenarios. Unfortunately, simple correlations between iodine volatility and key parameters (e.g., scaling, temperature, dose rate, pH, initial iodine speciation, organic impurities, surfaces, etc.) are not readily obtained from experimental data obtained under a narrow range of conditions. Furthermore, one cannot easily determine representative accident conditions. For an iodine behaviour code to be confidently applied to modelling accident conditions, it should therefore be able to reproduce experimental data obtained under a wide range of conditions.

The first ISP 41 comparison exercise was based on a simple Radioiodine Test Facility (RTF) experiment and demonstrated that all of the iodine behaviour codes had the capability to reproduce iodine behaviour for a narrow range of conditions (single temperature, no organic impurities, controlled pH steps). However, the exercise also demonstrated that the performance of these codes is extremely reliant upon the judicious choice of user-defined kinetic parameters. If code calculations are to be used as predictive or interpretive tools, then the kinetic parameters used in the codes must be applicable to the entire range of conditions that are anticipated in post-accident containment.

The second step of ISP 41 (the work reported in this document) was an opportunity for code users to assess their codes over a wide range of accident conditions. The exercise examined the sensitivity of code output to input parameters such as pH, dose rate, initial iodine concentration, and the presence of organic impurities, painted surfaces, and silver. The parametric study identified several areas of discrepancy between the various codes. In general, the codes agree regarding qualitative trends, but the actual amount of volatile iodine predicted by each of the codes varies considerably. The largest source of the discrepancies between code predictions appears to be the differences in modelling the formation and destruction of organic iodides in each code.

Ideally, the results of step 1 and step 2 of the ISP 41 exercise should be used to improve the organic iodide sub-models within the iodine behaviour codes. Although the exercise identified the organic iodide sub-model as one of the most significant contributors to the discrepancy

between the code predictions, the calculations cannot tell us which (if any) of the sub-models are correct, and what the range of user-defined input parameters for each of the sub-models could be. The next logical step of the ISP 41 exercise is the performance of code comparison exercises against experimental data on organic iodide formation, preferably data obtained over as large a range of experimental conditions as possible. This comparison will allow each of the code users to realistically evaluate and improve the organic iodide behaviour sub-models within their codes.

In the interest of covering as large a range of experimental conditions as possible, we recommend that the final step of ISP 41 be a code comparison against four intermediate scale studies: two Caiman facility experiments, and two RTF experiments, which were performed over a very large range of experimental conditions (dose rate, painted surface areas, temperature, pH, etc.). We recommend that the calculations be performed first as blind calculations (i.e., each code is used with default parameters). Subsequently, the results can be made available to each of the participants, and a second set of calculations can be performed, in which user-defined kinetic parameters (such as those within the organic iodide sub-models) are optimized to provide a best fit to all of the experimental data. In each of the experiments, the presence of painted surfaces resulted in organic iodides contributing significantly to the volatile iodine fraction. This comparison exercise should therefore provide insight into the performance of the organic iodide models in each code. The exercise will provide code users with improved values for the user-defined input parameters in their iodine behaviour codes. The exercise may also provide insight into the organic iodide formation and destruction mechanisms, and identify whether future experiments or changes in modelling strategy are required.

The main objective of ISP exercises is to increase confidence in the validity and accuracy of the tools that are used in assessing the safety of nuclear installations. The secondary objective is to enable code users to gain experience and demonstrate their competence. Due to the complexity of iodine behaviour in containment, the ISP 41 exercise on iodine codes has required three steps to achieve these objectives, which are

1. ISP 41: Computer code exercise based on a simple RTF experiment on iodine behaviour in containment under severe accident conditions.
2. ISP 41 Follow-up Step 1: Parametric calculations.
3. ISP 41 Follow-up Step 2: Computer code exercise based on complex experiments performed at the RTF and Caiman facilities.

We have completed the first two steps and recommend completing the final step.