

June 6, 2013

MEMORANDUM TO: Kathy H. Gibson, Director  
Division of Systems Analysis  
Office of Nuclear Regulatory Research

FROM: Scott C. Flanders, Director */RA/*  
Division of Site Safety and Environmental Analysis  
Office of New Reactors

SUBJECT: USER-NEED REQUEST TO DEVELOP AN iPWR-GALE COMPUTER CODE TO ASSESS COMPLIANCE OF SMALL MODULAR REACTOR APPLICATIONS AGAINST 10 CFR PART 50, APPENDIX I DESIGN OBJECTIVES AND PART 20, APPENDIX B ECLs

This memorandum presents a user-need request from the Office of New Reactors (NRO) to develop an alternate version of the GALE12 computer code to support the review of applications for new small modular reactors (SMRs) or integral pressurized water reactors (iPWRs) submitted under 10 CFR Part 50 and Part 52. The alternate version of the GALE12 code, herein referred as the iPWR-GALE code, would be used to assess compliance with the public dose criteria of Appendix I to 10 CFR Part 50 and 10 CFR Part 20, and the liquid and airborne effluent concentration limits (ECLs) of Appendix B to 10 CFR Part 20.

The first SMR applications are expected by mid calendar year (CY) 2014, which include the NuScale, mPower, and Westinghouse designs. The review of the designs involves an evaluation of liquid and gaseous effluent releases and associated doses to members of the public under 10 CFR Part 20 and 10 CFR Part 50, Appendix I design objectives. For typical large LWR designs, the staff is using GALE86 code (current version) to confirm the applicant's estimates of yearly releases of radioactive materials in liquid and gaseous effluents. The staff has determined that GALE86 has inherent limitations when compared to the unique design characteristics of SMRs. It is NRO's understanding that the Office of Nuclear Regulatory Research (RES) has a completed beta version of GALE12, a replacement for GALE86, and that some incremental work is needed to make it a releasable version with a documentation package and user's manual. The GALE12 code is being developed for large LWR designs and has similar limitations as GALE86 that make it inappropriate for use with SMR or iPWR designs. As a result, NRO is seeking the development of a separate version of the GALE12 code that would accommodate the review of SMR or iPWR designs. NRO requests that RES prioritize the completion of GALE12 and use this final version of the code as a template for the development of the iPWR-GALE code and supporting documents. NRO requests that this work be completed by the schedule and milestones described herein to support the review and evaluation of the new applications for SMRs.

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### 1. Technical Issue:

Under recent efforts, the electric power industry has begun the process of seeking licenses for new nuclear power plants. In addition to current license applications submitted for large power reactors, a new generation of smaller light-water cooled reactors with advanced designs and operating characteristics is being considered for construction. The new designs, in part, are based on the knowledge gained over the past 50 years of nuclear power generation. With the advent of new licensing efforts, NRO needs to have licensing and compliance tools relevant to new reactor technology, contemporary operating experience, and current scientific and engineering knowledge.

In licensing new power plants, NRO evaluates the radiological impacts from routine gaseous and liquid discharges and associated doses to members of the public. The requirements are contained in Appendix I to 10 CFR Part 50, 10 CFR 20.1301, and in 10 CFR Part 20, Appendix B, Table 2.

In the late 1970's, the NRC developed two sets of computer codes for assessing compliance with above noted regulatory requirements. Two documents, NUREG-0016 (BWR-GALE) and NUREG-0017 (PWR-GALE), provide the technical bases for the GALE codes, commonly referred as GALE86. Since then, the nuclear power industry has made technological advances in fuel cladding composition, manufacturing, and reactor coolant chemistry in maintaining fuel integrity and reducing radionuclide concentrations in primary and secondary coolant. GALE12 is intended to be an update of the GALE86 code and its documentation. This update of the code was conducted under a prior user need request in which NRO asked RES to update GALE86 code (ML101250608). As a result of this work, RES has issued a beta version of the GALE code, currently identified as GALE12. The beta version incorporates various updates and enhancements when compared to GALE86. Among other features, the GALE12 code operates in a Windows Graphical User Interface (GUI) environment, allows users to update any input parameters, provides more flexibility in modeling different types of liquid and gaseous effluent treatment systems, redresses some overly conservative results for releases associated with anticipated operational occurrences, and fixes a number of issues on data displays and result presentations. The results of GALE12 have also been benchmarked against releases of radioactive effluents reported by operating nuclear power plants.

### 2. Regulatory Application:

NRO will use the alternate version of the code (iPWR-GALE) to assist it in licensing new small modular reactors. The iPWR-GALE code will be the basic tools used to assess the applicant's program for compliance with offsite dose requirements of Appendix I 10 CFR Part 50, 10 CFR Part 20.1301, and liquid and gaseous effluent releases under Appendix B ECLs to 10 CFR Part 20. NRO will use the code to assess reactor design certifications, early site permits, and combined license applications submitted under 10 CFR Part 52, and construction permit and operating license applications under 10 CFR Part 50.

### 3. Deliverables:

NRO requests that RES prioritize the completion of GALE12 and use the final version of the code as a platform for the development of the iPWR-GALE code and supporting documentation

by the schedule and milestones noted below in order to support the review and evaluation of new applications for SMRs. The scope and deliverables of this effort should include the following tasks:

Task 1: Finalize the completion of the beta version of the GALE12 code.

- A. Finalize the completion of the beta version of the GALE12 code as a releasable version. The completion of the code should incorporate staff comments and recommendations generated during joint RES and NRO evaluations and testing of the beta version.
- B. Provide an updated documentation package, i.e., consolidation of NUREG-0016 and NUREG-0017 and RG 1.112, and a V&V package on the development and testing of the code.
- C. NRO will provide the results of its evaluation and testing of the code and review of the documentation package.

Task 2: Review design features of newly proposed small modular reactors and provide recommendations on how to incorporate these features into the iPWR-GALE code.

- A. Review and evaluate the design features of the mPower design (B&W), describe design features that need to be incorporated in GALE12, and provide recommendations on how to incorporate these features into the code once converted to iPWR-GALE. In support of this effort, RES should review and evaluate a PNNL report (May 2012) that provides an initial comparison and recommendations on specific modifications that should be made to GALE86. NRO will provide a copy of the PNNL report.
- B. Review and evaluate the design features of the WSMR (Westinghouse) design, describe design features that need to be incorporated in the code, and provide recommendations on how to incorporate these features in iPWR-GALE. NRO will provide information on the proposed design as made available to the staff by Westinghouse as pre-FSAR submissions.
- C. Review and evaluate the design features of the NuScale (NuScale Power) design, describe design features that need to be incorporated in the code, and provide recommendations on how to incorporate these features in iPWR-GALE. NRO will provide information on the proposed design as made available to the staff by NuScale as pre-FSAR submissions.
- D. Provide a progress report that summarizes the findings and recommendations noted in the completion of subtasks A – C above, describe any technical challenges, and outline a schedule, level of effort, and cost in effecting these changes in iPWR-GALE once converted from GALE12.
- E. For any of the above subtasks, NRO staff will review RES findings and recommendations and provide directions on how to proceed.

Task 3: Initiate the revision and conversion of GALE12 into the iPWR-GALE code for small modular reactors.

- A. Evaluate the basic mathematical algorithms, assumptions, and input parameters of iPWR-GALE, compare them to the plant design features of SMRs, and make changes to code subroutines and GUI in entering new parameters and selecting options in modeling different process and effluent stream treatment options and discharge paths to the environment. As part of the subtask, RES staff should identify all proposed revisions and provide recommendations on how to implement such changes in code algorithms, subroutines, assumptions and parameters, and GUI interfaces.
- B. Based on the results of the evaluation of subtask A, update and revise the mathematical algorithms, assumptions, and parameters, and modify the GUI in entering new parameters and selecting treatment options and discharge paths.
- C. Revise the GALE12 Windows-based PC computer code to reflect the appropriate updates and revisions in supporting the modeling of SMR designs in the iPWR-GALE code as a beta version.
- D. Incorporate in the iPWR-GALE code a sample problem with a set of default parameters that would be used to confirm the proper installation and initial operation of the code on a PC.
- E. Validate and verify the iPWR-GALE code and document V&V process.
- F. Update and revise the supporting NUREG document, accordingly.
- G. Release the iPWR-GALE code (as a beta version) and its documentation package for evaluation and testing by staff, industry, and members of the public.
- H. Provide a progress report that summarizes the work status and issues in the completion of subtasks A – G above, describe any technical challenges, and outline the progress in schedule, level of effort, and cost.
- I. For any of the above subtasks, NRO staff will review RES findings and recommendations and provide directions on how to proceed.

Task 4: Finalize the iPWR-GALE code and issue the releasable version and documentation.

- A. Compile and review recommendations provided by staff, industry, and members of the public on the beta version of the iPWR-GALE code. Prioritize recommendations in order of decreasing importance.
- B. Identify significant recommendations and describe process and implications in effecting key recommendations into the final version of the iPWR-GALE code.

- C. Provide an estimate of time and resources needed to implement key recommendations and revise the documentation package and default sample problem.
- D. NRO staff will review RES recommendations and provide directions on how to proceed, as needed in finalizing the code and its documentation.
- E. Finalize the iPWR-GALE code and issue the releasable version and documentation package and NUREG.
- F. Provide a progress report that summarizes the work status and issues in the completion of subtasks A – E above, describe any technical challenges, and outline the progress in schedule, level of effort, and cost.

#### 4. Schedule:

Work on the iPWR-GALE code should be assigned the highest priority and be completed with no delays in order for NRO to support its review and licensing of SMR applications. In matching the development of the iPWR-GALE code with the expected licensing milestones of NRO's review of design and COL applications and construction permits, the following events (as CY) are critical:

- 1) June – Nov. 2013 – RES and NRO evaluate the beta version of GALE12 code
- 2) Dec. 2013 - Expected completion date of GALE12 code and supporting documentation
- 3) Jan. 2014 – RES/Contractor initiate work on iPWR development via a new contract
- 4) Third Qtr 2014 – Expected first 10 CFR Part 52 SMR applications for design certification
- 5) Dec. 2014 – Dec. 2015 – NRO staff starts the review and evaluation applications
- 6) Dec. 2014 – RES/Contractor issue beta version of iPWR-GALE code and documentation
- 7) Jan.- Feb. 2015 – RES/NRO test beta version of iPWR-GALE code, review documentation, and issue comments
- 8) May 2015 – RES issues final version of iPWR-GALE code and documentation
- 9) June 2015 – NRO issues an ISG on the acceptability of the iPWR-GALE code in developing information in completing FSAR Chapter 11 of SMR applications
- 10) June 2015 – Cut-off date for NRO SER in confirming radioactive effluent source terms using the iPWR-GALE code
- 11) March 2017 - NRC issues first SMR design certification, based on a 30-month review cycle

In supporting NRO's anticipated schedule for the review of SMR applications, the following completion dates and interfaces are identified:

- 1) The work under Task 1 should be completed by December 2013 to support the initiation of Tasks 2 and 3 in January 2014.

- 2) The work under Task 2 should be conducted on a parallel effort along with Task 1 and completed by March 2014 in order to support the initiation of Task 3. The results of Task 2 will form the basis of how mathematical algorithms, assumptions, and input parameters will be incorporated in the iPWR-GALE code, given plant design features of SMRs.
- 3) The work under Task 3 should be completed by December 2014 since this effort will lead to the release of the beta version of the iPWR-GALE code. This milestone is critical in that NRO intends to use the beta version of the code to perform its second tier of reviews, issue RAIs, and draft the results of its initial findings in draft safety evaluation reports. Until the beta version of the iPWR-GALE code is available, NRO staff is expecting to use GALE12 and other tools in performing its initial review and evaluation of the information provided by applicants.
- 4) The work under Task 4 should be completed by May 2015 since the releasable version of the iPWR-GALE code will be used to validate interim results generated by other methods and finalize the preparation of safety evaluation reports in the last phases of the licensing schedule. The completion of Task 4 is critical since it documents that the staff's evaluation is complete and no further technical and regulatory issues remain open in determining the acceptability of liquid and gaseous effluent source terms, and confirming compliance with NRC regulations and guidance on radioactive effluent releases and associated doses to members of the public.

5. Priority:

NRO places a high priority on this request given that the iPWR-GALE code will be used to review the applications of design certifications and assess compliance with NRC regulations.

6. Points of Contact:

The NRO staff responsible for this request is Jean-Claude Dehmel, Senior Health Physicist, NRO/DSEA/RPAC. The RES staff responsible for this request is Ralph Cady, Senior Performance Assessment Analyst, RES/DRA/ETB, and Steven Schaffer, Senior Health Physicist, RES/DSA/RPB. NRO/DSEA will be responsible for resolving and providing comments on draft RES work products, computer code, and associated NUREG.

7. Additional Information:

NRO realizes that it is proposing an extremely aggressive schedule, and that RES may have some difficulties in supporting this effort given the uncertainty in the availability of resources due to budgetary constraints. NRO further notes that even if this schedule were met, the iPWR-GALE code and documentation package still would not be available in time to be incorporated into NRC guidance (NUREG-0800, Chapter 11 of SRP and DSRS and Regulatory Guide 1.206) before DCD and COL applications are formally docketed in late CY 2014. As an interim measure, NRO intends to issue an ISG on the acceptability of the iPWR-GALE code in developing information in completing FSAR Chapter 11 of SMR applications – see DC/COL-ISG-5 as an example on the use of GALE86. Until the iPWR-GALE code is available for use by staff and applicants, NRO staff is expecting to use GALE12 when performing their initial reviews

and evaluations. In order to compensate for the differences in GALE12 and design information presented in applications, the staff will use engineering judgment and other tools (spreadsheets) during these reviews in order draw preliminary conclusions on the applicant's approach and reasonableness of assumptions and results. NRO expects to be able to draw adequate findings and determination of reasonable assurance of safety when reviewing these applications based on staff experience and use of other tools, with results to be confirmed later using the iPWR-GALE code in the latter phases of the licensing process, but in time to support the completion of safety evaluation reports. Based on prior staff experience with the ACRS review process, the use of alternate or interim methods to assess the adequacy of the technical information and assertions of regulatory compliance presented in applications for new reactor designs is not expected to be acceptable given that the staff has had ample time to prepare itself and develop the necessary tools. Therefore, NRO requests that this work be assigned a high priority.

#### References:

1. NUREG-0016, "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Boiling Water Reactors (BWRs)."
2. NUREG-0017, "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Pressurized Water Reactors (PWRs)."
3. NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition."
4. Regulatory Guide 1.112, "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Light Water Cooled Power Reactors."
5. Regulatory Guide 1.206, "Regulatory Guide for Combined License Applications for Nuclear Power Plants."
6. Applicability of GALE86 Codes to Integral Pressurized Water Reactor Designs, PNNL, May 2012.
7. DC/COL-ISG-5, "GALE86 Code for Calculation of Routine Radioactive Releases in Gaseous and Liquid Effluents to Support Design Certification and Combined License Applications."

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3. NUREG-0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition.”
4. Regulatory Guide 1.112, “Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Light Water Cooled Power Reactors.”
5. Regulatory Guide 1.206, “Regulatory Guide for Combined License Applications for Nuclear Power Plants.”
6. Applicability of GALE86 Codes to Integral Pressurized Water Reactor Designs, PNNL, May 2012.
7. DC/COL-ISG-5, “GALE86 Code for Calculation of Routine Radioactive Releases in Gaseous and Liquid Effluents to Support Design Certification and Combined License Applications.”

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