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Division 1

DRAFT REGULATORY GUIDE

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DRAFT REGULATORY GUIDE DG-1198

(Proposed Revision 2 of Regulatory Guide 1.125, dated October 1978)

PHYSICAL MODELS FOR DESIGN AND OPERATION OF HYDRAULIC STRUCTURES AND SYSTEMS FOR NUCLEAR POWER PLANTS

A. INTRODUCTION

This guide describes the detail and documentation of data and studies that an applicant should include in the preliminary and/or final safety analysis report (PSAR/FSAR) to support the use of physical hydraulic model testing for predicting the performance of hydraulic structures and systems for nuclear power plants. Hydraulic structures are defined as anything that can be used to divert, restrict, stop, or otherwise manage the natural flow of water. The regulatory position of this guide is applicable only to physical models used to predict the action or interaction of surface waters with features located outside the containment. The recommendations of this guide do not apply to internal plant systems or structures.

Title 10, Paragraph 50.34(a)(3)(ii), of the *Code of Federal Regulations* (10 CFR 50.34(a)(3)(ii))[1] requires that the PSAR include information on the design bases of the facility and the relation of the design bases to the principal design criteria. In part, 10 CFR 50.34(a)(4) requires a preliminary analysis of the adequacy of structures, systems, and components provided for the prevention of accidents and the mitigation of the consequences of accidents. Additionally, 10 CFR 52.47(a) and 10CFR 52.79 describe the required technical content of the final safety analysis report (FSAR) that must accompany applications for early site permits, standard design certifications, and combined licenses for nuclear power plants.

[1] All NRC regulations listed herein are available electronically through the Electronic Reading Room on the NRC's public Web site, at http://www.nrc.gov/reading rm/doc collections/cfr/. Copies are also available for inspection or copying for a fee from the NRC's Public Document Room (PDR) at 11555 Rockville Pike, Rockville, MD; the mailing address is USNRC PDR, Washington, DC 20555; telephone (301) 415-4737 or (800) 397-4209; fax (301) 415 3548; and email PDR@nrc.gov.

The NRC issues regulatory guides to describe to the public methods that the staff considers acceptable for use in implementing specific parts of the agency's regulations, to explain techniques that the staff uses in evaluating specific problems or postulated accidents, and to provide guidance to applicants. Regulatory guides are not substitutes for regulations and compliance with them is not required.

This regulatory guide contains information collection requirements covered by 10 CFR Parts 50 and 52 that the Office of Management and Budget (OMB) approved under OMB control numbers 3150-0011 and 3150-0151 respectively. The NRC may neither conduct nor sponsor, and a person is not required to respond to, an information collection request or requirement unless the requesting document displays a currently valid OMB control number.

B. DISCUSSION

Physical hydraulic models are often used to predict prototype performance in designing and rehabilitating hydraulic structures. The physical modeling studies ultimately increase the safety of the hydraulic structures by identifying and eliminating potential problems, thus reducing construction and maintenance costs. They are particularly useful where hydraulic structures and systems are of unusual design or configuration and hydraulic parameters cannot be adequately evaluated by state-of-the-art analytical or computational methods. Furthermore, physical models will incorporate the appropriate governing equations without the simplifying assumptions that are often necessary in analytical or numerical models. Physical hydraulic models may also be used to establish conservative and reasonable design or operating bases for sites, structures, or systems involving thermal and erosional problems.

Examples of types of physical modeling studies of hydraulic structures and systems for nuclear power plants include, but are not confined to, the following:

- intake structures and pump designs,
- discharge structures,
- energy and wave dissipation structures,
- spillway and tailwater ratings for dams (water level and discharge relations),
- release of water resulting from dam failures,
- wave propagation and runup on a coastal structure, including tsunami effects,
- stability of structure when exposed to waves and protection from waves,
- erosion and deposition in streams and other water bodies and protection from these processes,
- flow patterns and dispersion and dissipation of heated or contaminated effluents in receiving water bodies,
- heat dissipation in receiving water bodies,
- response of moored floating bodies to incident wave systems, and
- response of harbors to waves.

The applicant should incorporate the information described in the regulatory position in the PSAR/FSAR as required. However, the staff recognizes that it will not always be possible to incorporate such information in the initial application for a reactor license, since studies of this type may not be undertaken until after the safety analysis report is submitted. Such information may be added to the PSAR/FSAR, either by reference to separate reports or by insertion into the PSAR/FSAR.

C. REGULATORY POSITION

Because not all hydraulic design problems can be resolved by the mechanics of similitude and because there are limitations to hydraulic modeling, the applicant should supply the NRC staff with certain documentation for any structural, thermal, erosional, or other physical hydraulic models that it used to establish design or operating bases. The regulatory position contained in this guide applies only to physical models used to predict the action or interaction of surface waters with hydraulic features located outside the containment.

Generally, Regulatory Positions 1 and 2 describe information that should be furnished before the building and testing of the physical model, and Regulatory Positions 3 through 5 describe information needed after testing has been completed. It is desirable for the applicant to solicit staff reviews and recommendations before model construction and following or coincident with the submittal of the information listed in Regulatory Position 1, as well as to invite appropriate members of the NRC staff to be present periodically during model testing to observe the performance of the model. In addition, the applicant should provide partial test results for staff review and acceptance during the course of testing to allow for the consideration of those parameters that partial data collection shows to be important.

1. Regulatory Position 1

Before constructing the physical model, the applicant should submit a test plan that includes the following information:

- the problem(s) to be resolved;
- reasons for selecting the physical hydraulic model chosen to resolve the problem(s);
- expected results and how these results will solve the stated problem(s);
- a detailed description of the model, including a description of materials, instrumentation, and methods used to measure parameters, including resolution and error of instrumentation, scale relations, and other physical characteristics of the model;
- a detailed description of the testing facilities;
- methods that will be used to analyze the data obtained from the model studies; and
- a schedule of expected tests, including proposed start and completion dates, and estimated dates for submitting information for NRC staff review.

2. Regulatory Position 2

In addition, the applicant should furnish documentation describing how it considered the various conditions of geometric, kinematic, dynamic, and thermodynamic similitude that take into account the physical properties and flow state of the fluid (i.e., Froude, Reynolds, Euler, Cauchy, Weber, and other related numbers). Because certain forces may act differently in a model than in a prototype, the documentation provided should justify the neglect of any forces by showing that these forces (1) are of negligible magnitude, (2) compensate for other neglected forces in such a manner that the effects of both forces are negligible, or (3) are such that their neglect leads to conservative model results and the establishment of conservative design or operating bases.

The applicant should document the methods used to satisfy the equations of similitude in the model and the effects of scale distortions on data obtained from the model studies. Where applicable, the document should describe model adjustment and verification procedures and furnish information on the validity of the model over a range of likely flow conditions, heat regimes, atmospheric conditions, and

other physical parameters. The document should demonstrate, where applicable, that the model will simulate known flow conditions and provide this verification when measured historical data are available.

3. Regulatory Position 3

Where full-scale structures or systems having characteristics similar to those being modeled exist and information about the observed or measured performance of the existing structures or systems is available, the applicant should compare the physical model results with the available information. If testing is or has been performed on existing full-scale structures or systems, the applicant should describe such tests and their results. The document should address the applicability of such tests to the problem in question and discuss any conclusions derived from the tests. If using the results of other model tests, the applicant should justify the use of these results and verify and document the ability of these other models to reproduce or predict prototype performance.

The applicant should provide detailed documentation of data obtained from existing full-scale structures and systems, including:

- instrumentation used;
- description of the data collection network;
- frequency of collection;
- methods of collection; and
- physical parameters existing at the time of collection, such as heat regimes, flow conditions, and atmospheric conditions.

4. Regulatory Position 4

The applicant should discuss any changes to the original design of the prototypes that result from the model test, documenting the designs that were modeled and the basis for modifying the design. The discussion should address any undesirable flow characteristics or failure modes for the design tested, as well as any other relevant problems.

5. Regulatory Position 5

The report covering the completed model tests should provide the data obtained from the tests, as well as the (1) instrumentation used, (2) description of the data collection network, (3) frequency of collection, and (4) method of collection. Figures, drawings, photographs, and text submitted as documentation for Regulatory Positions 2, 3, and 4 should be sufficiently detailed to allow the staff to evaluate independently the applicability of the model to the design problem in question. This report will provide the basis for the interpretation of model results and for any conclusions reached. The applicant should not dismantle the models until the staff has reviewed the submittals. Preserving the model for a maximum of 1 year after the submission of the model documentation to the NRC will be acceptable in most cases.

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants and licensees regarding the NRC's plans for using this draft regulatory guide. The NRC does not intend or approve any imposition or backfit in connection with its issuance.

The NRC has issued this draft guide to encourage public participation in its development. The NRC will consider all public comments received in development of the final guidance document. In some cases, applicants or licensees may propose an alternative or use a previously established acceptable alternative method for complying with specified portions of the NRC's regulations. Otherwise, the methods described in this guide will be used in evaluating compliance with the applicable regulations for license applications, license amendment applications, and amendment requests.

REGULATORY ANALYSIS

1. Statement of the Problem

The NRC published Revision 1 of Regulatory Guide 1.125 in October 1978. The regulatory guide describes the details and documentation an applicant should include with its PSAR to support the use of physical hydraulic model testing for predicting the performance of safety-related hydraulic structures and systems for nuclear power plants.

The methods of measuring, reporting, and evaluating the results of physical modeling have evolved and improved over the past 30 years. Revision 1 of Regulatory Guide 1.125 does not fully reflect current staff positions that have changed, based on the lessons learned and the operating experience gained since it was published. New guidance is needed to inform the licensees of current staff-approved detail and documentation of data and studies that an applicant should include in the PSAR or FSAR, as required, to support the use of physical hydraulic model testing for predicting the performance of hydraulic structures and systems for nuclear power plants.

2. Objective

The objective of this regulatory action is to provide the licensees and applicants with current guidance on the detail and documentation of data and studies that should be included with the PSAR or FSAR, as required, to support the use of physical hydraulic model testing for predicting the performance of hydraulic structures and systems for nuclear power plants.

3. Alternative Approaches

The NRC staff considered the following alternative approaches:

- Do not revise Regulatory Guide 1.125.
- Update Regulatory Guide 1.125.

3.1 Alternative 1: Do Not Revise Regulatory Guide 1.125

Under this alternative, the NRC would not revise this guidance, and the original version of this regulatory guide would continue to be the available guidance. This alternative is considered the baseline or "no action" alternative and, as such, involves no value/impact considerations. However, this alternative would not address inefficiencies in preparing and reviewing applications.

3.2 Alternative 2: Update the Regulatory Guide 1.125

Under this alternative, the NRC would update Regulatory Guide 1.125, taking into consideration the current risk-informed, performance-based approach to licensing and improved modeling methods and state-of-the-art analytical and computational methods.

One benefit of this action is that it would enhance the safety of the hydraulic structures by identifying and eliminating potential problems, thus reducing construction and maintenance costs. Implementation of the revised guidance in this proposed draft regulatory guide is useful where hydraulic structures and systems are of unusual design or configuration and hydraulic parameters cannot be adequately evaluated by state-of-the-art analytical or computational methods. In addition, physical models can incorporate the appropriate governing equations without the simplifying assumptions that are often necessary in analytical or numerical models. Physical hydraulic models may also be used to establish conservative and reasonable design or operating bases for sites, structures, or systems involving thermal and erosional problems.

The cost to the NRC would be the one-time cost of issuing the revised regulatory guide (which is expected to be relatively small), and applicants would incur little or no cost.

4. Conclusion

Based on this regulatory analysis, the staff recommends that the NRC revise Regulatory Guide 1.125. The staff concludes that the proposed action will enhance the safety of hydraulic structures through improved design review and verification. It could also lead to cost savings for the industry, especially with regard to applications for standard plant design certifications and combined licenses.