U.S. NUCLEAR REGULATORY COMMISSION

March 1977

REGULATORY GUIDE

OFFICE OF STANDARDS DEVELOPMENT

REGULATORY GUIDE 1.125

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

A. INTRODUCTION

Paragraph (a) (3) (ii) of §50.34, "Contents of Applications; Technical Information," of 10 CFR Part 50, "Licensing of Production and Utilization Facilities," requires that the Preliminary Safety Analysis Report (PSAR) include information on the design bases of the facility and the relation of the design bases to the principal design criteria. Paragraph (a) (4) of §50.34 requires, in part, 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.

This guide describes the desired coordination of an applicant with the NRC staff and the detail and documentation of data and studies that an applicant should include in the PSAR to support the use of physical hydraulic model testing for predicting performance of hydraulic structures and systems for nuclear power plants. 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 of containment. The recommendations of this guide are not applicable to internal plant systems or structures.

B. DISCUSSION

Physical hydraulic models are often used to predict prototype performance. 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 methods. 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 include, but are not confined to, the following:

1. Intake structures.
2. Discharge structures.
3. Energy dissipation structures.
4. Spillway and tailwater ratings for dams (water-level discharge relations).
5. Release of water resulting from dam failures.
6. Wave runup, including tsunami effects.
7. Erosion from waves and protection therefrom.
8. Erosion and deposition in streams and other water bodies and protection therefrom.
9. Flow patterns and dispersion of heated or contaminated effluents in receiving water bodies.
10. Heat dissipation in receiving water bodies.

It has been the experience of the NRC staff that some applicants have not furnished sufficiently detailed information on physical hydraulic model studies for the staff to perform an adequate review. In some instances, staff involvement in the early planning of a model study would have resulted in savings of both NRC and applicant funds and time in the review and acceptance of the results.

Accordingly, the regulatory position details the documentation that should be furnished and the type of coordination between the staff and the applicant that should minimize the time necessary for acceptance of the results of model studies.

The information described in the regulatory position should be incorporated in the PSAR. However, the staff recognizes that it will not always be possible to incorporate such information in the initial application for a construction permit since studies of this type may not be undertaken until after the PSAR is submitted. Such information may, therefore, be added to the PSAR by amendment, either by reference to separate reports or by insertion into the PSAR.

C. REGULATORY POSITION

Because all hydraulic design problems cannot be resolved by the mechanics of similitude and because there are limitations to hydraulic modeling, the NRC staff should be furnished with certain documentation for any structural, thermal, erosional, or other physical hydraulic models used by the applicant 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 features located outside of containment.

Generally, regulatory positions 1 and 3 describe information that should be furnished prior to actual model testing, and regulatory positions 4 through 6 describe information needed after testing is completed. Additionally, partial test results should be provided for staff review and acceptance during the course of testing to ensure reconsideration of parameters whose importance becomes apparent on the basis of partial data collection. After completing the entire study, all the information should be consolidated either (1) as a separate report with appropriate reference added in the PSAR or (2) for insertion into the PSAR.

1. Prior to construction of the model, the applicant should submit information outlining (a) the problem to be resolved, (b) reasons for selecting the hydraulic model chosen to resolve the problem, (c) expected results to be obtained, (d) a detailed description of the model, including a description of materials, methods used to measure parameters, scale relations, and other physical characteristics of the model, (e) methods that will be used to analyze the data obtained from the model studies, and (f) a schedule of expected tests, proposed completion dates, and estimated dates for submittal of information for NRC staff review.

2. Staff views and recommendations should be solicited prior to model construction and following or coincident with the submittal of the information listed in regulatory position 1, and arrangements should also be made for appropriate members of the staff to be present periodically during model operation to observe the actual performance of the model.

3. Documentation should be furnished on how 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) have been considered. Because certain forces may act differently in a model than in a prototype, documentation should be provided to justify the neglect of any forces by showing that these forces (a) are of negligible magnitude, (b) compensate for other neglected forces in such a manner that the effects of both are negligible, or (c) are such that their neglect leads to conservative model results and establishment of conservative design or operating bases.

Documentation should be furnished on the methods used to satisfy the equations of similitude in the model. The effects of scale distortions on data obtained from the model studies should be documented. Where applicable, model adjustment and verification procedures should be described, and information should be furnished on the validity of the model over a range of likely flow conditions, heat regimes, atmospheric conditions, and other physical parameters. Where applicable, it should be demonstrated that the model will simulate known flow conditions; this verification should be provided when historical data are available.

4. Where full-scale structures or systems having characteristics similar to those being modeled exist and information relative to the observed or measured performance of the existing structures or systems is available, the physical model results should be compared with the available information generated by the existing structures. Testing performed on existing full-scale structures or systems and the results of these tests should be described. The applicability of such tests to the problem in question should be documented, and any conclusions derived from the tests should be discussed. If the results of other model tests are used by the applicant, justification for the use of these results and verification of the ability of these other models to reproduce or predict prototype performance should also be provided.

Detailed documentation of data obtained from existing full-scale structures and systems should be provided, including (a) instrumentation used, (b) description of the data collection network, (c) frequency of collection, (d) methods of collection, and (e) physical parameters existing at the time of collection, such as heat regimes, flow conditions, and atmospheric conditions.

5. Any changes to the original design of the prototypes as a result of the model test should be discussed. The designs that were modeled and the basis for modifying the design should be documented. Undesirable flow characteristics or failure modes for the design tested, as well as any other problems, should be discussed.

6. Figures, drawings, photographs, and text submitted as documentation for regulatory positions 3, 4, and 5 should be provided in sufficient detail to allow the staff to evaluate independently the applicability of the model to the design problem in question. (A typical model investigation report as published by the U.S. Army Waterways Experiment Station has been found acceptable in the past.) Bases

for the interpretation of model results and for any conclusions reached should be provided. In many instances, it may be advisable to provide partial test results for review. The models should not be dismantled until the staff has reviewed the submittals.

D. IMPLEMENTATION

The purpose of this section is to provide information to license applicants regarding the NRC staff's plans for implementing this regulatory guide.

Except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method described herein will be used in the evaluation of submittals for construction permit applications docketed after November 1, 1977. If an applicant wishes to use this regulatory guide in developing submittals for construction permit applications docketed on or before November 1, 1977, the pertinent portions of the application will be evaluated on the basis of this guide.