Comments on

INTERIM REPORT

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Contract Program or Project Title: Comments on preliminary "Final Report on Model Testing of Containment Sump Recirculation Intakes for Joseph M. Farley"

Subject of this Document: Contract letter containing consultants' comments relative to containment sump recirculation tests performed for Farley Units 1 and 2 (Docket Nos. 50-348 & 50=364)

Type of Document: Contract Letter

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Responsible NRC Individual and NRC Office or Division: J. J. Watt, NRR/DSS

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NRC Research and Technical Assistance Report

NRC Contract Number: NRC-03-078-130

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Review of Western Canada Hydraulic Laboratories' "Final Report on Model Testing of Containment Sump Recirculation Intakes for Joseph M. Farley Nuclear Plant - Units No. 1 and 2"
(Subject of Letter)

December 18, 1978
(Date of Letter)

University of Iowa, Institute of Hydraulic Research
(Name of Consultant)

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Watt

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18 December 1978

Mr. James Watt
U.S. Nuclear Regulatory Commission
Washington D.C. 20555

Re: Contract No. NRC-03-078-130

Dear Mr. Watt:

We have completed our review of "Final Report on Model Testing of Containment Sump Recirculation Intakes for Joseph M. Farley Nuclear Plant - Units No. 1 and 2", prepared by Western Canada Hydraulic Laboratories (WCHL). Although this report is marked "PRELIMINARY", we feel that we can formulate our opinions on Farley Nuclear Plant No. 2 (FARLEY 2) since we have visited the plant with you, and during our visit to WCHL, observed a series of demonstrations of the type of laboratory tests involved. We would like, however, to postpone making final recommendations until a copy of the FINAL REPORT, which is not subject to any restrictive classification, is obtained.

We believe, that it is unfortunate that delays have developed in this project, and that our opinions, which were in advanced state of definition in May 1978, must be formulated in December 1978, and that they cannot yet be accompanied by our recommendations. But it appears that formulating the opinions at this moment is a contribution we can make to the needs of NRC in relation to our contractural relationship.

OPINION 1

The model studies for FARLEY 1 and 2 were carried out at a geometric scale of 1:1. Since temperatures could not be reproduced in the model in the ratio 1:1 (the maximum temperature in the prototype is 212°F; in the model only 180°F could be obtained), exact dynamic and kinematic similitude were not attained. Of course, departures from exact similitude were small compared with the ones that would have resulted at other geometric scales (see Table 1 of REPORT). In the model studies, conservatism was generally practiced by testing for larger flow rates and for water levels lower than the normal ones. Also, the expected circulation was increased in the model to establish a margin of safety. Although the report does not include photographs of flow-visualization tests, videotapes were provided by WCHL containing such visualizations, and during the visit to WCHL a number of flows were observed. All this has led us to the opinion that the choice of geometric scale of 1:1 plus the flow distortions is justified, and should provide more reliable information than tests with geometric scales smaller than unity, or combinations of other scales and distortions.

OPINION 2

The model study for FARLEY 2 did not include an investigation of the far field. From an examination of flows recorded on video tapes for FARLEY 1, it appears that the flow in the case of FARLEY 1 was quite free from any important vortex formation. In the model for FARLEY 1, the detailed geometry in the neighborhood of the sumps was reproduced rather faithfully, down to any structural elements larger than two inches in diameter. From an examination of the drawings for the two plants (FARLEY 1 and 2) it is apparent that the far field lay-out for FARLEY 2 is simpler than that of FARLEY 1 (the elevator shaft was removed and Intakes 2 and 3 were separated in Unit 2), and one should expect a less disturbed flow in this case. More important, however, is the fact that velocities in the far field are lower in FARLEY 2 than in FARLEY 1. In our opinion, this makes acceptable the claim of WCHL that there was no need to repeat a study of the far field for FARLEY 2, because no dangerous vortices formed in the 1:1-scale model of FARLEY 1. It should be clear, however, that without this parallel between FARLEY 1 and FARLEY 2, a study without due consideration of the far field flow would be unacceptable. The model results for FARLEY 1 also influenced the approach and methodology used in FARLEY 2 in regard to determining the boundaries for the model. Once the need for outer and inner grating cages was recognized for FARLEY 1, it appears logical to proceed on a similar basis for FARLEY 2. The selection of a single, 14-in. diameter intake in the test program also appears to be justified due to the fact that the 14-in. intakes take larger flows (5,900 gpm) than the 10-in. intakes (3,050 gpm), and the tests of Unit 1 demonstrated that the 14-in. intakes can produce slightly higher intake loss coefficients than the 10-in. intakes.

OPINION 3

The model for FARLEY 1 demonstrated that a flow with few upstream disturbances could develop serious circulations and vortices inside the outer cage if the different possibilities of blockage were tested. It appeared that the outer cage would take care of those circulations approaching the cage from the outside, but obviously would become ineffective in suppressing inside circulations originating in the flow after the fluid had passed the grating. It is our opinion that in the specific case of FARLEY 2, the boundaries of the model were properly determined because blockage of the outer cage outweighed by far the possible effects of generated vortices in the far field.

OPINION 4

Testing of vortex suppressors by subjecting them to a generalized flow field should be done with extreme care. Although it is true that any cascade of plates or foils will induce a change in direction of an oncoming flow (as was initially shown both theoretically and analytically by Betz, and after him by others), one should not assume the change

of direction to be entirely in the direction of the guiding plates, unless a certain aspect ratio is exceeded. Such an aspect ratio is still an unknown function of the different parameters involved, especially for gratings of different types. Tests are therefore absolutely necessary at the present time for any new vortex suppressor in a new situation. Tests at a scale of 1:1, and with increased discharges and circulations, surely provide conservative conclusions about the performance of gratings to be used in vortex-suppressing devices, both from the points of view of determining their head-loss coefficients, and of estimating their effectiveness in suppressing or abating circulation. Therefore, our opinion is that the vortex suppressors were properly tested.

OPINION 5

The outer grating-screen cage and the inner grating cage tested for BARLEY 2 appear to be very effective in suppressing air entraining vortices. However, internal vortices were seen to develop (either in video tape or in the laboratory) when smooth walls were present. In the laboratory tests, the internal vortices became visible because they picked up dirt from the walls, and also because vapor, gas, or other tracers made them evident. When grating was placed over the vortex smooth wall over which the vortex had attached itself, the vortex was obviously abated, if not destroyed. This can be explained in terms of the Bodewadt boundary layer which feeds organized near-wall vorticity into the core of the circulation maintained by the incoming flow. When the grating is applied, the boundary layer is disrupted, and the vortex may break down because turbulent lumps of fluid may now be fed into the core. Whatever the actual mechanism may be, the fact is that lining smooth walls with grating surely abates the vortex formation, as demonstrated by some of the tests in WCHL. The model tests conducted at a scale of 1:1, to investigate the effectiveness of the outer and inner grating cages in suppressing vortices, appear to indicate that no air-entraining vortices would form in the prototype. However, internal vortices may form in the space between the two cages. From the results of the tests, as reported in the "Preliminary" Final Report, it appears that such internal vortices would not produce serious disturbances. In our opinion, however, it is necessary to require additional measures which would tend to eliminate those internal vortices. This could be accomplished by lining any smooth walls existing in the space between the cages with the same kind of grating used in the cages. A short clearance between wall and lining is acceptable, in our opinion.

OPINION 6

The reported values of the head losses observed in the model study are lower than those predicted by WCHL. Since the model was at a geometric scale of 1:1 and was run with increased discharges, there appears to be incontrovertible experimental proof that the losses will in fact be less than those estimated analytically by WCHL.

If there is any question, or clarification that you wish, we remain ready to expand on any of the opinions, and to provide details of our reasoning and our calculations to verify data contained in the WCHL report on the model study.

Sincerely yours,

Enzo O. Macagno

Enzo O. Macagno
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