Consumers Power Company

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US Nuclear Regulatory Commission
Att Mr Albert Schwencer
Office of Nuclear Reactor Regulation
Washington, DC 20555

MIDLAND PROJECT
DOCKET NO 50-329, 50-330
CONTAINMENT SUMP MODEL TESTING
FILE: M-382/942.9 UFI: 10801 SERIAL: 9069

Enclosed are five (5) copies of the report "Model Testing of Containment Sump ECCS Recirculation Intakes" prepared for the Midland Plant. This transmittal satisfies Consumers Power Company commitments made in the Midland FSAR and will be referenced in that document accordingly.

In addition, attached to each copy of the report are comments on the NRC trip report "Summary of Trip to Observe Midland Sump Tests," dated September 17, 1979. The purpose of these comments is to clarify discussions held between the parties witnessing the tests and to correct erroneous statements in its content.

Consumers Power Company

By *James W. Cook*
James W Cook, Vice President
Midland Project

Dated: June 26, 1980

Sworn and subscribed to before me on this 26th day of June, 1980.

Betty L. Bishop
Notary Public, Jackson County, Michigan
My commission expires September 21, 1982

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Comments in Response to the NRC's "Summary of Trip to Observe Midland Sump Tests"

The following material presents comments on the concerns expressed by the Nuclear Regulatory Commission (NRC) on the Midland sump model demonstration performed at the WCHL facilities on August 2, 1979. The responses are a result of input by Western Canada Hydraulic Laboratories Ltd. and Bechtel, and address NRC concerns in the order in which they appear in the NRC document.

Page 1, Paragraph 5

> The sump pit has two outlet pipes, one for each train. A solid plate divides the sump and only one side is modelled. Flow interactions between outlets can not be evaluated.

The paragraph implies that the approach flow pattern to a single sump in operation would be modified when the second sump is put into operation. This indeed would happen, particularly in the approach flow area in the immediate vicinity of the sump partition. There would be one approach flow pattern with a single train in operation and another for two train operation. To put this in perspective, there are an infinite number of flow patterns that can occur following a LOCA depending on the location of the pipe break, the quantity of water delivered to each opening in the secondary shield wall, and the blockage conditions which may occur in the containment area.

The question of a change in flow pattern due to pump "interaction," therefore, falls into the category of questions related to the modeling of the "far field" which is discussed in response to the following paragraph.

Page 1, Paragraph 6

> The sump is enclosed in a room like area. The outer screen cage is about three feet from walls on two sides. The clearance is variable but generally greater on the other two sides. There are five passages leading to the sump area. There is no simulation of approach flow or obstruction outside of the outer screen-cage in the test program.

The Midland test program is the fourth such series of tests which have not modeled the containment area in the vicinity of the sumps. The decision to not model the external field was made after previous studies had shown it was not necessary. In support of those observations, auxiliary flume tests in previous studies were conducted from which a similar conclusion was reached. A rational approach to the test program was then adopted to test for vortex potential and sufficient margin in npsh under the most adverse conditions.

The conditions which produce vortices and large intake losses are non-uniform flow and strong circulations in the vicinity of the intake. The key to the issue at hand, therefore, is what factors effect the flow conditions near the intakes, that is, within the boundaries defined by the sump walls and the screen-cage. Since the flow all enters through the screen-cage, the answer to the question lies in close scrutiny of the entering flow and of obstructions within the sump. Tests performed on model sumps from Davis Besse and Farley Unit 1, where the containment was modeled, indicated that no matter what the flow conditions were in the far field, the flow entered the sump area through the screen cage at right angles to the plane of the screen cage. No vortices or swirling flow penetrated the screen cage which was acting as a flow straightener. Thus, the directionality of the flow into the sump area enclosed by the screen cage is independent of conditions in the far field.

Further investigations of the flow straightening ability of the screen cage were undertaken during the San Onofre test program. Two types of tests were performed in a flume:

a) The grating of the screen cage was tested for flow straightening properties when the approach flow direction was 30 to 60 degrees to the plane of the grating. Velocities were equal to or greater than prototype velocities.

b) Vortices were artificially produced and observations were made to see if they could pass through the grating.

The conclusions were:

a) Flow exited at right angles to the plane of the grating and the direction of the exiting flow was retained for an appreciable distance downstream, even when attempts were made to influence the flow to the contrary.

b) No eddy or vortex penetrated the grating.

Since Midland's grating was the same as that used in the San Onofre tests, these test results are applicable to Midland also.

Having demonstrated that the direction of the flow in the vicinity of the intake is independent of the far field flow, the only remaining variable is the distribution of velocity passing through the screen cage. Modeling the containment area with no blockage will give a single velocity distribution. Flow conditions generated in this fashion are not unique and do not create the most adverse flow within the sump. Other, more serious conditions can be created following a LOCA depending on the location of the break, conditions within the containment, and blockage of the screen cage. An infinite number of velocity distributions are possible; therefore, the test program was devised to have the following goals:

a) Recognizing that time and economic considerations constrained the test program to be finite in extent, test those velocity distributions which experience indicates will lead to the most adverse flow conditions in the vicinity of the intake relative to vortex potential and high intake losses.

b) Rationally choose blockage conditions which produce velocity distributions of an adverse nature and which can be hypothesized as realistic with respect to simulating blockage produced by positively buoyant, neutrally buoyant, and negatively buoyant material. Consideration was given to containment flow paths to identify areas of the screen-cage most likely to be affected.

c) Perform extensive tests to determine the bounds on experimental error.

The goals of this test program were pursued in an extensive series of tests. The test results indicated that the Midland ECCS intake will not be subject to degrading effects on pump performance such as high intake loss and/or vortex action which can lead to air ingestion.

To summarize:

a) High intake losses and vortices are caused by adverse flow in the vicinity of the intake, within the screen cage.

b) The screen cage behaves like a flow straightener such that the flow entering in the proximity of the intake is normal to the plane of the screen grating.

c) There is an infinite number of ways the flow velocity can be distributed on the screen cage of which the flow produced by modeling the containment area without blockage is only one single example.

d) For this reason the screen cage was chosen as the model boundary and velocity distributions deemed most adverse with respect to vortex formation were imposed.

e) The Midland intake performed its intended task without any vortices and with losses well within design values in all cases.

Documentation of evidence referred to in this section can be found in the final ECCS test reports on Davis Besse, Farley Units 1 and 2, Arkansas Nuclear One, and San Onofre Nuclear Plants.

Page 2, Paragraph 1

> Only the minimum water level is to be tested. During other sump tests followed by NRC, initial vortex formations have occurred at other than the minimum water level.

Experimental evidence has conclusively shown that for a given circulation, the lowest water level is the most adverse condition with respect to incipient vortex formation. For incipient vortex formation to be more adverse at higher water levels, the circulation in the vicinity of the intake must change with water level. For this to happen, there must be a drastic change in containment plan form in the water level range expected. This feature is absent in the Midland Plant, thus the minimum water level is the most adverse.

Page 2, Paragraph 4

> When necessary, they have modified the inner cage until adequate suppression of adverse conditions is achieved.

The Midland and other grating cages were designed prior to commencement of testing, using sound engineering principles, and those designs were not modified during testing.

Page 2, Paragraph 5

> There are diverse opinions as to the validity of the above approach.

To date, no studies or opinions by independent testing laboratories including the Iowa Hydraulic Institute or other qualified hydraulic testing engineers have been published which disaffirm the approach used for the Midland tests.

Page 2, Paragraph 5

> In licensing plants having tests similar to that proposed for Midland, the staff has found other bases (usually conservative design criteria) to compliment the test results.

No documentation exists of conservative design criteria being required to supplement the full-scale tests performed in previous studies before licenses were granted. This information should be in the public domain, and yet a literature search has disclosed no such information.

Page 3, Paragraph 3

> Those in attendance had learned no more about the B&W concern for core blockage by particles .080 inch or larger. This is being pursued by the applicant. The NRC desires to know what is unique about the B&W core and how it is different from other pressurized water reactors with respect to blockage.

The characteristics of the B&W core affects sump design since the sump screens must be sized to meet B&W design interface criteria. However, core characteristics have no relevance with respect to the testing program of the containment sump model and, therefore, will not be addressed relative to the sump tests. The sump tests have successfully shown the screens to be of sound hydraulic design.

In addition, the applicant is not currently pursuing investigation of B&W core blockage criteria, but rather, implementing a design which is consistent with such criteria as provided by B&W.

Page 3, Paragraph 5

> The NRC had expressed concern that screen blockage could not be simulated by blockage of the outer surface of the trash racks. The outer screen cage was described as consisting of vertical modules with no flow possible horizontally from one module to the next. Therefore, to the extent that such module is totally blocked on the outer surface, an equivalent area of screen would be blocked. Screen blockage by a combination of floating and sinking debris can not be simulated, however, unless the screens are blocked directly.

The construction of the Midland screen grating is shown in Figure 1. The fine screen blockage was simulated by placing sheet metal, 1/8 inch thick, in front of the 2-1/4 inch grating. As suggested in the above statement in Page 3, Paragraph 5, if an entire module of trash rack is blocked, then there is no question about the simulation of fine screen blockage. If only a portion of a module is blocked, then the 2-1/4 inch grating sees a velocity profile shown schematically in Figure 1. The velocity profile broadens in the region between the blockage plate and the fine screen due to the action of viscosity.[1] The extent of the affected zone δ can be estimated from boundary layer theory as:

$$\frac{\delta}{x} = 5.0(Ux/\nu)^{1/2}$$

where U and x are defined in Figure 1 and ν is the kinematic viscosity of water. Assuming 50% blockage, the affected zone is approximately 0.17 inch in extent. Compared with the overall vertical open area dimension of 42 inches, the error in simulating fine screen blockage by panels outside the 2-1/4 inch grating is insignificant.

Page 4, Paragraph 2

> The above conditions were repeated with the inner cage installed. No air entraining vortices connected to the outlet pipe from the free surface. No significant vortices formed from the floor.

The laboratories' record of that test notes some swirl as evidenced by the motion of small particulates suspended in the water. There was no observation of any hydrodynamic flow structure which could be construed as a vortex, as implied by "significant vortices" in the above statement.

Page 4, Paragraph 5

> Vortices forming outside the outer screen cage did entrain floating debris and deposit it on the outer surface of the screens and trash racks.
>
> It could be expected that once such a process started all floating debris would be drawn to

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1) See, for instance, Schlicting, Boundary Layer Theory, 6th Edition, McGraw-Hill, 1968.

these surfaces until the safety pumps failed. (The propensity for vortex formation increases with increasing sink velocity or screen through velocity in this case).

The NRC observer would expect that debris entraining vortices in the plant during post-LOCA conditions would be more severe than those demonstrated, the tests were performed at reduced temperature and without simulation of approach conditions.

The statement that the safety pumps would eventually fail due to entrainment of surface debris is pure conjecture. Such an eventuality would depend on the amount of debris available, the nature of the debris, flow conditions in the containment area, and the blockage condition leading to surface entrainment. It is not accepted that such an occurrence is inevitable.

The severity of vortices is a function of circulation, Reynolds numbers, and the geometry of the flow. The effect of water temperature is only to increase the Reynolds number. The obsered tests were undertaken at enhanced discharges, up to 1.5 times Froude scaled discharge, a practice which has long been accepted to overcome a lack of Reynolds scaling in vortex tests. Furthermore, while the containment was not modeled, the minimum water level was used because the lowest water level leads to the most severe vortex condition.

<u>Page 5, Paragraph 1</u>

All concerned agreed that the potential for full blockage of the Midland screens under post-LOCA conditions existed.

There was no agreement between those individuals present at the demonstration that a potential for full blockage of the screens existed. We are aware of NRC concerns regarding foam-glass insulation and are currently evaluating this application in regard to sump reliability and performance.

<u>Page 5, Paragraph 2</u>

It was acknowledged that the blockage considerations of the test program were in conformance with or exceeded current 59 percent requirements of Regulatory Guide 1.82.

This statement should read "...current 50% requirements...."

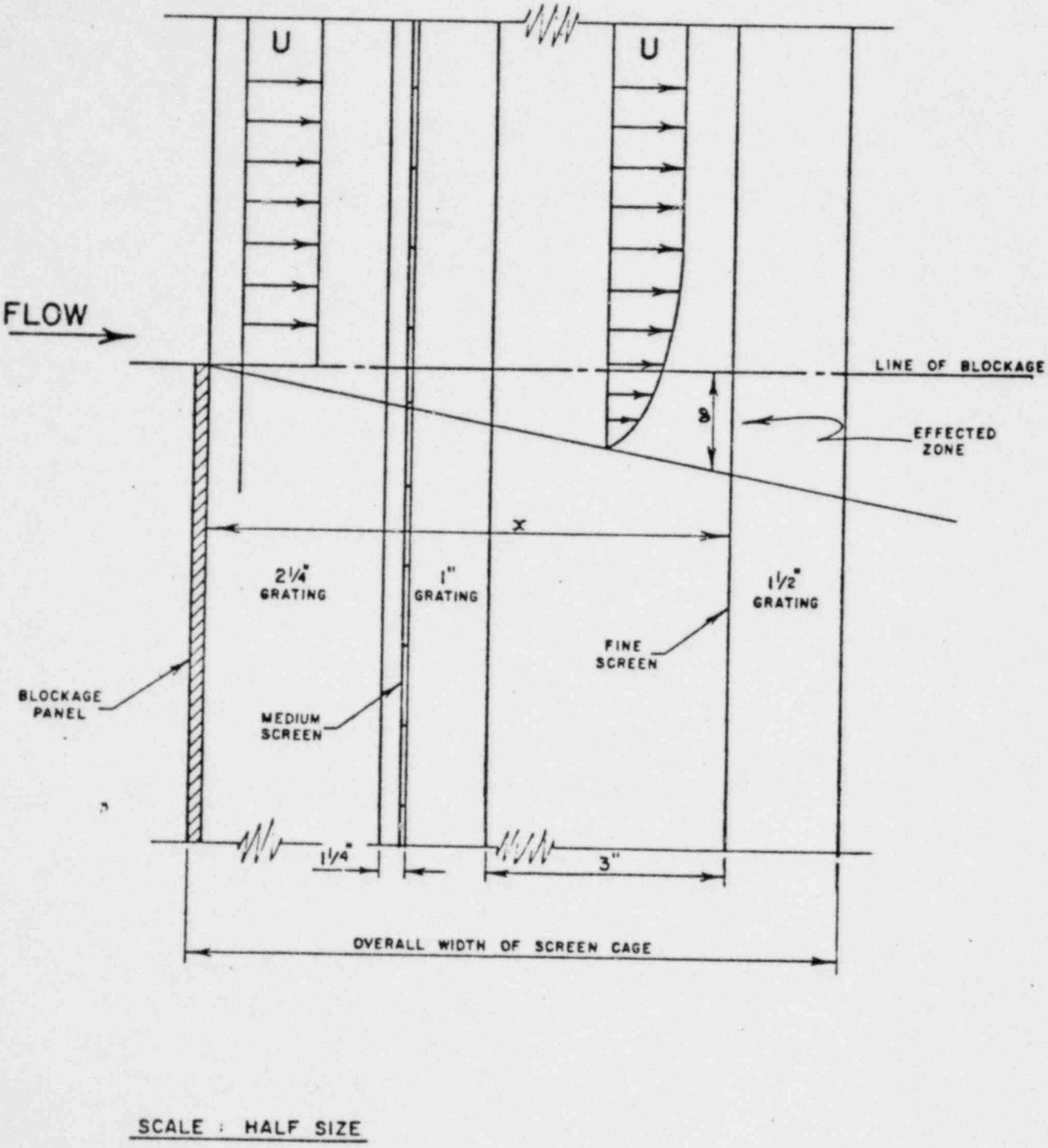
Page 5, Paragraph 3

It was agreed that the following would be evaluated in the subsequent tests and presented in the final report:

1. The five passages (Figure 1, Attachment 2) providing approach flow will be simulated during subsequent screen-cage blockage experiments. The half sump will be visualized relative to these approach paths, first as the north sump and then as a south sump.

2. The above will be repeated presuming that blockage has occurred due to the debris from the dominate approach directions.

No agreement was reached between those individuals present at the demonstration to create a model simulation of the five passages. The reasons for not modeling approach flows outside the outer screen cage have been stated in response to the comment of Page 1, Paragraph 6 of the NRC document. However, in spite of the above, model tests performed with various screen blockages could be construed to represent approach flows from various paths including the five passages addressed above.



MIDLAND UNITS 1 & 2

Figure 1

FINE SCREEN BLOCKAGE

WESTERN CANADA HYDRAULIC LABORATORIES LTD.