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AUTH.NAME AUTHOR AFFILIATION
TILLINGHAST,J. Indiana & Michigan Power Co.
RECIP.NAME RECIPIENT AFFILIATION
DENTON,H.R. Office of Nuclear Reactor Regulation

SUBJECT: Submits Thermal-Hydraulic Analysis for Spent Fuel Storage Capacity Expansion Program.Fee remitted to NRC on 781221 & required structural analysis will be submitted at later date.

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January 22, 1979
AEP:NRC:00116

Donald C. Cook Nuclear Plant Units 1 & 2
Docket Nos. 50-315 and 50-316
License Nos. DPR-58 and DPR-74
Spent Fuel Storage Capacity Expansion Program
Thermal-hydraulic Analysis

Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Denton:

Please be advised that the Exxon Nuclear Company has performed the required Thermal-hydraulic Analysis for the Spent Fuel Storage Capacity Expansion Program. The details of this analysis are presented in Attachment 1 to this letter.

The fee for processing this and other submittals associated with the Spent Fuel Capacity Expansion Program was remitted to the Nuclear Regulatory Commission on December 21, 1978.

The required structural analysis will be forwarded to you at a later date.

Very truly yours,

John Tillinghast
Vice President

Sworn and subscribed to before me
this 22 day of January, 1979 in
New York County, New York

Notary Public

[illegible]
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7901290260

cc: R. C. Callen
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ATTACHMENT 1

DONALD C. COOK NUCLEAR PLANT
DOCKET NOS. 50-315 &50-316
SPENT FUEL POOL CAPACITY EXPANSION PROGRAM
THERMAL HYDRAULIC ANALYSIS

3.5 Thermal Considerations

3.5.1 Fuel Assembly Heat Removal

The D. C. Cook spent fuel racks utilize storage cells comprising 4 Boral plates encapsulated in stainless steel shrouds supported in a stainless steel structural lattice. Adequate flow paths to the fuel assembly inlet are provided by space beneath the racks and between the racks and the pool walls. A six-inch hole at the bottom of the fuel storage cell serves as the coolant inlet. Flow paths between fuel storage cells within a rack module are provided to permit circulation of the inter-cell coolant to remove gamma heating.

Design Criteria

The high density spent fuel storage rack design provides storage capacity for slightly more than 10.6 cores (2050 spent fuel assembly storage cells). The original fuel storage design provided for storage of about 2.6 cores. Because of the high density storage (compared to the original design) analyses were performed to confirm that adequate natural convection cooling is available during normal operation to: (a) maintain fuel rod clad temperatures at acceptable levels; and (b) preclude boiling within the fuel assemblies. Fuel rod clad temperatures were also evaluated under hypothetical loss of forced coolant circulation conditions where the pool surface is assumed to reach a saturation temperature of 212°F.

Methods of Analysis

The methods employed by Exxon Nuclear Company in these thermal-hydraulic analyses are similar to those submitted by the Power Authority of the State of New York in its letter dated September 1, 1977 and as approved by the NRC in its Safety Evaluation Report for the Indian Point 3 Nuclear Power Plant Spent Fuel Rack Modification dated March 22, 1978. The following is a summary of that methodology.

In order to perform conservative calculations for defining fuel rod cladding temperature, the following information was utilized:

1. Maximum fuel heat generation rates per assembly and maximum local fuel rod heat generation rates;
2. Fuel assembly inlet temperature;
3. Flow resistance of worst case paths within the fuel assembly, within the storage rack, and between the racks and the pool walls and floor for worst case fuel assembly placement within the storage array; and
4. Heat flow resistance between the fuel clad and coolant.

3.5.1 Continued

Methods of Analysis (Continued)

This information was obtained in the following way.

Maximum fuel assembly heat generation rates were calculated using NRC Branch Technical Position APCSB 9-2. Based on 1080 effective full power days within the reactor and an average 156 hour cooling period, maximum in-pool heat generation rates of 54.1 kW/(fuel assembly) were calculated.

Maximum local fuel rod heat generation rates were obtained by subsequently applying a conservative peaking factor of 1.6.

Under forced coolant circulation conditions, the fuel assembly inlet temperature was taken as the maximum expected pool coolant discharge temperature, 150^{O}F. Under the assumed loss of forced coolant circulation conditions, the inlet temperature was taken as local saturation temperature at the top of the fuel storage cells, 240^{O}F, since this represents a maximum upper limit for the inlet temperature. Flow paths and flow resistances were identified on a worst case basis assuming worst case fuel assembly placement and conservative values for flow resistances. The flow network assumed for this analysis is illustrated in Figure 3.5-1 where all fuel storage cells are assumed to contain fuel at maximum heat generating rates.

Heat flow resistance was obtained from classical and experimental relations developed for laminar, turbulent, and boiling flow regimes.

With the above information, simultaneous solution of the continuity, momentum, and energy equations is achieved using the COBRA code. Subsequent hand calculations provide local and maximum spent fuel clad temperatures, coolant temperature rise, mass flow rates, local pressure, and pressure drops within the fuel assembly. For the two phase flow situations which can occur during a loss of forced coolant circulation, two additional parameters, void fraction and quality were also computed.

The COBRA thermal hydraulics code is used extensively throughout the nuclear industry for thermal hydraulic analyses. Hand checks of this code have been made on spent fuel storage rack thermal-hydraulic analyses.

3.5.1 Continued

Results

Thermal-hydraulic analysis of the natural convection cooling of a single fuel assembly indicates that there is adequate cooling under normal and even under hypothetical conditions where a loss of forced coolant circulation is assumed to occur. This result is based on the two (2) cases presented in Table 3.5-1. The table results are for the fuel storage cell located at the pool center as shown in Figure 3.5-1 and are therefore the worst case.

The first case is the normal situation where the heat generation rate is 54.1 kW per assembly and the fuel storage cell inlet temperature is taken as 150°F, the maximum expected pool operating temperature under normal conditions. The fuel rod peak cladding temperature is 178.3°F; therefore, there can be no boiling within the fuel assembly and the flow is single phase.

The second case is similar to the first except for the assumed inlet temperature, 240°F. This is the saturation temperature corresponding to the hydrostatic pressure at the top of the fuel storage cell. This is the maximum temperature that water flowing towards the fuel assembly inlet can attain under the hypothetical conditions where forced coolant circulation is assumed lost--and the surface of the pool is assumed to reach 212°F which is the saturation condition at that location. Under these assumed conditions, boiling does occur in the upper portion of the fuel assembly. Maximum cladding temperature under this case is calculated to be less than 250°F.

In summary, the analysis indicates that even under hypothetical extreme conditions, peak clad temperatures are well below conditions where any degradation of the clad would occur.

3.5.2 Spent Fuel Cooling Capability

An evaluation has been performed to determine the capability of the spent fuel pool cooling system (SFPCS) for providing the cooling capacity required for both the annual discharge of 65 fuel assemblies from Unit 1 and 88 fuel assemblies from Unit 2 on a 1-½ year cycle. It has been determined that the existing SFPCS, with both cooling loops in operation, can provide all necessary cooling for the normal discharge of fuel in the modified storage capacity condition. However, the design criterion for the cooling system, as stated in the FSAR, is that each of the two independent cooling loops be capable of providing adequate heat removal capacity in the event one loop is out of service. That design criterion states that with a

3.5.2 Spent Fuel Cooling Capability (Continued)

supplied component cooling water flow of 3000 gpm at a maximum temperature of 95°F, each cooling loop be designed to remove the incremental decay heat produced by 1/3 of a core from each Unit's reactor with a pool temperature at or below 120°F. Also, under the abnormal conditions of an additional full core discharge, each cooling loop should maintain the pool temperature at or below 150°F. Since the residual pool heat load increases with the number of fuel assemblies stored in it, we can meet the existing criterion until the pool contains 500 spent fuel assemblies. Under expected operation that will occur in early 1982. Analyses will be performed to determine the extent of the necessary modifications to the SFPCS needed by that date in order to meet our design criterion. Heat load monitoring, temperature measurements, and future actions of the Federal Government concerning spent fuel disposal/reprocessing will also be considered when determining the magnitude and timing of the SFPCS modification.

The spent fuel pool has approximately 660,000 gallons of water when filled to the normal level. Assuming a complete loss of all cooling systems, the heat up rate of the pool water following a normal reload discharge is expected to be $< 5.3^{o}F/hr.$ and $< 8.2^{o}F/hr.$ following a full core discharge.

3.5.3 Flow Blockage

The spent fuel is cooled by convective flow of coolant up through the fuel bundle from a 6" diameter hole in the bottom plate of the rack. The water returns to the bottom of the pool by traveling down between the outer most rack surface and the pool wall. The minimum clearance between the pool wall and the outermost rack surface is 7", and the space between the pool floor and the bottom of the rack is 6". Thus, it is extremely unlikely that any sufficiently sized object dropped or inserted in the pool could be carried to a position where it could fully block the flow of water into a storage cell.

TABLE 3.5-1

Thermal Hydraulic Parameters for 54.1 kW

Fuel Assembly Located at Pool Center in Width Direction

Flow Type	Single Phase	Two Phase
System Parameter	Case 1	Case 2
Cooling Loop Operational	Yes	No
Fuel Assembly Heat Generation Rate, kW	54.1	54.1
Fuel Assembly Coolant Bulk Inlet Temperature, °F	150	240
Fuel Assembly Coolant Bulk Discharge Temperature, °F*	178.3	240
Bundle Coolant Bulk Maximum Temperature, °F	178.3	242.3
Fuel Rod Film Temperature Drop °F, Max.	9.2	4.4
Fuel Rod Peak Cladding Temperature, °F	187.5	246.7
Equilibrium Quality*	0	.005
Void Fraction*	0	<.50

* At top of assembly.

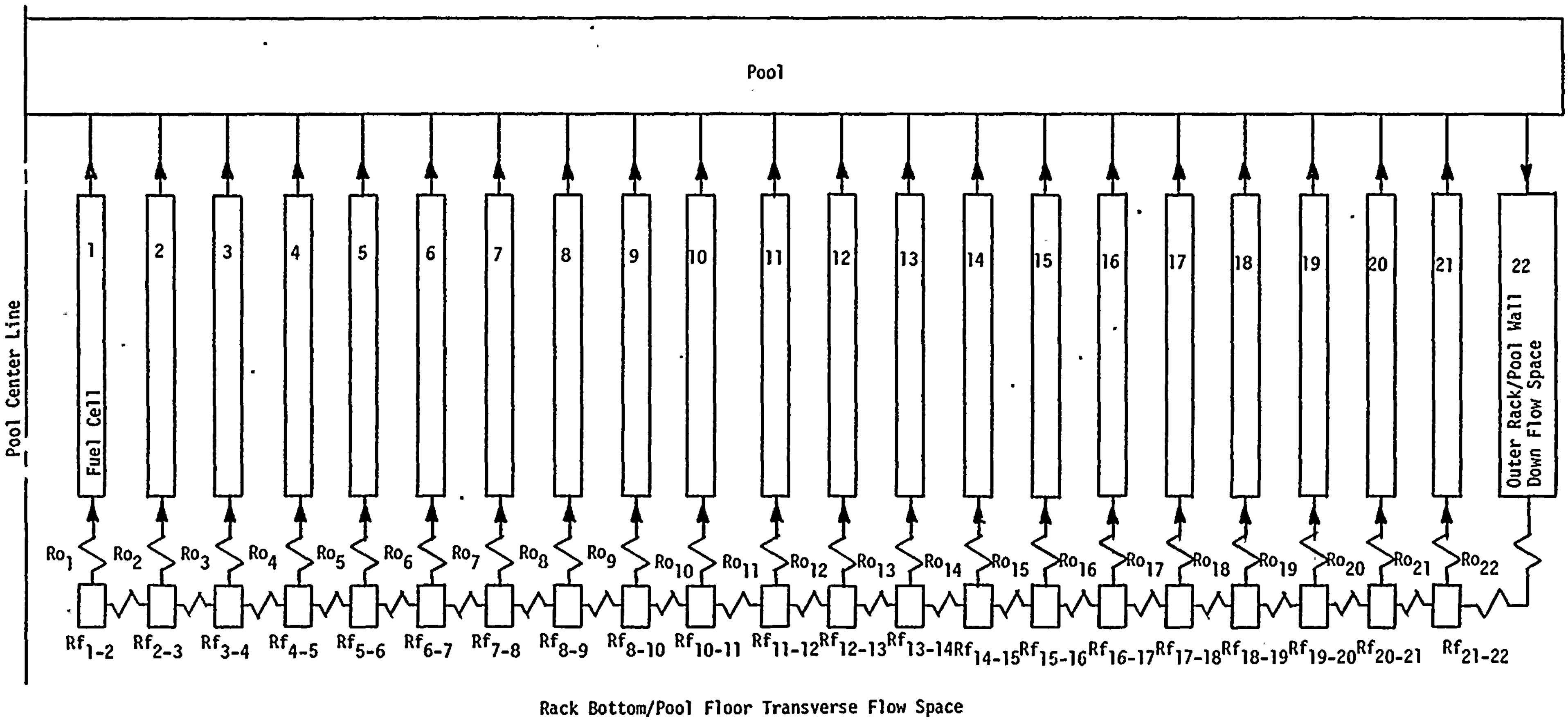

FIGURE 3.5-1

NATURAL CONVECTION THERMAL - HYDRAULIC NETWORK FOR HIGH DENSITY RACKS

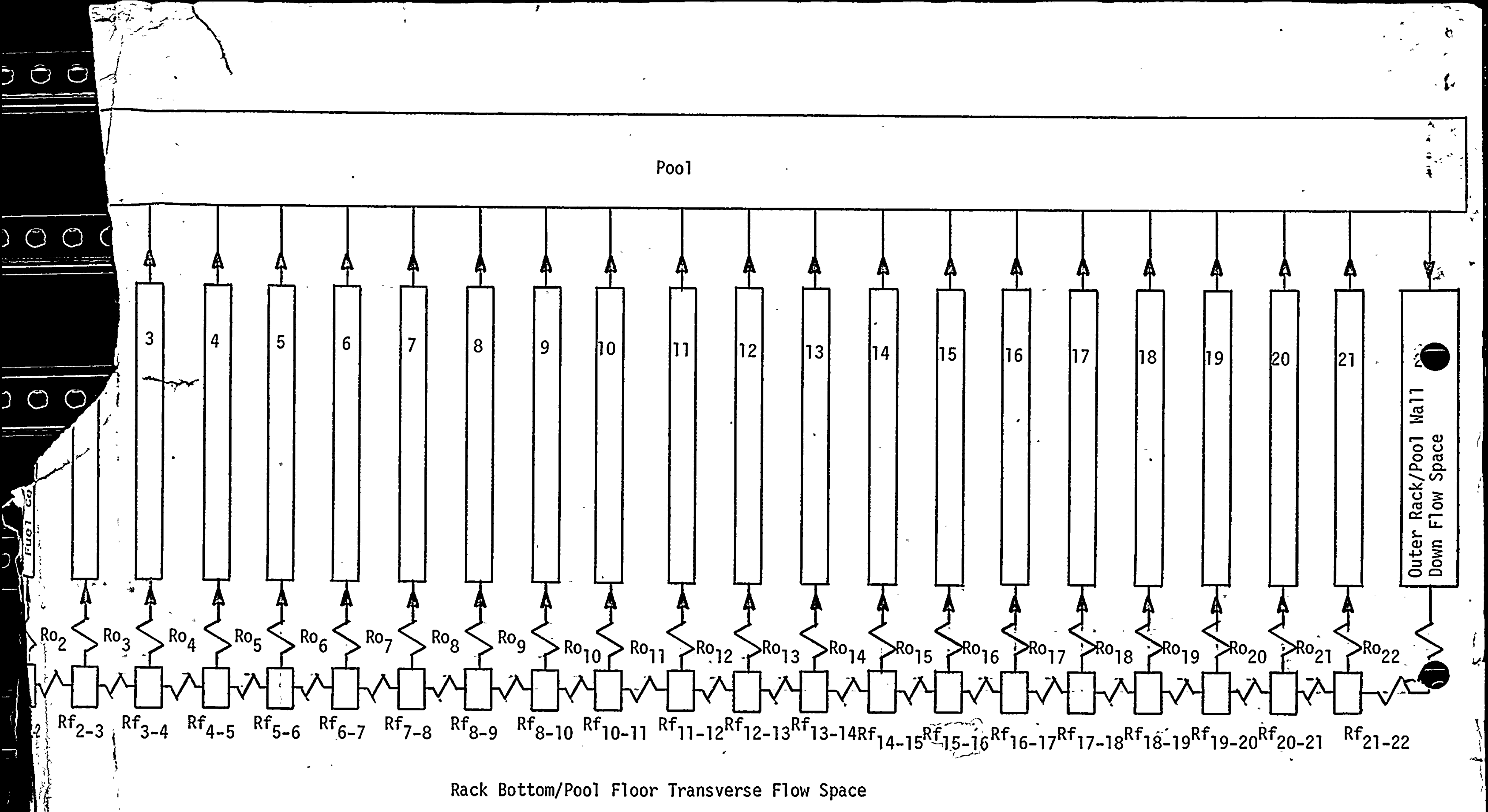

FIGURE 3.5-1

NATURAL CONVECTION THERMAL - HYDRAULIC NETWORK FOR HIGH DENSITY RACKS