STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS

Rhode Island Atomic Energy Commission
NUCLEAR SCIENCE CENTER
South Ferry Road
Narragansett, R.I. 02882-1197

May 12, 1995

Docket No. 50-193

Mr. Marvin Mendonca, Senior Project Manager
Non-Power Reactors, Decommissioning and
Environmental Project Directorate
Division of Reactor Projects - III/IV/V
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Mendonca:

Enclosed you will find a copy of the second revision to the Emergency Core Cooling System(ECCS) for Facility License No. R-95. This revision incorporates comments from the design review conducted by Argonne National Laboratory. All previous comments from your organization have been answered. The 1/2 orifices cited in the last correspondence on this matter have been installed. Mr. Tom Dragoun of NRC Region One recently viewed the partially installed system. He can provide third party comments regarding the installation. If there are any questions, please call me at 401-789-9391.

Sincerely,

Terry Tehan

Terry Tehan
Director

TT:cd

Enclosure

cc: Dr. James Matos, Argonne National Laboratory

A020 1/1

INTRODUCTION

The Rhode Island Nuclear Science Center research reactor has a design capability of 5 MW (thermal) power level. The current licensed power level is 2 MW. The recent conversion to the LEU fuel necessitated a Safety Analysis Review (SAR) which addressed a postulated loss of coolant accident (LOCA). The Nuclear Regulatory Commission approved the SAR and related information for the postulated loss of coolant for 2 MW operation.

This report addresses the postulated loss of coolant for 5 MW operation and the proposed emergency core cooling system (ECCS) required. Since the original GE reactor design did not include provisions for emergency cooling, it was necessary to originate a design plan which would incorporate some of the positive features available at the reactor site.

DESIGN CONSIDERATIONS

The pool is specifically designed to preclude the probability of drainage. It is constructed of reinforced concrete with a heavy aluminum liner to resist the most severe earthquake that might be reasonably be expected in the area. There are no penetrations below the top of the core that is open to pool water.

All penetrations of the pool are provided with multiple barriers against the possiblilty of leakage of pool water.

Four 6 inch and two 8 inch beamports penetrate the liner at the core centerline. Each beam port is closed by a bolted cap at the pool end, by a heavy lead shutter located within the pool wall, and by a bolted shield plug at the outer end. Each beam port is equiped with a vent/drain line 1/2 inch diameter orifice and an isolation valve to limit pool leakage in the event the primary barrier of a beam port is breached. Administrative controls are in place to limit potential leakage through any beam port experimental appratus, which takes the place of the outer bolted flange, to the equivalent of a 1/2 inch diameter hole.

It is highly unlikely that the beam ports could be severely damaged while the reactor core is in the high power section of the pool because of the restricted space and the protection afforded by both the reactor and the bridge which cover a major part of the area.

Additionally, severe damage to a penetration in the pool could be prevented from uncovering the core by:

1. Opening the bypass valve on the automatic pool filling system;
2. Closing the beam port vent/drain isolation valves;

3. Moving the bridge/core to the adjacent pool and closing the gate between the two pools;

Operations that can be completed in a matter of a few minutes.

DESIGN BASIS ACCIDENT

In view of the inherent integrity of the design features, a loss of pool water to the point of uncovering some portion of the core and damaging the aluminum cladding is unlikely.

The basic assumptions used were:

1. An 8 inch diameter beam tube is ruptured followiwg an infinite period of operation at a 5 Megawatt power level.
2. The reactor scrams concurrent with the beam tube rupture.
3. Emergency cooling System fill starts.

Initial pool level remains at 23 feet above the datum (appendix C) for 44 hours while the campus water supply tank is drawn down. Emptying of the reactor pool to the datum will require an additional 31 hours due to the flow restrictions of the 1/2 inch diameter orifice and the 1/2 inch maximum opening in the outer end of the beam port. The total time required to empty the pool is 75 hours, The lower active portion of a fuel plate will then be standing in slightly more than 8 inches of water (Appendix C; SAR, Section X, Loss of Cooland Accident)

FACILITY WATER SUPPLY

The Wakefield Water Supply Company provides water to the University of Rhode Island Bay Campus. The Rhode Island Nuclear Science Center reactor facility is located on the Bay Campus.

Water at 40 psi is supplied from the Wakefield Water Supply Company to a 300,000 gallon tank located adjacent to the Bay Campus. The tank booster pump delivers water at 75 psi to the Bay Campus distribution system. If pressure drops or more flow is needed a standby fire pump energizes maintaining system flow rate and pressure. The 3 fire pumps in the system have emergency generator backup. The Bay Campus demand (1992 records) is about 83 gpm. The ECCS flow rate will be set at 30 gpm. The total Campus demand will be 113 gpm (83 gpm + 30 gpm). This provides a reserve supply in the 300,000 gallon tank to maintain both the Bay Campus demand and the pool filling requirements for 44 hours.

A copy of the fire pump test results conducted for the system by Keily Associates, the design firm, is enclosed.

The reliability of the system was discussed in the SAR dated December 1992 in Section B, IX.

The URI 300,000 gallon tank* can be cross connected to the Wakefield Water Company which also has a 300,000 gallon tank about 1 mile away providing additional reserve capacity.

*See Appendix D - Administrative Controls

PRESENT POOL FILL SYSTEM OPERATION

The existing pool is filled through the make-up demineralizer system. The pool fill system has an automatic electrically operated valve which opens when the pool level float switch is activated for a nominal one inch drop in pool water level. The pool fill system has a manual by-pass valve should the automatic valve fail. Measurements reflect that the make-up system can provide 25 gpm to the pool. This is sufficient to maintain pool water level at 17 feet above the datum with the postulated maximum pool leak (ref. TABLE A).

PROPOSED EMERGENCY CORE COOLING SYSTEM OPERATION

Refer to the Emergency Core Cooling System (ECCS) Schematics in Appendix A and B.

The ECCS will operate under AC power with emergency power backup from the emergency generator. This assures operation of electrical components with loss of AC power.

At present the RINSC emergency generator has 1600 watts of excess capacity. The solenoid valve and flow measuring instrument would require less than 100 watts and would be a minimal load.

The reactor control system will be provided with two alarm circuits to be used for 5 MW operation. The first is an ECCS water line pressure sensor located between the pressure regulator and the automatic valve (AV) which monitors the water supply line pressure. The second alarm function would indicate that the ECCS automatic valve is opened. The alarms will sound at the front desk and in the Control Room.

The line also contains a flow meter indicating ECCS water flow during testing (Appendix D) or during a pool fill event. This unit will read out locally in the Demineralizer Room.

The automatic valve has a manual bypass valve in case of the failure of the electrical activator. The manual valves are used for a system by-pass flow testing.

A manual valve is used to isolate the system. It will be locked open. The four inch supply gate valve to the fire main and the ECCS system will be locked in the open position.

Activation of the automatic valve is from a low level pool switch. The unit will have a low pool level limit of 24

inches below the suspension frame base plate. The ECCS system will cycle (on and off) to maintain the pool water level at the 24 inch limit. This level corresponses with an actual pool level of 23 feet above the datum.

The reactor is scrammed on a low pool water level limit of 16 inches below the suspension frame base plate from a separate low water level sensor. (Tech. Spec. Table 3.1).

ECCS WATER SUPPLY ANALYSIS

An analysis of the 4 inch sprinkler supply connection point of the ECCS with a proposed 1 1/4 inch line supply to the pool indicates sufficient flow capacity to maintain the reactor pool full with the postulated maximum leak rate.

The pressure (supply) at the 4 inch pipe entering the building is based on the accompanying fire test report. Due to high pump pressure available, the proposed 1 1/4 inch line (ECCS) will have a pressure reducing value. A 55 psi setting is more than adequate for expected demand. The valve would prevent excessive ECCS line pressures when the Bay Campus fire pumps are in use.

The analysis was performed with a 55 psi supply pressure.

Assumptions:

Flow through a 1.25 in smooth pipe;
Friction loss 1.25 in, 50psi = 21psi/100ft of pipe*;
Equivalent loss (pipe lengths) for fittings:

1 Press. reducing valve			1ft
3 valves	@ 1 ft/valve		3ft
7 tees	@ 3 ft/tee		21ft
7 elbows	@ 4 ft/elbow		28ft
		Total	53ft
Actual pipe length			68ft
Equivalent loss			121ft

Friction head loss = 121ft/100ft * 21psi = 25.4psi
Elevation head loss = 32ft * 0.43psi/ft = 13.8psi
Total head losses = 25.4psi + 13.8psi = 39.2psi

Demand Flow = Supply - Head losses
= 50gpm @ 55psi - 39.2psi = 50gpm @ 15.8psi

TABLE A

HEAD ABOVE DATUM	CALCULATED MAXIMUM FLOW RATE (GPM) FROM BEAM PORT
25.29	30.13
24.29	29.53
23.29	28.91
22.29	28.28
21.19	27.64
20.29	26.98
19.29	26.31
18.29	25.62
17.29	24.91
16.29	24.18
15.29	23.42
14.29	22.65
13.29	21.84
12.29	21.00
11.29	20.13
10.29	19.22
9.29	18.26
8.29	17.25
7.29	16.17
6.29	15.02
5.29	13.78
4.29	12.40
3.29	10.86
2.29	9.06
1.29	6.80
0.79	5.31
0.00	0.00

It is assumed that (1) the diaphragm valve to the beamport vent line is fully OPEN;
(2) The beamport "shutter" is in the full OPEN position.

CONCLUSIONS

A postulated "Loss of Coolant" accident for power levels above the existing 2 MW licensed power level could lead to possible reactor core damage due to decay heat generation. An Emergency Core Cooling System has been installed which will ensure that pool remains full for at least 44 hours after a design basis accident occurs. An additional 31 hours are required to drain the pool. The resulting 75 hour time period is sufficient to carry out emergency procedures to resolve the situation.

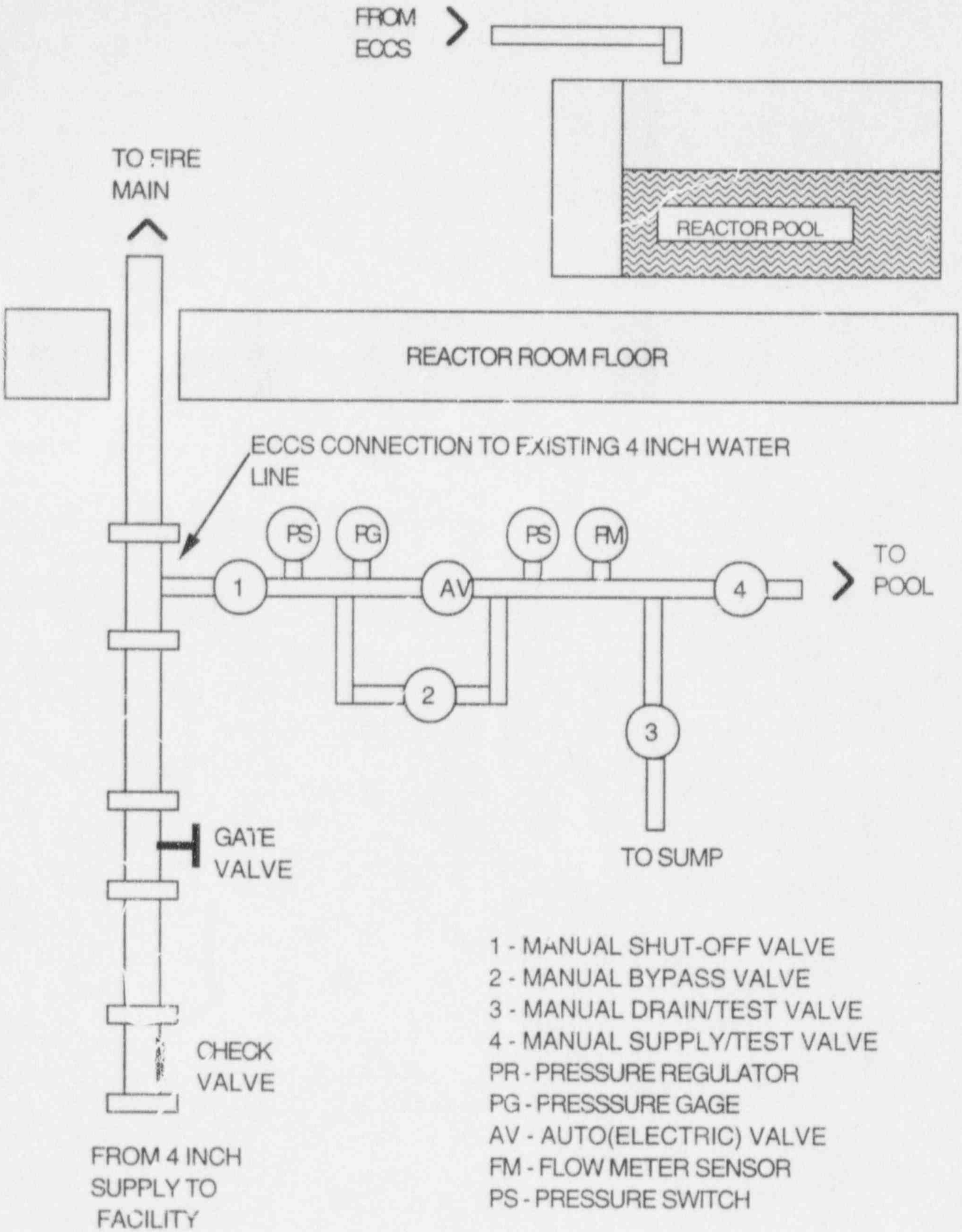
In the event that the casualty occurs during normal operating hours, personnel will be available to stop the leak or move the core from the high power section and install the dam. In the worst case situation, the core could be unloaded to the fuel racks which would provide significant additional cooling. In the event that the casualty occurs when the facility is unmanned, a low pool level alarm will be actuated when the pool level decreases by 1 inch. This alarm will be transmitted to the command center of the company which monitors reactor systems on a 24 hour/day basis and RINSC staff will be notified. An individual will be called in to check the reactor status and necessary corrective action will be taken. The 44 hour time period provided by the ECCS before the pool level begins to decrease is more than sufficient to allow corrective action prior to the pool draining to a point where the water level would not provide adequate shielding to personnel working above the core. Operating procedures have been developed to ensure that the system remains in a high state of readiness. These procedures specify the steps to be taken in the event of a serious Loss of Coolant Accident.

The above analysis is conservative in a number of areas. The facility operating cycle is much less than the postulated case which would result in lower initial decay heat. The maximum LOCA is assumed with no operator action to close the beam port shutter and the vent and drain lines. The time allowed to move the core or unload the core is very conservative. Also, a sumptions regarding the available water supply are very conservative.

The conclusion of this report is that the proposed ECCS and its operating procedures provide a very high degree of assurance that the design basis accident will not result in situation where the fuel elements are not adequately cooled.

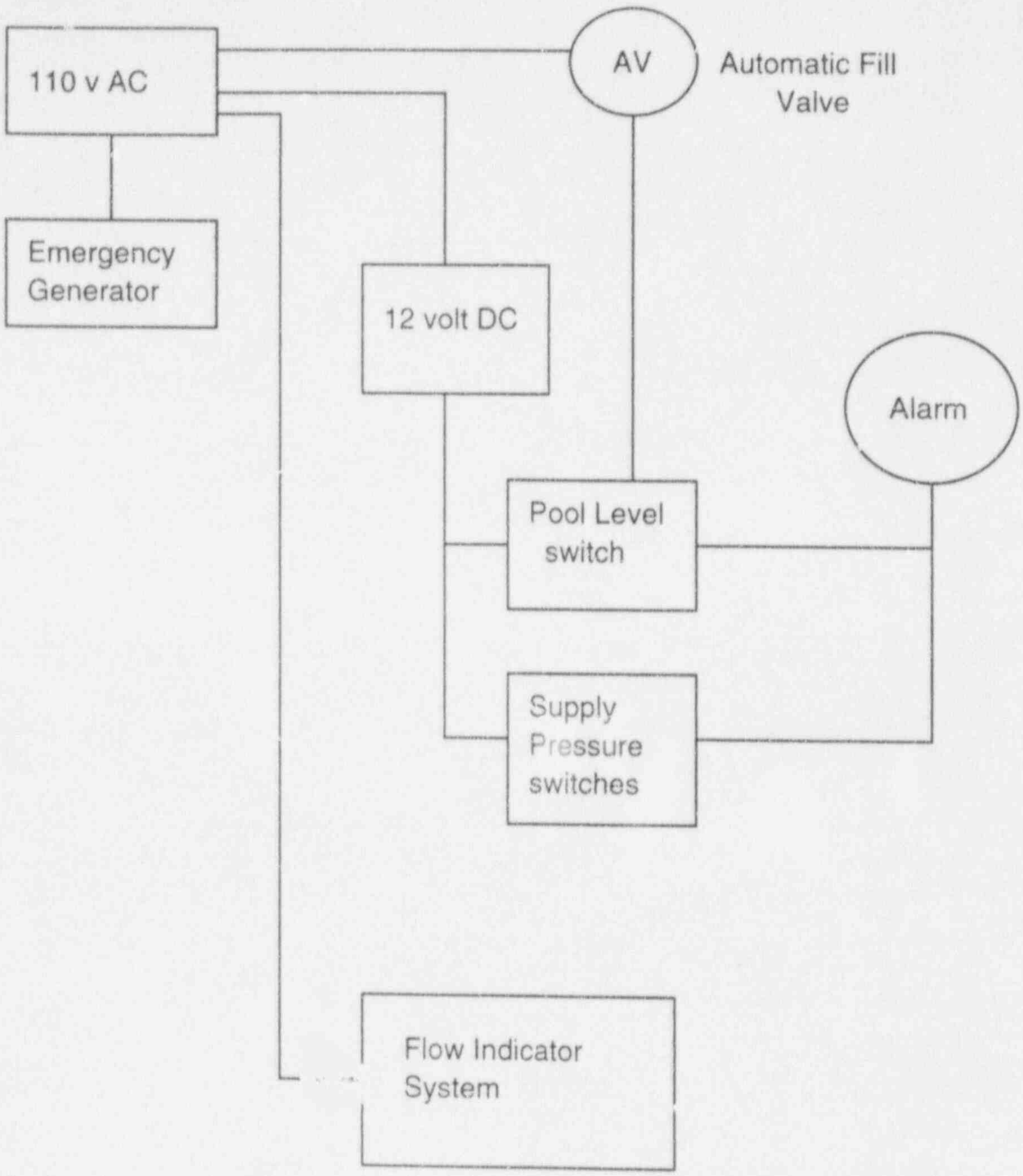
APPENDIX A

EMERGENCY CORE COOLING SYSTEM DIAGRAM



1 - MANUAL SHUT-OFF VALVE
2 - MANUAL BYPASS VALVE
3 - MANUAL DRAIN/TEST VALVE
4 - MANUAL SUPPLY/TEST VALVE
PR - PRESSURE REGULATOR
PG - PRESSSURE GAGE
AV - AUTO(ELECTRIC) VALVE
FM - FLOW METER SENSOR
PS - PRESSURE SWITCH

INSTRUMENTATION BLOCK DIAGRAM



CALCULATIONS

LEAK RATE (MAX)
Datum is el. 114.1 feet (invert of bottom of 8" beam tube)
el. 139.4 feet (water level of pool)

head = 139.4 feet - 114.1 feet = 25.3 feet
area of leak = two 1/2 inch diameter holes

$a = 2\pi r2 = 2\pi(\underline{0.5/24})^2$
$a = 2.727 \times 10^{-3}$ feet^2
0.61 - void coefficient/see attached
(Mechanical Engineering Handbook)

Flow through the standard orifice:

$$V = 0.61a\sqrt{2\,gh}$$

$$V = 0.61 \times 2.727 \times 10^{-3}\sqrt{2 \times 32.2 \times 25.287}$$

$$V = 0.067\ ft^3/sec$$

$$V = 0.067\ ft^3/sec \times \frac{60\ sec}{min} \times \frac{7.48\ gal}{ft^3}$$

$$V = 30.127\ \frac{gal}{min}$$

Drain time of pool with two 1/2 inch diameter holes:
Discharge under falling head

$$t = \frac{2a(\sqrt{h_1} - \sqrt{h_2})}{Ca\sqrt{2g}}$$

h_1 = 139.417 feet - 114.13 feet = 25.287 feet
h_2 = 0
A is the area of surface of pool = .50 feet^2
C is the orifice coeficient = 0.61
a is cross sesction area of two 1/2 inch diameter holes = 2.727×10^{-3} feet^2

$$t = \frac{2 \times 150 \times \sqrt{25.287}}{0.61 \times 2.727 \times 10^{-3} \times \sqrt{2 \times 32.2}}$$

$$t = \frac{1508.6}{0.01335} = 113{,}010\ \text{seconds}$$

$$t = 31.39\ \text{hours}$$

1. Bay Campus 300,000 gallon Tank Water Level:
   The Bay Campus 300,000 gallon tank has an altitude valve that automatically maintains the water level at 128.1 feet using Wakefield Water Company's water supply at 40 psi. The automatic valve is monitored by a remote recorder at URI's maintenance office with malfunction alarms at the water station, maintenance and security offices.

   If the Bay Campus tank fails, the pipe line supplying the Bay Campus can be cross connected to the Wakefield Water Company's 300,000 gallon tank that is about 1 mile away. This cross connection can provide 200 gpm at 40 psi.

   The Bay Campus and the Wakefield Water Company tanks do not provide for gravity feed.

2. Use and testing of the ECCS:

   The normal position of the valves are:

   Valve #1 - Locked open
   Valve #2 - Locked closed
   Valve #3 - Locked closed
   Valve #4 - Locked open
   Gate Valve (4 inch) - Locked open

   Mannual Operation:

   a. Open valve #2.
   b. Check for proper water flow rate on local indication.(minimum 30 gpm).
   c. Return all valves to normal positions and locked.

   Testing:

   a. To test the ECCS for proper operation, depress float switch to simulate a low water level in pool.
   b. Check for proper water flow rate on local indication. (minimum 30 gpm).

   Procedures:

   a. Section 3.7 of the RINSC Emergency Plan Implementing Procedures (Appendix E) provides the procedure for isolation of the pool in the event of a pool leak.

3.7 POOL LEAKAGE

3.7.1 Isolation Of High Power Section Of The Pool

If the pool leak is determined to be in the west end (high power section of the pool, the reactor grid box containing fuel must be moved eastward to the low power section followed by isolation of the west side of the pool by the following procedure:

1) Shut all (6) beam port vent/drain isolation valves.
2) Using a remote hook, uncouple the cooling system piping from the reactor suspension frame.
3) Clear track rails of cables, lines, tubing, etc.
4) Release the bridge brake by turning the lock device on the tram column counterclockwise.
5) Hand tram the bridge east until it reaches the rail stops.
6) Place the cable attached to the gate into the crane hook. Center the crane hook by moving crane over the gate.
7) Lift gate until it is clear of hangers & any devices in the bottom of the pool.
8) Slowly move gate south & begin gate rotation so that gate gasket will be on **west** side of gate.
9) With gate elevated, move crane west until gate contacts pool wall. Be sure gate hangs parallel to and is centered with the pool wall protrusion.
10) With gasket gently contacting protruding walls, lower gate slowly into its hangers.
11) If necessary inflate gate gasket to provide seal.
12) Turn off clean-up demineralizer pump.
13) Refer to Operating Procedures Section 5, and move fuel elements to the fuel storage racks.
14) Arrange for temporary and permanent repairs for damage in west end.

3.7.2 Isolation Of The Low Power Section Of The Pool

If the pool leak is determined to be in the east end (low power section) of the pool, any stored fuel must be moved westward to the mid section of the pool followed by isolation of the east side of the pool by the following procedure:

1) Using cables attached to the portable storage racks, move each rack to the fuel storage section of the pool. Be sure that rack is balanced when lifted and do not lift rack more than necessary to clear floor surfaces. Move racks slowly and carefully.
2) Arrange racks in the fuel storage section with greatest possible space between them. Allow room for movement of the gate.
3) Place cable attached to the gate into the crane hook. Center crane hook over the gate by moving crane.
4) Lift gate until it is clear of hangers & fuel storage racks.
5) Slowly move gate south & begin gate rotation so that gate gasket will be on **east** side of the gate.
6) With gate elevated, move crane east until gate contacts pool wall. Be sure gate hangs parallel to and is centered with the pool wall protrusion.
7) With gasket gently contacting protruding walls, lower gate slowly into its hangers.
8) If necessary, inflate gate gasket to provide seal.
9) Turn off clean-up demineralizer pump. Attach hose to water fill line and divert automatic fill to east end.
10) Arrange for temporary and permanent repairs for damage to east end.