UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	§	
	§	
HOUSTON LIGHTING & POWER COMPANY	§	Docket No. 50-466
	§	
(Allens Creek Nuclear Generating Station, Unit 1)	§	
	§	

TESTIMONY OF T. R. McINTYRE
REGARDING TEXPIRG ADDITIONAL
CONTENTION 6 - MANNINGS COEFFICIENT

Q. Would you please state your name and your position, and describe your educational and employment background?

A. My name is T. R. McIntyre. I am currently employed by the General Electric Company as Manager, Containment Methods in the Nuclear Power Systems Engineering Department. My educational and employment background is described in Attachment TRMc-1.

Q. TexPirg Additional Contention 6 alleges that the vent clearing time following a LOCA has not been calculated correctly because the calculation fails to account for the Mannings factor. Does the Mannings factor have any application to determining vent clearing time?

A. No. The Mannings friction factor and equation are applicable to gravity flows in sloping, free surface conduits. In a Mark III pressure suppression system the vent clearing process is primarily governed by static differential pressure forces, not gravity forces.

Q. Does the GE vent clearing model account for friction?

A. The Applicant's vent clearing model is developed in Section 4 of a GE Topical Report, "The General Electric Mark III Pressure Suppression Containment System Analytical Model", NEDO-20533, June 1974. The model includes a control volume for each vent and three control volumes for the weir area. The model assumes that wall friction in the weir and vents is negligible. Friction associated with turning of the flow from the weir to vent pipe, and the head losses associated with water penetration into the suppression pool are considered, however.

Q. What is the basis for the assumption that wall friction is neglible?

A. This assumption is based on earlier studies reported in another GE Topical Report, "The General Electric Pressure Suppression Containment Analytical Model," NEDO-10320, April 1971, wherein it was determined that the irreversible friction losses are in the order of 1% of the pressure difference being applied to the vent water. This report included the results of calculations of irreversible friction losses for the Limerick nuclear plant, reports on vent clearing times measured during pressure suppression tests at the Humbolt Bay nuclear plant, and comparisons with experimental data from GE's Pressure Suppression Test Facility (PSTF). Additional work at the Idaho Nuclear Corporation with the CONTEMPT-PS Code has also proven that the vent clearing transient is not affected by friction losses for reasonable values of vent roughness factors (November 1970 Monthly Report of the Nuclear Safety Division of the Idaho Nuclear Corporation Hai-436-70, Page 16).

Q. Why is data from Limerick, which has a Mark II containment, applicable to the Mark III containment to be used for Allens Creek?

A. The difference in vent system geometry between Mark II and Mark III containments is irrelevent from a fluid friction standpoint. Fluid friction (pressure drop) is generally calculated in terms of a loss coefficient times a velocity head, in the well-known Darcy-Weisbach equation.

$$\Delta p = k\frac{\rho V^2}{2g_c} \qquad (1)$$

where the loss coefficient, k, is expressed as a friction factor, f, times the flow length in pipe diameters.

$$k = f\frac{L}{D} \qquad (2)$$

Examining equations (1) and (2), it may be seen that the friction pressure drop will be similar in two systems as long as the density (ρ), the velocity (V), the friction factor (f), and the flow length $(\frac{L}{D})$ are similar.

Comparing Mark II and Mark III vent systems, both use water at about the same temperatures so the density condition is satisfied; both systems have peak vent clearing velocities on the order of 50 ft/sec.; and both have steel (or steel lined) vent systems so the friction factors, (f), are similar. For the flow path length, Mark II systems use a 2 ft. diameter vent and a submergence of about 11 ft., yielding a $\frac{L}{D}$ of about 5.5. The top vent of a Mark III as a flow path which consists of a 27-1/2 in. (2.3 ft.) diameter horizontal vent 5 ft. long, plus 7-1/2 ft. of water in the weir annulus with a hydraulic diameter of about 2 ft. Thus $\frac{L}{D}$ is equal to 5 ft. divided by 2.3 ft. plus 7-1/2 ft. divided by 2 ft. or an $\frac{L}{D}$ of about 6. Thus, when all factors are considered, the frictional effect on vent clearing is very similar in Mark II and Mark IIIs (the Mark III effect is, perhaps, 10% larger); thus, the Limerick results will be suitably applicable to a Mark III configuration for these purposes.

Q. Why is data from the PSTF applicable to Allens Creek?

A. The PSTF is a very large containment system transient test facility which is operated by General Electric at San Jose, California, and has been used for the Mark III Confirmatory Test Program. Tests have been performed with the PSTF in a variety of configurations, all approximately 1/130 volumetric scale of a Mark III containment system. From the standpoint of vent clearing, 41 blowdown tests were performed in a single cell configuration of the PSTF in which the weir annulus, vent system, and suppression pool were simulated in full scale. Differences in configuration between the PSTF and Allens Creek are minor, as illustrated by Table 1. The model data comparisons utilize PSTF geometry and initial conditions, and show that the model is valid and capable of predicting PSTF response. Since Allens Creek geometry and initial conditions are very close to that of the PSTF, the model can be expected to predict Allens Creek response to a LOCA as well.

Q. With regard to the fourth question in the September 1 Order, does the GE calculation accurately account for the existence of concrete walls, drywell corner weakness, right-angle turns and the necessity to clear more than one set of vents?

A. The vent system is steel lined, so with respect to the fluid dynamics of vent clearing, the fact that the drywell is concrete is irrelevant. The model does account for turning losses as I noted earlier in this testimony, and as explained in Section 4 of the GE Topical Report, "The General Electric Mark III Pressure Suppression Containment System Analytical Model", NEDO-20533, June 1974. Similarly, the model accounts for clearing of each row of vents, in turn. This is also described in the referenced topical report.

TABLE 1

Comparison of PSTF and Allens Creek Vent System Geometry

Parameter	PSTF	Allens Creek
Vent Diameter	2'3-1/2"	2'3-1/2"
Vent Length	5'0"	5'0"
Cell Size	8°	9°
Top Vent Submergence	Note 1	7'3"
Weir Width	2'4"	2'2"
Vent to Weir Area Ratio	0.91	0.93

Note 1

PSTF submergence is variable. Tests were run over a range of submergence from 2'0" to 12'0".

TERRY R. McINTYRE

I am currently Manager, Containment Methods and Testing in the Nuclear Power Systems Engineering Department of the General Electric Company. In this position I am responsible for analytical modeling of pressure suppression system response to Loss-of-Coolant Accident (LOCA) and other transient conditions.

I have a Bachelor of Science degree in Engineering Science from San Francisco State University (1969) and a Master of Science in Mechanical Engineering from the University of California at Berkeley (1972). My Master's thesis was on the subject of horizontal vent clearing in pressure suppression systems. I also have completed over 50 units in a post masters' program in Mechanical Engineering at Stanford University on a part-time basis. My specialty is fluid mechanics.

I have been registered as a professional mechanical engineer in the State of California since 1974.

I have been employed by General Electric Company since 19 9 and have been involved with containment systems modeling and experiments for the past nine years. Following my masters' degree completion in 1972, I accepted a position as a development engineer in the Containment Experiments Unit at General Electric Company's Nuclear Technology Department. In this position I was responsible for analysis of data from the Mark III Confirmatory Test Program. Specific data analyzed included that from te :s of pool swell and pool swell impact, vent clearing, drywell pressurization, and two phase flow.

In 1976 I became Technical Leader - PSTF Experiments, responsible for all experimental work at the Pressure Suppression Test Facility. Specifically, this included test planning, execution, data analysis, and reporting, and overall responsibility for completion of the Mark III Confirmatory Test Program. During my two years in this position, testing to determine Mark III condensation dynamic loads and pool thermal response were performed.

In 1978 I accepted a position as Technical Leader - LOCA methods in the Containment Methods Unit of the Nuclear Power Systems Engineering Department. In this capacity I was responsible for development and maintenance of engineering computer programs to predict pressure suppression containment response to Loss-of-Coolant Accidents.

In June 1980 I was appointed Manager of Containment Methods with overall responsibility for development and maintenance of engineering computer programs to predict containment transient response. My responsibilities have recently been expanded to further include all containment LOCA experiments.