August 14, 1989

Mr. Denwood F. Ross, Jr.
Deputy Director for Research
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Ross,

Re: NUREG - 1150, June 1989 version.

The June 1989 draft of NUREG-1150 shows no indication that any effort has been made to correct the worst technical error of the February 1987 draft. The cart remains before the horse. Probabilistic assessment of computer output has taken precedence over verification of the computer models. Computer programs which are intended to produce realistic results or predictions must be meticulously written and checked. Otherwise, in computer-users language: "garbage in, garbage out". When, as the N.R.C. has done, conservative assumptions are incorporated in a mathematical model, the results are skewed away from reality. Such a model may be checked against hand calculations and, thereby, be shown to be mathematically and programmatically operational. But, the probability that a model containing conservative assumptions will produce realistic results is near zero. Since the N.R.C. requires the nuclear industry to verify its computer models using realistic data, someone at the N.R.C. is aware of the importance of this procedure, called "verification".

The following are examples of potential verification exercises for the models in NUREG-1150. The failure of all of them inspires no confidence in the models:

Trial verification: Figures 3.2 and 3.3 indicate a total mean core damage frequency from both internal and external events of about 1.9E-4 per RY for Surry. The available real data indicate that as of July 1, 1989, all U.S. nuclear power plants had accumulated about 1300 reactor years of operating experience. One significant core damage accident occured at TMI-2 in March, 1979. One accident in 1300 RY is a frequency of 7.7E-4 for all reactors per RY. Since Surry is only one of 110 operating reactors, the core damage frequency applicable to it is about 7.0E-6 per RY. Stated another way, 110 reactors with a core damage frequency of 1.9E-4 per RY would have a cumulative core damage frequency of 2E-2 per 110 RY; and Figures 3.2 and 3.3 would seem to predict two core damage accidents per year among 110 reactors similar to Surry. Thus, the frequency models in NUREG-1150 seem to be in error by at least an order of magnitude.

Trial verification: Figure 10.1 indicates that the source term, specifically the iodine release fraction to the environment, can approach 1.0 under extreme and infrequent accident conditions. Some real data were obtained when the Chernobyl-4 reactor experienced a reactivity excursion, breached its containment building, caught fire, and burned out-of-control for about three days. The core exposed to the environment reportedly released 1.0 fraction of its fission gases, about 0.1 fraction of its cesium, and about 0.2 fraction of its iodine. Thus, Figure 10.1 appears to be in error by about a half order of magnitude for the worst possible accident (as exemplified by Chernobyl-4). The Three Mile Island-2 reactor experienced a loss-



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of-coolant condition which reduced about 70% of the core to rubble. If reactor source terms were to be properly quantified or rated in relation to the amount of fuel damage or the fission gas released from the core, then the TMI-2 accident was nearly as severe as the Chernobyl accident. The TMI-2 core released 0.7 fraction of its fission gases, about 0.6 fraction of its cesium, and perhaps 0.35 fraction of its iodine. Only about 0.05 fraction of the fission gases and about 1E-7 fraction of the iodine were released to the environment. Thus, Figure 10.1 doesn't even include the TMI-2 accident and appears to be meaningless. Figure 10.1 doesn't include any effect of reactor design upon the different chemical elements. In reality, the reactor damage source terms were similar; but the design of the American reactor reduced the environmental hazard source term by a factor of a million times compared to the design of the Russian reactor.

Trial verification: Figure 13.5 indicates population dosages for persons continuing their normal activities in the event of an early containment failure during a severe accident at Zion. It indicates that the probability of exceeding 200 rem would be about 0.65 at one mile from the reactor, and about 0.3 at 5 miles. In reality, only several score fire-fighters working within about 0.02 mile of the exposed Chernobyl-4 core received radiation dosages exceeding 200 rem. Only 29 died of radiation burns. Since there were over 4000 workers at the four units on the Chernobyl site, Figure 13.5 indicates that more than 2600 would probably receive dosages exceeding 200 rem. The population dosage error is about an order of magnitude. The dosage as a function of distance from the reactor is in error by about two orders of magnitude.

The failure of the above three attempts to verify the models used in NUREG-1150 confirms that the models still contain conservative assumptions. Four of these conservative assumptions are:

Assumption: Cesium iodide is sufficiently unstable that up to 10% of the iodine can evolve from water. See the fourth paragraph on page D-25 of NUREG-1150. This assumption has been shown to be false (Reference: Besmann, Lindemer, Nuclear Technology, 40, 1978, pp 297-305). The assumption implies that up to 10% of the chlorine in sea water should be evolving into the atmosphere; because sodium chloride and cesium iodide are similarly stable or unstable salts.

Assumption: A light water reactor core must achieve extremely high temperatures and melt to release its fission products and slump. See page D-26 of NUREG-1150. This assumption is contradicted in the fifth paragraph on page D-27 of NUREG-1150. With regard to the "TMI-2 core debris"....."much of which had never been completely melted". Apparently, much of the TMI-2 core degraded into debris, released fission products, and slumped into piles of dust and debris at temperatures well below melting. Oxidation of the Zircaloy and fuel by steam is a probable cause of the observed degradation.

Assumption: The hot, moist, radioactive gases escaping from an early containment failure tend to flow down onto the site most of the time. This assumption was necessary to produce Figure 13.5 of NUREG-1150. This figure shows some exposures of 200 rem at distances of 10 miles from the accident. This assumption is contradicted by the observations at Chernobyl-4 as stated in the first four paragraphs on page D-29 of NUREG-1150. The Chernobyl accident resulted in no "offsite prompt fatalities". The assumption defies the accepted laws of buoyancy. The density of moist air at 320 C is about half that of air on a reactor site at 20 C.

Assumption: A shut-down reactor has sufficient residual power to melt itself, volatilize large amounts of "aerosols", melt through a thick steel reactor vessel and attack and melt through the thick concrete floor of a reactor building while evolving nonvolatile fission products even under an "overlying pool of water". See fourth paragraph on page 9-18, seventh paragraph on page 10-3, and third paragraph on page D-21 of NUREG-1150. This preposterous assumption is partly the result of unrealistic laboratory experiments. Melt behavior has been studied using heat inputs of the order of 1000 watts per gram. "aerosol" behavior has been studied using heat inputs of the order of 50,000 watts per gram. Reference: Nuclear Technology, 81, May 1988. In the real world, a reator at full power generates 30 watts per gram; ten minutes after shutdown it generates 0.6 watt per gram; and ten hours after shutdown it generates 0.2 watt per gram. In the real world, melting of a portion of a reactor core is possible; but only if a portion of the fuel is well insulated from cooling by water, steam, air, radiation, and conduction. The insulating medium must confine the melt to prevent heat loss by radiation. The insulating medium is likely to grow thicker as the heating power of the fuel decreases with time. If the insulating medium cracks, the melt may flow to a cooler region and cool more rapidly.

In summary: Conservative assumptions in; unverifiable results out. Or, more crudely "garbage in, garbage out".

It is apparent that the N.R.C. is in no hurry to provide Congress, the President, or the public with realistic estimates of the hazards of nuclear power plants. If it were to do so, it would lose its power to control the energy policy of the United States. That power would revert to elected officials. The N.R.C. should understand that the longer it continues its policy of over-estimating the hazards of nuclear power plants, the greater will be the damage to the economy of the U.S., and the greater will be the reaction of the people as the truth comes out. And the truth is coming out as each year passes without a serious injury from radiation at a nuclear power plant.

Sincerely,

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