TECHNICAL SUPPORT DOCUMENTATION

• **Assessment of Official Findings**

# RELEASES OF RADIATION TO THE ENVIRONMENT

The Kemeny Commission findings concerning the releases of radiation into the environment led them to conclude that there would be no long-term health effects associated with those releases. Those findings were apparently based on release figures presented by Metropolitan Edison and the Nuclear Regulatory Commission.

During our investigation the members of this investigatory team held positions in the specific area of release monitoring, and as such, became familiar with release data and monitoring inefficiencies not reflected in the figures presented to the Commission. It is our contention that those figures do not reflect an accurate assessment of actual releases from the plant during and immediately following the accident, or for a period of several weeks thereafter.

## 1 Kemeny Iodine-131 Release Findings

The Kemeny Commission found that 13 to 17 curies of Iodine-131 [Iodine] were released along with an estimated 13 million curies of noble gas (primarily Xenon) during the month following the accident:

> "13. The total release of radioactivity to the environment from March 28 through April 27 has been established as 13 to 17 curies of Iodine and 2.4 million to 13 million curies of noble gas." [Kemeny Conclusions]

## 1.1 Available Iodine

Iodine accounted for 8 to 12 percent of the overall releases of radioactivity according to the Commission's own Technical Assessment Task Force [TATF] in their separate volume. This means, using the 13 million curie figure listed above as the *total amount* of radioactive gas released (rather than merely the Xenon portion), the actual figure for Iodine release would be over 1 million curies, not the mere 15 (avg.) stated in the Commission's conclusions.

It is reasonable to assume that the actual figure on overall releases (including Iodine) is much higher, as many millions of curies of both Xenon and Iodine were released from the fuel during the course of the accident.

According to a Bettis Laboratory analysis of a reactor water sample taken on March 30, 1979 (an evolution which in itself caused a significant release of radioactivity to the environment), the



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concentration of Iodine in that 10 milliliter sample (thus having been released from the fuel) is given as:

- 8.5 x $10^3$ microcuries per cc, a cubic centimeter being equivalent to one milliliter.

When that amount of Iodine is multiplied by the amount of water contained in the RCS, the makeup and letdown lines, the storage tanks and the amount of water loose in containment and in the auxiliary building, which was given as:

- approximately 9 x $10^8$ milliliters

the figure on the amount of Iodine available ~~to generate releases~~ was approximately:

- 7.65 million curies.

According to the Kemeny TATF, a total of 22,103,615 curies of Iodine were released from the fuel. In addition to the 15 curies it said were released to the environment, the desposition of the rest of the available Iodine was described:

> "a. Five hundred thousand times as much radioactive Iodine (7.5 million curies) was retained in the primary loop. On April 1, 10.6 million curies of Iodine were retained in the containment water, and 3600 curies were in the containment atmosphere. Four million curies were in the auxiliary building tanks." [TATF Report]

That the Commission's TATF could coome up with so precise a number of curies of Iodine (22,103,615) is impressive. Yet notice that the figure listed above for the amount of curies remaining in the primary loop is given as 7.5 million rather than the 7.65 million curies the Bettis Laboratory figures add up to. The only estimated value in those numbers is the approximation of how much primary coolant was in the RCS and its makeup and letdown lines. The figure listed by Bettis, 9 x $10^8$ milliliters, is equivalent to 250,000 gallons. This is an accurate estimate.

Thus, while the apparent difference between 7.5 and 7.65 seems inconsiderable at first glance, this convenient rounding off served to "lose" a hundred and fifty thousand curies of radioactive Iodine. This looks like 150,000, not 15. We see that the Iodine release figures in this instance could conceivably be off by a factor of $10^4$, and that would assume that none of the other figures have also been rounded off, thereby "losing" other hundreds of thousands of curies in the process.

Also according to the isotopic analysis of the reactor water samples taken on March 30, which are found in the TATF technical appendices, 48 percent of the total core inventory of Iodine was released by the fuel into the RCS water.

The percentage of the core inventory of Iodine released from the fuel (48%) coincides quite closely with the Kemeny TATF estimation of the percentage of Xenon released from the fuel:

> "Cohen (reference 10) concludes that 57% of the Xenon was released [from the fuel]..."
> [TATF Report]

Xenon and Iodine are the two most commonly produced fission products. We can directly relate the amount of Xenon present to the amount of Iodine which would be produced due to the same fission process. The 48% figure for Iodine released from the fuel is consistent with the estimated 57% of Xenon inventory released, although the differing percentages no doubt represent more hundreds of thousands of curies of Iodine.

The "loss" through manipulation of numbers of hundreds of thousands of curies of radioactive Iodine makes the official estimation of a total Iodine release of a mere 15 curies highly suspect.

## 1.2 Kemeny Public Information Task Force Assessment

The Public Information Task Force arm of the Kemeny Commission was charged with determining what, if anything, the general public should be told about the accident and its severity. The result was Mark Stephen's book, *Three Mile Island*. We have already mentioned elsewhere in this report Mr. Stephen's liberal attitude toward facts as they exist within the Commission report itself, but what he has to say about why there was *no* Iodine released into the environment is particularly interesting. It states a premise which is not found or even alluded to in any of the volumes of the Kemeny Commission Reports on their investigation of the accident at Three Mile Island:

> "The radioactive Iodine that was of greatest concern to public health officials was never released in large quantities *because it reacted with molten silver from what once had been the reactor's control rods. It now lies, decaying, in a slurry of silver iodide at the bottom of the reactor pressure vessel.*
>
> *What Iodine survived the melting of the control rods was killed by sodium hydroxide sprays* which went off accidentally after the hydrogen explosion that caused Wednesday's 28-pound pressure spike." [Emphasis ours]

Mr. Stephens has made sweeping assumptions about the severity of the accident based on erroneous information. He has entirely disregarded the danger of Iodine releases because of two events, which we will discuss below.

[I] Silver iodide–What Mr. Stephens has said in his attempt to discount the problem of Iodine is that the control rods at Three Mile Island Unit II were composed of silver, which has a very low melting point. According to his logic, when the Silver control rods melted, the Silver bonded chemically with the free compressed Iodine gas to form a rare chemical called silver iodide.

The truth is that control rods contain very little Silver, for just the reason that its melting point is so low. The control rods are actually composed of metals which can withstand the intense heat, pressure and neutron activity in the reactor core without melting, warping or becoming neutron activated. The standard composition of reactor control rods is Zirconium/Hafnium impregnated with two neutron absorbers which help it to control the chain reaction, which is a control rod's job. Those neutron absorbers are Boron and Silver.

The silver used in control rods is not only a good neutron absorber, but is also an extremely stable elementary isotope. There would not be enough of it to react significantly with any isotopes released from the fuel in the fission process or in the melting process. The amount of silver in TMI-II's 69 control rods is a minor percentage, and certainly not enough to neutralize more than 22 million curies of Iodine. There are more than 36,000 fuel rods composing the reactor core. Stephens' assertion that there was enough silver available in the minor percentage of metal making up only 69 control rods is a fantasy.

[II] Sodium hydroxide sprays–The 28 pound pressure spike, which was a hydrogen explosion in the containment atmosphere, occurred more than nine hours after the accident began. Sodium hydroxide sprays were activated at that time for a short period, but were turned off because the chemical is caustic to the metal of the machinery. Those sprays are located inside the containment structure, but not in the reactor vessel or anywhere near the RCS.

The sodium hydroxide sprays could have had no effect whatsoever on Iodine free within the RCS, or in the makeup/letdown lines, auxiliary building storage tanks, or anywhere else outside of the reactor building or the inside of the reactor. The Iodine being released into the environment from the plant was escaping from the auxiliary building, not the containment structure, thus the sprays could have had no effect in reducing releases. This appears to be another of Stephens' techni-cal fantasies which have absolutely no basis in fact.

<u>It is the position of this investigatory team that the product of the Kemeny Commission's Public Information Task Force (Stephens' book) may be completely disregarded in the matters of technical analysis for any and all aspects of the accident at Three Mile Island.</u>

## 2 Actual Iodine-131 Releases

It is the conclusion of this investigation that large amounts of radioactive Iodine gas was released from Three Mile Island during the course of the accident and for several weeks thereafter. This conclusion is based on the personal involvement of investigation personnel in monitoring the releases from the plant as well as in monitoring the conditions inside the plant.

### 2.1 The Auxiliary Building Air Filtration System

From volume II of the Technical Assessment Task Force Report to the Kemeny Commission:

"If the Iodine filters had been in good condition, the release of Iodine to the environment would have been reduced from about 15 curies to less than 1 curie." [TATF Report]

Even given the Kemeny Commission's low estimation of 15 curies of Iodine released, and the capacity of the auxiliary building filtration system which they insinuate is less than 100 curies (based on the fact that they were saturated and needed an extra capacity of just 15 curies), one might wonder how a nuclear plant can be licensed with such pitifully inadequate safety measures designed to prevent releases. Yet compared to the more than 22 million curies of Iodine which equates to 48% of the core inventory, the previously quoted finding can easily be seen for the mis-representation it is.

The Commission arbitrarily set the overall Iodine release figures at a low enough level to make the auxiliary building air filtration system *appear* as though it might provide an adequate barrier against meltdown-produced levels of radiation. While they may indeed prove quite effective during normal plant operations, the fact that the entire bank of filters became saturated quickly at the start of the accident makes it clear that they are simply not designed to minimize releases of such magnitude.

## 2.2 The Filters at Three Mile Island

The auxiliary building air filtration system consists of a series of large rectangular aluminum cases filled with activated charcoal granules. The cases are arranged into tiers of rows. These rows of filters create a large bank through which air leaving the auxiliary building via the vent stack must pass.

As the air passes through the filters, the activated charcoal traps radioactive gases, in particular Iodine. Each filter weighs approximately 80 pounds, which makes replacing them even under normal conditions a significant task. At Three Mile Island, the filters were totally saturated, which means that each filter's charcoal components had absorbed its entire capacity. For each new radioactive atom entering the filters as air continued to flow toward the vent stack, an atom was released to exit the stack.

Aside from the problem of the filters being unable to provide air filtration shortly after the start of the accident (and for several weeks thereafter until they were changed), the filters themselves held so much radioactive Iodine that workers could not have changed them even if replacement filters had been available. They were, in short, "too hot to handle." It took two weeks for the activity to decay enough to enable workers to approach the filters.

Due to the inadequacy of the filtration system at Three Mile Island, no one could have prevented the largest initial releases of radioactivity into the environment.

## 2.3 The Filter Changing Evolution

Two of the members of this investigating team were among the top-ranking Health Physics personnel assigned to the recovery operation at TMI during April of 1979. Both were involved in the planning and implementation of the filter changing evolution.

Because the levels of Iodine being released were increasing during mid-April as the water on the auxiliary building floor continued to evaporate, the filter changing operation was one of the most important tasks facing the engineers in charge of the initial recovery.

## 2.4 Other Iodine Sources

The releases during the first days following the accident were the most serious, despite the mid-April increases. During the first hours of the accident and continuing for nearly a week thereafter, *the releases of Iodine were uncontrollable*, as the inadequacy of the filtration system indicates. The reasons for the presence of such vast amounts of Iodine and other fission products, however, has to do with the fact that the reactor was fissioning out of control during the course of the accident.

As the Xenon and Iodine were released from the fuel by runaway fission, it remained in the form of a dissolved gas until it reached a point in the Reactor Coolant System or the RCS adjuncts where the pressure surrounding it was eased. There were several routes of exit for the dissolved gases during the 16 hours of the accident itself, a few of which are listed below:

### 2.4.1 PORV

The PORV (Pressurizer Overhead Relief Valve) was forced open in the first moments of the accident to prevent a reactor breach as fission continued unchecked in the area of rod group 8 in the center of the core, while at the same time the feedwater system to the steam generators failed. Due to the fact that the steam generators were no longer removing heat, pressure inside the reactor vessel built up dangerously.

The PORV remained in the open position, and in fact was jammed into that position from the force of its opening, for the first 2 and a half hours of the accident. Once the block valve could be operated to control the pressure manually, RCS water and dissolved gases continued to be vented for short periods throughout the next 13 hours.

### 2.4.2 "B" Steam Generator (Secondary Loop)

After the steam generators had boiled dry as a result of being deprived of feedwater, the heat inside them continued to rise. When the Emergency Feedwater Block Valves were manually opened just minutes into the accident, cold water flowed into the generators. The "B" generator, closest to the feedwater supply, received a thermal shock which destroyed its inner tubing, allowing RCS water and dissolved gases to escape that route at will.

The conditions inside the reactor did not allow the operators the luxury of isolating the "B" steam generator, despite the massive breach of loops it presented. The operators needed every cooling option they had in order to bring the reactor under control. Once the interior tubing which served to isolate the secondary loop from the pressurized primary loop no longer served that purpose, the secondary–supposedly radiation-free–loop which drives the turbines and proceeds to the cooling tower became highly contaminated with RCS water. This served as yet another escape route for radiation being released uncontrollably into the atmosphere outside the plant.

The releases originating in the secondary loop were not monitored prior to exiting the plant area.

### 2.4.3 Other Relief Valves

Relief valves on auxiliary lines and tanks all vented gases as the pressure and temperature levels fluctuated wildly during the course of the accident. The RCS water which traveled through the letdown lines was degassed by a relief system called the *vent gas header*. Then the water was filtered through the makeup demineralizer system, and then pumped back into the reactor to pick up more fission products, or diverted into holding tanks. The pressure relief valves downstream of the demineralizers discharge to the *waste disposaldrain*. The waste disposal drain sends the water to the *auxiliary building sump*.

The Kemeny Technical Assessment Task Force reported:

> "At the time of the accident the rupture disc on the line from the sump tank had previously burst. This presents an open 2-inch line from the auxiliary building sump tank to the sump. The auxiliary building sump tank is equipped with a pressure relief valve that discharges to the *relief valve vent header*."
>
> It should be noted that the header discharges directly to the station vent.
>
> If the auxiliary building vent header had any leaks at the inception of the accident, this pathway would take even minor amounts of radioactive gas and liquids directly over to the auxiliary building." [TATF Report, Vol. IV]

The question occurs as to whether there was such a leak in the auxiliary building vent header at the inception of the accident, thus providing this pathway for escaping radiation. The Kemeny TATF discovered that there indeed was such a leak, although it may not be considered a "leak" per se.

> "It was reported that the vent valves were found open after the accident and subsequently closed on June 5, 1979." [TATF Report, Vol. IV]

Thus during the hours when the reactor was out of control, huge amounts of radioactive fission gases were being forcefully expelled into the auxiliary building vent header from two sources, both highly contaminated, where it quickly saturated the filtration system. From that point until the filters were changed the vented gases went straight out the station vent stack and into the atmosphere. The valves which would have prevented this direct RCS escape route were left open for more than two months following the accident, when they were finally "discovered" and closed.

## 3 Particulate Releases

The subject of particulate releases was not addressed by either the Kemeny Commission in its findings or by the Technical Assessment Task Force staff. TATF simply stated:

> "No radioactive Cesium, Strontium, Barium or Lanthium has been detected in the environment, *even though significant quantities of these materials were transported to the auxiliary building*." [TATF Report]

The Commission reported in its Findings that:

> "b. No detectable amounts of the long-lived radioactive Cesium or Strontium escaped to the environment, *although considerable quantities of each escaped from the fuel to the water of the primary system, the containment building, and the auxiliary holding tanks*." [Kemeny Findings]

### 3.1 Particulate Filtration

It is unclear why the TATF came to the conclusion that no particulates (in the form of heavy isotopes) were released, despite the fact that great amounts of them were present in the auxiliary building and other locations shown to be leaking or failed.

Because particulate contamination is by definition "off limits" in the auxiliary building, there is no particulate filtration system which would serve to stem the release of particulates which were present at Three Mile Island. Nuclear power plant auxiliary systems are designed to function under normal operations, and are not engineered with the foresight included in containment design.

*There is no particulate filtration system to prevent the release of particulate contamination from the auxiliary building at Three Mile Island Unit II*.

### 3.2 Particulate Monitoring

The monitoring of radiation at Three Mile Island took the form of air sampling, dose readings, smear samples processed through one of the two GELIs (Germanium Lithium Isotopic Identification System). The smears which were taken by members of this investigation team did, in fact, show that particulate contamination was present, and that the particulate contamination contained heavy isotopes. The particulate filter at the vent stack monitoring station showed that particulates were being released along with radioactive gases from the stack.

A particulate filter changed by Mr. Thompson as Surveillance Technician for a 12-hour sampling period on April 3, 1979 indicated particulates being released at a level of 2.5 x $10^6$ DPM (Disintegrations Per Minute). This filter was located in the vent stack monitoring station.

The importance of particulate releases from Three Mile Island is that such releases would indicate that alpha particles and heavy alpha-emitting isotopes were being released to the environment.

## 4 Conclusions About Releases and Health Effects

The Kemeny Commission, in its Summary of the Public Health and Safety Task Force (PHSTF) report, chose not to consider possible health effects to the population surrounding Three Mile Island from exposure to beta radiation given off by Iodine-131 and Xenon gas. Their justification for failure to consider beta doses was given in their description of how doses to the population were estimated.

Possible health effects from exposure to Iodine-131, which is a limiting isotope that causes specific biological damage, was also minimized by the Kemeny Commission through its calculations of the amount of Iodine released, divided by the number of people living within a 50-mile radius of the plant. If this were a valid method of estimating exposure, no one would have been exposed to enough Iodine to cause any of the usual health problems associated with such exposure.

And any specific biological hazard presented by alpha particles and heavy metal isotopes went completely unaddressed by the PHSTF because the Commission flatly refused to investigate the possibility of particulate releases from TMI.

### 4.1 Beta Radiation Exposure from Xenon and Iodine Gas

The estimated doses of radiation to the population surrounding Three Mile Island were determined by the placement of many Thermoluminescent Dosimeters (TLDs) in locations at various distances outside the plant in the towns and countryside around TMI. The TLDs were then processed by the Dosimetry department of the Health Physics staff. According to the Kemeny Findings:

> "[The Health Physics and Dosimetry Task Group did not attempt to assess beta irradiation damage because]...a) there were no reported measurements of integrated beta dose from TLD." [PHSTF Report]

In reality, the TLD measures both beta and gamma radiation via two separate Lithium crystals. One is unshielded, and the other is covered by a thin sheet of metal. When the crystals are heated in the TLD reader, the displaced (by radiation) atoms within the crystals are realigned, the computer counts the number of misaligned atoms, and converts the information to dose in millirems. The unshielded crystal is radiated by both beta and gamma radiation, and registers accordingly. The shielded crystal registers only gamma radiation, the beta having been prevented by the shield from coming in contact with the crystal. It is a simple matter for the computer to subtract the gamma-only dose reading from the beta/gamma one to come up with a beta dose measurement.

At Three Mile Island the logging of doses registered on *all* TLDs read was arbitrarily programmed not to record beta doses into the permanent record for workers, extremity measurements or for stationary TLDs in the community.

Mrs. Thompson, a member of this investigation team, was assigned as an HP to the Dosimetry department, where her job was to process the TLDs daily. Although beta doses were not entered into the automatic record, the processing machines digitally displayed both the beta/gamma and gamma doses as the TLDs were read. These displays indicated that throughout the month of April, 1979, the beta doses accounted for approximately 90% of all radiation exposure.

Health effects which may be attributable to beta radiation exposure were described briefly by the PHSTF, which concluded that a "few" additional cancers might be expected in the future due to beta exposure, but did not consider them significant enough to address.

> "3. The additional potential radiogenic cancer contributions and risks to the TMI offsite population associated with beta radiation doses to the skin from external sources, beta and gamma radiation doses to the lungs from inhaled radionuclides, beta radiation doses to the thyroid gland from inhaled or ingested Iodine-131, and doses from Cesium 137, are very small in comparison with the projected numbers of cancers and radiogenic cancer risks from the whole-body gamma radiation...exposure doses." [PHSTF Report]

In addition to the +10 damage factor from internal beta exposure (1mr of beta being the internal equivalent to 10mr gamma), any significant external beta exposure to the eyes presents the future risk of cataracts development. Because 90% of the actual radiation exposure of the population was in the form of beta, this investigation concludes that the health risks associated with that exposure are indeed significant.

## 4.2 Beta/Gamma Radiation Exposure from Iodine-131

This investigation has demonstrated in this report that at least 48% of the core inventory of Iodine was released into the Reactor Coolant System water during the accident, and that this 48% equates to approximately 22 million curies of radioactive Iodine in gaseous form.

We have listed five separate sources of de-pressurized RCS leaks, and shown that there were at least four routes of escape of available radioactive Iodine in two separate loops exiting from different parts of the island, both undeterred by any form of filtration protection from just a few hours into the accident.

Most importantly, we have testified to the fact that most of the initial releases and many of the subsequent releases of radioactivity into the environment from Three Mile Island went unmonitored by either Met-Ed or the NRC, based on our personal experience as HPs at the plant during that time.

It is therefore our conclusion that the Kemeny Commission findings concerning Iodine releases are unreliable because they ignore the findings of their own Technical Assessment Task Force.

We conclude that the Kemeny Technical Assessment Task Force findings are unreliable because they based their estimations on release figures supplied by Metropolitan Edison and the NRC.

We know for a fact that the release figures supplied by Met-Ed and the NRC are unreliable because we were the ones taking the release monitor samples at TMI beginning just 5 days after the accident.

Because the abovementioned figures are unreliable, we conclude that releases of Iodine following the accident at TMI could have been significant enough to cause Iodine-specific biological damage to the public exposed either by proximity to the plant or through plume touchdown in isolated areas.

## 4.4 Alpha Radiation Exposure

This investigation has demonstrated that particulates were being released from Three Mile Island in the weeks following the accident. Particulates include alpha particles and heavy isotopes which emit alpha particles as part of their decay process, which also releases gamma and beta radiation of relatively high energies. Thus particulates pose by far the greatest biological hazard of all types of releases from TMI.

It is our conclusion that a small population of people living within 3 miles of the plant, as well as people who were in the locations where the plume of radioactivity touched down (which includes isolated areas much farther away from the plant) were put at risk for alpha-specific cancers and other health effects. These would include lung cancers, throat and stomach cancers, bone cancers and leukemias.