Massachusetts Institute of Technology

MIT Nuclear Reactor Laboratory

April 9, 2012

MIT respectfully provides answers, below, to the questions submitted via e-mail by a Cambridge citizen, Mr. Brad Bellows. About a dozen of these questions were asked by Mr. Bellows at a hearing of the Committee on Cable TV, Telecommunications, and Public Utilities. We note that although a number of the questions do not pertain to the safety and security of the MIT reactor, we have answered all questions to the extent we have relevant information.

Below we have included supplemental information and modifications to answers in response to follow-up questions, where appropriate. For questions for which modifications or supplements are not indicated, none have been made.

Safety & Security Questions

1. ***How does MIT's 6 kW reactor compare in size to other research reactors in the US?***

   The MIT reactor is 6 MW. There are about 25 research reactors located on university campuses across the United States and another few at the various National Laboratories. These range in power from a few Watts to 250 MW.

   Modification to answer by adding: At 6 MW, the MITR is the second largest university reactor. The one at Missouri-Columbia, which is 10 MW, is the largest university reactor. The largest reactor that is comparable to the MITR in terms of setting and purpose is that at the National Institute of Standards (NIST) which is 20 MW. .

   Supplemental information: There are many factors that determine risk. The commentary provided by Mr. Bellows mentions power rating, urban location, and the size of any buffer zone. Two other factors that merit inclusion are the presence or lack thereof of a containment and the use of passive safety features. We note that the MITR has a full containment, which is capable of sealing any non-routine radioactive emissions so that nothing is released to the public and that the MITR is designed for natural circulation cooling on loss of off-site electricity. A reactor that operated at a lower power but which lacked these features might be judged as more of a risk. In any event, the fifty-plus-year safe operating record across the research reactor community indicates that these facilities are safe.

2. ***How many research reactors the size of MIT's are located in an urban area in the US?***

   Most research reactors are located on university campuses hence are in highly populated settings.

   Supplemental information: University reactors are by definition located on a university campus and hence most are near large populations. MURR is an exception - it is on the Missouri-Columbia campus but in a remote part of that campus. If one looks at Massachusetts, the URR at UMASS-Lowell is in a very urban setting with a major highway in close proximity. The commentary provided by Mr. Bellows mentions HEU as a risk factor. HEU is a proliferation issue. But, in terms of a release, both HEU and LEU fuels have almost identical radiation levels.

3. ***Are there any other nuclear facilities in the US located within 50' of both an active railroad line and a public street?***

   The MIT reactor is located at the center of the containment building, 80' from the railroad and 100' from Albany Street. We do not have such information for other reactors.

   Modification to answer by adding: The nearest point of public occupancy is 68 feet.

   Supplemental information: NRC does not mandate a buffer zone around reactors. They do mandate zones for which emergency preparedness must be undertaken. For research reactors at power levels above 2 MW and below the maximum allowed of 10 MW, that zone is a 100 meters. It is small and that small size reflects the lack of hazard posed by these facilities. Our statement about the cargo on trains that pass behind the MITR is from the railroad itself. We are aware of the plan to extend passenger service on that rail line and foresee no vulnerabilities associated with it.

4. ***How many safety violations have occurred at the MIT NRL since it began operation, and what has been their severity?***

   The MIT reactor has operated safely since 1958 without a release that affected the general public. There have been some reportable occurrences, mostly procedural. These are rare (about one per year) and have had no radiological consequences.

   Supplemental information: There have been no exposures at the MITR in excess of legal limits. Please see response to question #6. The value of 1 kilogram in Mr. Bellows' comment should read 1 kilocurie. We put about 1000Ci per year of Ar-41 out the stack. The commentary by Mr. Bellows on the volume of water that the MITR discharges is incorrect. The MITR tries to minimize liquid discharges and these are currently about 9000 gallons per year and contain about 0.5 microcuries. The allowed sewer release is up to 7 curies. The 1.5 million gallons refers to the volume of other, non-radioactive water that is discharged to the sewer. This larger volume is reported annually to the NRC as a representation of our overall sewer discharge volume. The regulatory sewer release limits are conservatively based on the discharge being used as a sole source of drinking water for the public. Every licensee in the city is allowed to discharge to the sewers at the same regulated levels.

5. ***What changes were made following the discovery of an operator asleep and unreachable while on duty at the MIT NRP on June 30, 2003?***

   The changes that were made are those that were provided to the Nuclear Regulatory Commission in our report on this event. Our training program was revised to include a module on operator alertness and how to prepare physically for night shifts; routine activities such as data logging were split up so that the operator is required to do some physical activity every thirty minutes; and management reviewed research done on human factors to improve methods for assigning operators to the night shifts.

   Supplemental information: The minimum on-shift requirement of licensed personnel is two. Video is used extensively, primarily for security, but also for monitoring of some operations.

6. ***What changes were made following the exposure of a worker to excessive levels of radiation in 2007, when the NRC cited MIT for Severity Level IV safety violations?***

   No one was exposed to "excessive" radiation levels. The event involved a badge exposure that was above normal but still below the

safe limit. Both MIT and the Nuclear Regulatory Commission (NRC) carefully review all such exposures even when legal limits are not reached. The changes made included: improved training on the work in question, new radiation monitoring equipment with both local and remote alarms, and electronic dosimetry that allows real-time monitoring of one's dose. The NRC citation was not for the radiation exposure, but rather for procedural errors.

Supplemental information: The argument for and against a "safe" limit for radiation exposure has been under debate for decades and is not an issue that can be resolved here. For example, the commentary by Mr. Bellows states that "all exposure results in an increased mutation and cancer risk". That is not a proven scientific fact, but rather is a conservative safety principle, which ignores the presence of repair mechanisms that operate at the cellular level. Further scientific research, much of which is ongoing, is needed to resolve this. In the interim, we adhere to the NRC limits, which are conservatively set based on the linear no-threshold model. We question the validity of a further statement in the commentary from Mr. Bellows that states that the NRC both oversees and promotes nuclear energy. The NRC's mandate is to regulate nuclear activity. The U.S. Department of Energy is charged with research. No government agency has a responsibility to advocate nuclear energy.

7. ***Does the MIT reactor meet all current provisions of the Massachusetts Building Code, particularly regarding seismic design?***

The building was designed and built in the late 1950s and conformed to all building regulations at that time. It is regularly inspected by civil authorities/insurer for compliance on certain issues including fire, elevator safety, air compressor tanks, and the crane. The integrity of the containment building is verified annually with the results of the test being reviewed, also annually, by the NRC. The seismic design was reviewed by the NRC as recently as 2010.

Supplemental information: As mentioned above, the MITR employs passive safety for cooling of the core in the event of loss of off-site electricity. Loss of the cooling tower and other auxiliary equipment would mean that the reactor could not be operated. Such losses would, however, not create a safety issue provided that the containment vessel was intact.

8. ***Has a comprehensive seismic analysis and risk assessment been performed by a qualified engineering firm with no affiliation to MIT or the NRC, and if so, by whom and how recently?***

No. However, seismic analyses were performed by MIT personnel both for the license renewal in the early 1970s and for the more recent one in 2010. Both were reviewed by the NRC.

Supplemental information: As noted in our original answer, our "in-house" analysis was reviewed by the U.S. Nuclear Regulatory Commission.

9. ***Has this analysis included seismic and blast damage evaluation of all equipment, both internal and external, including backup power, water, communication and other systems?***

A summary of the analysis is contained in the MIT reactor's safety analysis report (chapter two), which is a public document on file with the NRC.

Supplemental information: The seismic analysis did not consider the combined effect of sabotage. This has been analyzed

separately as discussed below in response to question #10.

10. ***If so, has the blast analysis included the risk posed by explosive contents of freight railroad cars passing within 50' of the facility?***

    The MIT reactor is located 80' from the railroad and 100' from Albany Street. Blast analysis was performed subsequent to 9/11 by a qualified individual who was not affiliated with the MIT reactor. The study showed that the building that surrounds the MIT reactor might be damaged but the reactor core would not be damaged and there would be no radiation release to the general public. That analysis was provided to the cognizant government authorities including the City of Cambridge (Department of Emergency Management at the time).

    Supplemental information: Collapse of the vent stack was included in the seismic analysis. It was found not to be an issue. The blast analysis did not include the stack collapse, but did include the more severe assumption of the collapse of a fully loaded polar crane inside the containment building.

11. ***Has a risk assessment evaluated the potential for negligent or malicious acts by operators, including both students and employees, i.e., Fort Hood, etc.?***

    Yes. The nature of the checks is detailed in the Code of Federal Regulations (Part 10) and entails fingerprint checks by the FBI as well as a criminal background check for anyone having unrestricted access to the facility.

12. ***Are there fail-safe mechanisms in place to assure that operators follow established procedures and to limit damage if they do not?***

    Yes. The MIT reactor achieves safety through use of a defense in depth strategy. The first element of this strategy is good design and use of passive safety. For example, the core is designed for natural circulation should off-site electricity be lost. The second layer is a well-trained, qualified, licensed operator. All of our operators are licensed by the NRC. The third layer is administrative - procedures and well-designed control systems. The fourth layer is a safety system that will cause an automatic shutdown if certain license conditions are not met.

    Supplemental information: Operator fitness for duty is assessed at the time of hiring, through the continuous observation of personnel by management, and by periodic NRC-mandated physical evaluations.

13. ***What is the age of the oldest components of the cooling system, including piping, valves, and the heat exchangers which transfer heat from the reactor to the external cooling tower?***

    The oldest components in the cooling systems date to the early 1970s. However, most of the internal cooling system was replaced in 2010. Also, most of the external system (including the cooling towers) was replaced within the last few years. The MIT reactor is in excellent material condition.

    Supplemental information: Components essential to safety are kept current. We continue to replace all of our older equipment—that not essential to safety—in order to improve reliability. This is done as budgets permit.

14. ***How often is this piping inspected by X-ray or other means?***

    The frequency of inspections depends on the safety significance of the piping in question.

For example, in-core components are inspected monthly. Other systems are inspected on either a quarterly or annual basis.

Supplemental information: Most inspections are either visual or functional. By functional, we mean, can a certain component retain a certain pressure (or other pertinent requirement) for a designated interval. Ultrasonic testing is also used, particularly on our containment building.

15. Is the NRL connected to the public water supply and sewage systems?

The building is connected to public water and sewer. These connections incorporate special safety features. For example, the ones for city water all use backflow preventers and the ones for discharges employ physical separation between the reactor building and the pubic sewer.

Supplemental information: The commentary by Mr. Bellows is in error in that it says we store 1.5 million gallons of low-level radioactive liquid effluent in above ground tanks. We don't produce 1.5 million gallons of low-level radioactive liquid effluent. That figure refers to non-radioactive water that is discharged to the sewer. We do have two aboveground tanks for the storage of low-level radioactive effluent. Each can hold 1000 gallons. There are no belowground tanks. See response to question #4.

16. How is ventilation air provided to plant operators, and how long can the facility function without a connection to the outdoor atmosphere?

Ventilation is provided by intake and exhaust ducts that will be sealed automatically if abnormal radiation levels are detected in the building. Each duct has redundant dampers and the instruments that would initiate closure are quadruply redundant. In addition, the option exists for manual closure and the ducts seal automatically on loss of off-site electricity. Our operating procedures direct that the facility be shutdown on loss of ventilation.

Supplemental information: The facility is to be shut down in the event of loss of normal ventilation. We do not operate if we do not have ventilation; whether we could do so is therefore hypothetical. There is no set of circumstances that would warrant such action. As for the vulnerability of the damper penetrations, those for the exhaust are situated below ground. Those for the intake are interior to other buildings. Neither is therefore directly subject to an external blast.

17. Is the NRL located in a federally designated Flood Plain?

No.

18. How long is the facility capable of operating safely with the access door below water level?

Such a water level has never occurred, and the facility would not be operated under such circumstances.

Supplemental information: One cannot compare a reactor the size of Fukushima to the MITR. Research reactors do not have the inventory of radioactive fission products that does a Fukushima type reactor nor do they have the operating temperatures/pressures that could drive out that radioactive material, nor are they capable of generating such temperatures/pressures from decay heat.

19. How often is the reactor containment inspected for corrosion or other deterioration between the concrete and steel jacket

We perform an integral containment building leak test every year. That test would identify any incipient deterioration of the building.

Supplemental information: The containment test entails pressurizing the building to 50 inches of water, holding that pressure for several hours while monitoring for leakage. If a component were starting to deteriorate, it would either fail during this test or at least show excessive leakage.

20. What radiation exposure would be created if Highly Enriched Uranium or spent fuel were vaporized outside the reactor core during delivery or removal?

Neither of these scenarios is a credible event. There is no mechanism for vaporizing the fuel and there is a strong security presence. In the case of delivery, the fuel would be unirradiated and hence it is not a radiation hazard. In the case of spent material, the fuel is sealed in a DOT-approved shipping container before it is removed from our building.

Supplemental information: The commentary by Mr. Bellows raises the issue of an explosive being used to vaporize a fuel element. The possibility of such scenarios was considered by the NRC and that agency did retain experts in this field (explosives/terrorism) to assess such possibilities at all university research reactors. This was done in the aftermath of 9/11. The impact of detonating fresh fuel is minimal because that material is only nominally radioactive - one can hold it in one's hands. The impact of detonating spent fuel, which is very radioactive, was a primary focus of the NRC concern. The results of that study (actually several studies done over more than a year) are classified. However, had anything been identified in our facility that warranted changing, we would have been directed to change it. As for the DOT shipping container, we think that Mr. Bellows' commentary is referring to the containers used to transport fresh fuel. Fresh fuel is not a significant radiation hazard. The DOT shipping container used to transport spent fuel, which is a radiation hazard but not a significant proliferation one) is very robust and has been designed to withstand, among other things, a thirty foot drop followed by immersion in a fire for thirty minutes. To demonstrate this, Sandia National Laboratories once deliberately crashed a locomotive at full speed into such a container. Aside from some chipped paint, the cask was undamaged.

We note that there is no question #21 in the list received from the City Council.

22. How long would the radiation persist, and how long would it take and cost to clean up?

Not applicable given that the situation envisioned in question #20 is not credible.

Supplemental information: First, we feel that such a scenario is not credible. Second, the analogy to the Gulf spill is not relevant. That spill continued unchecked for months and spread over a vast area. Therefore, it required huge resources to do the clean up. Were vaporization to occur, its source would not (physically could not) continue unabated for months and it would not be allowed to spread unchecked. The unlikely potential of a dirty bomb is discussed elsewhere in these communications. The Price-Anderson pool for research reactors is $500M, not $500B, as Mr. Bellows indicated, but that is not an upper limit.

23. What is the likely evacuation radius and duration following a worst-case radiation event?

The worst-case event is the reactor's design basis accident, which is described and

analyzed in the Safety Analysis Report (public document on file with the NRC). The reactor building is designed to contain completely the radiation from this event. Thus, there would be no "likely evacuation radius" and no "duration." The public would not be affected because the MIT reactor is enclosed by a full containment building and that building could (and would) be sealed if such an event were to occur. The NRC mandates emergency planning for research reactors for a zone of only 100 meters around the site. This small radius is indicative of the low risk posed by such facilities.

Supplemental information: The design basis accident does not include the potential for sabotage. As discussed earlier, MIT did, after 9/11, commission an independent study of the potential consequences of an external blast event. The conclusion was that, under certain optimal conditions, the blast would damage our containment building but it would not damage our reactor core, which is housed within a reinforced concrete structure. The NRC also commissioned independent experts to examine sabotage scenarios, and while we have not seen those studies, we understand that no concerns were identified as regards the safety of the general public.

24. Is the MIT NRL participating in the latest NRC-mandated seismic upgrades which were implemented following the 2011 Virginia earthquake?

No, thus far the NRC has mandated actions only for the power plant community. Research reactors do not pose a significant risk to the community.

Supplemental information: Nuclear energy is a controversial topic. There are many reports prepared by its detractors that contend that it is not safe. Likewise, there are many reports prepared by its supporters that argue the opposite. The NRC is charged with sorting out the conflicting claims and regulating through the application of sound engineering and science. We adhere to the NRC mandates and so far there have been none for non-power reactors following the Virginia earthquake.

25. How much Highly Enriched Uranium is present at the MIT NRL, and how does this amount compare to the minimum amount needed to construct a functioning nuclear weapon?

That figure is given in our license which is a public document that is on file with the NRC. We see no value to discussing what is required to build a weapon. We do note that (1) the MIT reactor does "just-in-time" refuelings so that our inventory of fresh fuel is almost always zero, (2) that the amount of fresh fuel brought in for any given refueling is always significantly less than what would be required to construct a weapon, and (3) it is not possible to construct a weapon from spent fuel given the presence of highly radioactive fission products.

Supplemental information: We stand by our statement that it is not possible to construct a nuclear weapon from our spent fuel. The commentary provided by Mr. Bellows is mixing the idea of a nuclear weapon with a dirty bomb. A weapon involves an uncontrolled fission reaction and is capable of massive destruction from blast effects. A dirty bomb involves a conventional explosive and is capable of damaging only the immediate area in which it was detonated.

26. What is the status of MIT NRL's plans to convert to less enriched Uranium 235 (originally to have been completed by 2014)?

We are enthusiastic to implement the conversion and have a very active program in progress. We are awaiting qualification of low enriched uranium (LEU) fuel suitable for use at the MITR by the U.S. Department of Energy.

Supplemental information: The conversion date is set by the U.S. Department of Energy and it is responsible for the conversion schedule, currently 2016. MIT does not control the timing of the conversion but has in fact volunteered to be the first out of the five HEU higher power research reactors in the U.S. to convert. The issue is to identify and test a suitable LEU fuel and certify that it is safe to use. This is a scientific matter and not a matter of increased funding.

27. ***Is adequate (military level) security provided during delivery and removal of bomb-grade materials?***

Yes. Details of the security that is provided are "safeguards information." That information is shared with the cognizant civil agencies including those of the City of Cambridge and the Commonwealth of Massachusetts, as well as federal authorities.

28. ***Is the MIT NRL participating in the latest Homeland Security upgrades to secure weapons grade or "dirty bomb" materials?***

Yes, again details are "safeguards information." The City of Cambridge (Fire and Police) has been briefed on our upgrades under this federal program.

29. ***What is the maximum amount of spent fuel that is permitted to be stored at the MIT NRL, and what is the maximum amount that has actually been stored?***

We minimize the spent fuel that is stored on site by regular off-site shipment. The U.S. Department of Energy retains title to the fuel and they arrange for its return to a DOE site at a regular frequency. Again, shipment details are "safeguards information" that is shared with city and state authorities.

Supplemental information: The commentary by Mr. Bellows is correct in that MIT has not considered vaporization of spent fuel. However, as noted above, NRC has retained experts and has had the appropriate analyses performed.

Economic Risk Questions

30. ***Has there been any comprehensive, independent analysis of the economic impact which would result from a radiation leak at the MIT facility?***

No, because the worst-case event does not produce a radiation leak. Please see response to question #23 above.

Supplemental information: None, except to note again the research reactors do not have the source term associated with a Fukushima type facility.

31. ***Is the facility subject to the liability caps imposed by the Price-Anderson Act, and if so, what is that amount of the cap?***

According to the provisions of Price-Anderson, the government-sponsored insurers pay claims above $250k for nuclear incidents.

Supplemental information: None, except to note that the Price-Anderson Act is a matter of federal legislation enacted after much debate. It is not MIT's role to change that policy.

32. ***What is the current amount of liability insurance carried by MIT for the NRL?***

We have $3M in nuclear liability coverage

33. ***What is the current Assessed Value of property in the City of Cambridge, including both taxable and non-taxable properties?***

Information available on the City Assessing Department website shows the most recent total value of all taxable property as $24.2 billion.

34. ***What is the current value of the MIT Endowment, and is the University prepared to indemnify neighbors for all direct and indirect losses they might incur as the result of a leak?***

MIT endowment was $9.9B at the end of fiscal year 2011.

MIT exercises appropriate levels of controls and best practices in managing the activities of and access to our Nuclear Reactor Lab that are consistent with regulatory and insurer requirements and guidelines. To the extent that there is a nuclear incident resulting in a leak, MIT is prepared, through the Price-Anderson Act, to address all claims.

35. ***What is the potential value and alternative uses of the property currently occupied by the MIT NRL and its buffer zones?***

Given our education and research mission, the current use is the highest and best use.

36. ***What is the cost to the of the public safety coordination that the City provides to the MIT NRL, and how does this compare to that provided for other research groups and property owners?***

This question should be directed to the City of Cambridge Fire and Police Departments. We believe that our impact on those Departments is minimal. Our interaction primarily consists of cross training of our people and their officers.

37. ***What costs and benefits would result if the MIT NRL were located elsewhere (for example, at another existing nuclear facility, such as Pilgrim Station, Plymouth MA (40 miles from Boston) or Seabrook Station, Seabrook NH (45 miles from Boston)?***

The reactor is located on the MIT Campus to achieve synergy with the faculty and students. The reactor could not be relocated (one of the conditions of its license is its present location) and to do so would not benefit either education or research.

38. ***Has MIT formally investigated alternative locations for the MIT NRL (at either the Departmental or University level), and if so, how recently?***

No

39. ***What is the remaining "Useful Life" of the MIT NRL?***

The current license, which was issued in the fall of 2010, runs until the fall of 2030. So, the minimum useful life is 19 more years.

Supplemental information: The decision to request relicensing of the MITR through 2030 was made by the MIT Administration, based on the opinion that the reactor remains a useful contributor to education and research on the MIT Campus.

40. ***What is the plan for decommissioning the facility, and when is this likely to occur?***

MIT has no plans for decommissioning the reactor.

Supplemental information: The decommissioning plan referenced in the commentary provided by Mr. Bellows is an NRC requirement under which each licensee is directed to estimate the ultimate cost of decommissioning and then to provide assurance that funds will be available. The existence of such estimates does not mean that the licensee has any near-term or even long-term plans to decommission.