COMMENTS ON THE "EMERGENCY RESPONSE ASSISTANCE PLAN" FOR THE MOX FUEL SHIPMENT FROM MOSCOW TO CHALK RIVER

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Overall comments

The "Emergency Response Assistance Plan" (ERAP) prepared by Atomic Energy of Canada, Ltd (AECL) does a wholly inadequate job of informing the public of the potential risks of the air shipment of MOX fuel to Canada. Numerous assertions are made regarding the robustness of both the shipping package and the MOX fuel pellets themselves under extreme conditions typical of an air crash --- however, no technical documents are referenced and no other evidence is provided to support them. On the other hand, evidence is publicly available that contradicts many of these assertions. These statements call into question the ability of AECL to accurately assess the potential risks of an air crash involving the Parallex MOX fuel, and hence raise doubts about whether the ERAP that AECL has developed is based on a sufficiently conservative "worst case scenario."

The flaws in the ERAP are extremely damaging to the AECL's credibility with regard to its ability to safely oversee this shipment. Without having a realistic appraisal of the "worst-case scenario," AECL cannot make a convincing case that it is taking the necessary precautions to ensure that the public will be protected if the unthinkable indeed comes to pass. It should be noted that the public health consequences of the September 1999 criticality accident in Tokaimura were greatly worsened by the failure of government authorities and plant management to take into account a worst-case accident in their emergency planning guidelines.

Vulnerability of the shipping package

The ERAP contains numerous highly misleading descriptions of the robustness of the TNB-0145/4 shipping package that will be used for the MOX fuel air transport.

While the ERAP asserts that "the TNB-0145/4 packaging is specially designed to withstand transportation accidents," nowhere does it make clear that this statement refers to <u>ground-based accidents only</u>. The TNB-0145/4 is a "Type B(U)F" package, which means that it has been designed to meet "Type B" transport standards developed by the International Atomic Energy Agency (IAEA). These standards, which include a series of drop tests from a height of nine meters onto an unyielding surface (corresponding to an impact velocity of 13.2 m/s), followed by a 30-minute engulfing fire test at 800°C, have been determined by the IAEA to be inadequate to guarantee the same level of safety when applied to air transport as when applied to ground transport. This conclusion follows from the obvious point that the mechanical and thermal stresses experienced by a transport package during an air crash are likely to be considerably greater than those experienced during a typical accident on the ground. In fact, the IAEA assumes that Type B packages would leak when exposed to impact conditions typical of a plane crash.[1]

As a result, the IAEA developed a new, more stringent set of standards for packages intended for the transport of large quantities of radioactive materials by air, known as "Type C" standards. The Type C test regimen involves an impact test at a velocity of 90 m/s on an unyielding surface, and a (non-sequential) 60-minute fire test at a temperature of 800°C.

These standards, which took ten years to be developed and were heavily influenced by IAEA member states with a commercial interest in the air shipment of plutonium, fall far short of what would be necessary to guarantee an appropriate level of safety for air transport of radioactive materials. In fact, in developing the standards, the IAEA itself conceded that around 10% of plane crashes were likely to generate conditions more severe than those represented by the Type C tests. Nevertheless, they represent a considerably more severe accident environment than the Type B tests. For example, the Type C impact test delivers a kinetic energy more than forty times greater than the Type B test.

Current IAEA regulations allow an exemption from the Type C requirement for quantities of weapons-grade plutonium below about 3 terabecquerels (TBq), and that the amount in the Parallex shipment (about 1.4 TBq) is less than half this value. However, this exemption value was based on the (unsupported) supposition that a Type B package subject to a Type C impact would release from 0.3% - 3% of its contents. For the Parallex shipment, this corresponds to a release of 1.6 to 16 grams of weapons-grade plutonium. IAEA would consider this an "acceptable" release. However, a release of this magnitude, if occurring in a populated area such as southern Ontario, could have a significant radiological impact. In addition, there is little experimental evidence to support releases as small as those used by the IAEA in deriving the exemption values. It is likely that a Type B package would lose its containment function completely in a serious plane crash.

The ERAP asserts that "testing has shown that the actual reserve safety margins for packages licensed to ship radioactive materials extend well beyond the IAEA test requirements before failure," and infers that this applies to the TNB-0145/4 as well. However, AECL provides no references to credible, well-documented or reproducible evidence to support this claim, either for Type B radioactive material transport packages in general or the TNB-0145/4 in particular.

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[1] International Atomic Energy Agency (IAEA*), The Air Transport of Radioactive Materials in Large Quantities of With High Activity,* TECDOC-702 (Vienna, 1993), p. 31.

While large, heavy spent fuel transport casks may contain such a margin, since the thickness of their steel walls (on the order of 25 centimeters) is determined by gamma ray shielding considerations and not by structural requirements, there is no basis for a similar conclusion regarding the thin-walled TNB-0145/4 package.

On the contrary, there is considerable evidence to support the conclusion that packages are designed with little excess margin for cost reasons. One example is the use of elastomeric (rubber-like) lid seals instead of more expensive and heat-resistant metal seals. Although these seals degrade and lose their containment function after heating to 250-350°C, they are still in routine use in Type B packages because fire tests usually show that the seals remain below this temperature after a 30-minute fire at 800°C. However, the margin to failure is not very large. A recent study by Sandia National Laboratories (SNL) shows that for typical Type B spent fuel packages --- which are much more massive and would heat up much more slowly in a fire than the TNB-0145/4 --- the seal failure temperature can be reached in as little as 35 minutes at a fire temperature of 1000°C, and as little as 64 minutes for a fire temperature of 800°C.[2] Thus a package that passes the Type B fire test could well fail the Type C fire test. There is no indication that it could survive the even more severe fire that could result from a plane crash.

AECL tries to deny this by arguing that "packages similar to the one selected for the ... shipment have survived tests in the 1970s based on *then-current standards* [emphasis added] for aircraft flight recorders (black box) and impact tests onto a runway at more than 200 km/hr."

There are at least two misleading and technically unsound inferences in this sentence. First of all, tests on "packages similar" to the TNB-0145/4 have little bearing on the TNB-0145/4 itself. Variations in design assumptions, construction materials, and manufacturing quality control all play a significant role in the robustness of a package. Even two packages manufactured from an identical design may behave differently under test conditions. There have been numerous examples of individual packages constructed according to approved designs failing Type B drop tests, the most recent example being the DOE 9975 package, a 35-gallon drum designed for plutonium transport not unlike the TNB-0145/4. In April of this year, a Type B drop test caused a large gap to open in the seal area of a 9975, resulting in an effort to redesign the package.[3]

Second of all, even if one assumes (in the absence of actual data or references) that this "similar package" indeed survived the "black box" standards that were current in the 1970s, then one may ask if this provides any indication that the package could withstand the standards in place today. New black box standards were introduced in 1990 because, as the Transportation Safety Board of Canada pointed out in a letter to

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[2] J.L. Sprung et al., *Re-Examination of Spent Fuel Shipment Risk Estimates, Vol. 1,* NUREG-6672 (SAND2000-0234) (Albuquerque, NM: Sandia National Laboratories, March 2000), p. 6-5.
[3] U.S. Defense Nuclear Facilities Safety Board (DNFSB), *Savannah River Site Report for Week Ending April 7, 2000*, available on the World-Wide Web at www.dnfsb.gov.

Transport Canada in 1995, "as recorders certified to the [then-] existing standards failed, the standards were raised to improve the survivability."[4]

The revised black box standards are considerably more stringent than the IAEA Type C standards. First of all, a black box must be able to withstand an entire test sequence, involving impact, penetration, static crush, high or low temperature and fluid immersion, whereas different Type C packages can be used for the impact and thermal tests. Second, the impact test is equivalent to a crash at a speed of 130 m/s into an unyielding surface, about 1.44 times the Type C speed (and 10 times the Type B speed). Third, the thermal tests are much more severe than the Type C test. The high temperature test involves exposure to a temperature of 1100°C (typical of jet fuel fires) for 60 minutes, while the low temperature test involves exposure at 260°C for 10 hours to simulate a smoldering burn.

Given that the black box standards were developed based on experience from actual plane crashes and are far more stringent than Type C standards, AECL's assertion that the TNB-0145/4 would survive a plane crash is entirely incredible. If AECL is so confident on this point, then it should arrange to subject this package to the current black box test sequence and invite the public to observe. A successful test would go a long way toward convincing the public of the safety of the MOX shipment.

Dispersibility of MOX fuel

AECL's characterization of MOX fuel as a virtually indestructible material is not supported by publicly available information.

Its contention that "MOX fuel will not explode, ignite or react with air or water" is a highly misleading statement. While it is true that it will not explode and it would be difficult to ignite, there are accident conditions which certainly could cause it to react with air or water.

Most important of these from an accident perspective are oxidation reactions at relatively low temperatures (from 250-430°C), which can result in significant particulate formation. It has been demonstrated that exposing sintered MOX fuel pellets to a temperature of 430°C in air for 60 minutes resulted in release of nearly 70% of the fuel in the form of particles with diameters less than 25 microns, of which over 6% was observed to be of respirable size (below 10 microns).[5] An accident involving an impact which breaches the fuel cladding, followed by a relatively low-temperature fire, could cause the package seals to fail, oxygen ingress into the package, and fuel pulverization.

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[4] Letter from M. Poole, Transportation Safety Board of Canada, to M. Sastre, Transport Canada, April 24, 1995; Appendix 2 of the *Report of the Ottawa Meeting of the Dangerous Goods Panel of the International Civil Aviation Organization (ICAO)*, DGP/WG95-DP/2, 24-28 April 1995.

[5] H. Seehars and D. Hochrainer, "Durchfuehrung von Experimenten zur Unterstuetzung der Annahmen zur Freisetzung von Plutonium bei einem Flugzeugabsturz (Fraunhofer-Institut fuer Toxikologie und Aerosolforschung, March 1982), p. 50-54.

AECL also claims that for MOX fuel, "high energy impact tests do not generate a significant portion of the fuel as a fine powder that could be dispersed in an accident." However, ceramics are brittle materials and will indeed pulverize if subjected to the impacts typical of plane crashes. According to a correlation for uranium fuel used by DOE, an impact at 130 m/s would cause 1.7% of the initial fuel mass to be released in the form of respirable particles, hardly an "insignificant portion."[6] This corresponds to about 9 grams of plutonium for the Parallex shipment. If the impact were followed by a low-temperature fire as described in the previous paragraph, the production of respirable particles would be considerably greater.

Conclusion

The ERAP should be rejected in its current form. It should be rewritten, taking into account the most recent analyses and experimental evidence regarding the performance of Type B shipping packages and the dispersibility of MOX fuel in air crashes. A realistic worst-case scenario should be explicitly defined, the unmitigated consequences should be modeled, and the impact of proposed emergency planning measures on reducing those consequences should be assessed. Only then will Transport Canada have a basis for assessing whether the ERAP fully and credibly meets its requirement that it address "accidents in which the MOX fuel samples may be released outside of the ... package as a mixture of ceramic pellets and dust."

[6] J. L. Sprung et al., *Re-Examination of Spent Fuel Risks, Vol. 1,* p. 7-45.