U.S. Department
of Transportation
**Research and
Special Programs
Administration**

400 Seventh St., S.W.
Washington, D.C. 20590

OCT 19 2004

Dr. Gerald P. Jackson
President
Hbar Technologies, LLC
1275 Roosevelt Road, Suite 103
West Chicago, IL 60185

Ref. No. 04-0085

Dear Dr. Jackson:

Thank you for your March 24, 2004 letter regarding the classification of antiprotons under the Hazardous Material Regulations (HMR; 49 CFR parts 171-180). Specifically, you ask whether antiprotons, transported in quantities capable of producing a worst case acute exposure to the public of no more than 2 mrem or 1,000 rem from prompt ionizing radiation, are considered a hazardous material, and if so, which category (hazard class and division) applies. You state that the antiprotons are intrinsically stable and would only emit radiation upon contact with residual gas within the bottle or the walls of the bottle.

Your letter does not provide sufficient information on the hazardous properties of your particular material, the amount of material to be transported, or the manner in which the material is packaged to provide you with specific guidance. Nevertheless, based upon the information you provided, we believe that sufficient quantities of antimatter offered for transportation would meet the defining criteria of a Class 1 (explosive), a Class 7 (radioactive), and perhaps other Class material. For example, a dose of 1,000 rem of prompt ionizing radiation to the public is significantly greater than the defining annual dose criteria for Class 7 (radioactive) material. As with other hazardous materials, we also believe a graded approach based on the quantities of antiprotons and their related possible effects would be appropriate.

We recognize that antimatter is not specifically listed in the HMR and the need for possible future rulemaking on this emerging technology. In order to complete our review of your proposed single transport of antiprotons later this year from the Fermi National Accelerator Laboratory in Batavia, IL to the NASA Marshall Space Flight Center in Huntsville, AL, we have identified the following issues pertaining to your request.

Material

1) Provide information on the material purity as well as the method and accuracy of measuring the quantities of antiprotons proposed to be transported.

2) Provide the quantities of antiprotons that you may desire to transport, based on your evaluation of the information requested in this letter.

040085

171.8

Containment System

3) Describe the antimatter transport bottle, including design features such as materials of construction, barriers, shielding, vacuum system, cryogenics, superconducting magnets, detection systems for loss of design feature functions or annihilation of the antiprotons, and contingency backup systems.

4) Provide information on magnetic fields produced by the bottle system.

5) Describe any other hazardous materials present other than antiprotons, such as helium or other compressed or liquefied gas, batteries, or fuels.

Failure Modes

6) Detail the processes, such as prolonged or rapid loss of vacuum, cryogenics, or electromagnetic containment in the transport bottle, that could cause annihilation of the antiprotons with matter, as well as information on any steady state annihilation.

7) Provide information on any past experience with planned or unplanned stored antiproton annihilation.

Transport

8) Provide details on the truck and any design features, such as shielding or barriers, to be used for the transport.

9) Provide details on any operational controls or contingency planning to be used during transport.

10) Provide details on any personnel or environmental monitoring for hazardous materials to be instituted during transport, such as dosimetry selection for prompt or delayed radiation hazards, including radiation type and energy coverage as well as any applicable accreditation.

Consequences

11) Provide the supporting information for the ionizing radiation exposure determination you provided from antiproton annihilation with matter, specifying contributions from all products and processes, including energies and decay times. Provide information on the total effective dose equivalent, deep dose equivalent, committed effective dose equivalent if any, committed dose equivalent if any, shallow dose equivalent, and lens dose equivalent; and quality factors used. Include contribution from decay chain daughter products. Provide spatial and time data.

12) Provide an analysis of the level of safety of the bottle under normal and accident conditions during transport that could lead to annihilation of the antiprotons with matter.

13) Provide information on possible fission effects caused by antiproton annihilation with matter, such as caused by pions or high-energy gamma rays, on any transuranic and fissile material that may be impacted.

14) Provide information on airborne radioactivity, radioactive material contamination, and induced activation caused by the antiproton annihilation.

15) Your memo provides data for a single prompt dose to the public. Provide the quantity of antiprotons that would cause this dose and the assumptions used. Provide the total, and not just prompt dose, if the total dose is different. Provide estimated total doses to any transport workers and the assumptions, such as distance, utilized. Provide a time and spatial plot of total doses estimated.

16) Provide data on heat generated and the explosive potential of the antiprotons annihilating with matter.

17) Explain the correlation of effects based on the quantity of antiprotons, e.g., linearity, or any phenomena that would cause non-linear or threshold effects based on the quantity of antiprotons.

General

18) Estimate the margin of error in any calculations or experimental data you provide.

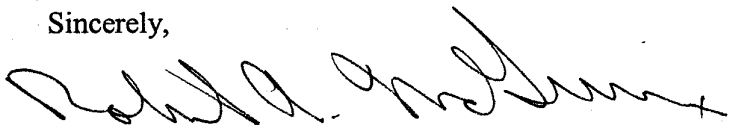
19) Provide references used and details on any computer codes used to provide information relevant to these issues, and any verification and validation performed.

20) Provide details on the credentials and backgrounds of personnel involved in providing information relevant to the issues, including peer reviewers.

21) Provide any test data that substantiates calculated data, or of any physical testing that is planned to be conducted to corroborate any calculated data.

Should you have further questions on this matter, please contact Mr. Jim Williams, Office of Hazardous Materials Technology, (202) 366-4545.

Sincerely,



Robert A. McGuire
Associate Administrator for
Hazardous Material Safety

In my opinion, this is a good start at a letter. I have annotated this using the Microsoft Word Track Changes features for my own convenience. Don Cossairt, October 12, 2004. Please kindly regard all of my suggestions in the context of USDOT practices and existing Regulations. As I explained over the telephone, I am not an expert per se on DOT procedures. We have others here at Fermilab who take care of that topic for me!

Betts
§ 171.8
Definitions
04-0085

Dr. Gerald P. Jackson
President
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Dear Dr. Jackson:

Thank you for your March 24, 2004 letter regarding the classification of antiprotons under the Hazardous Material Regulations (HMR; 49 CFR parts 171-180). Specifically, you ask whether antiprotons, transported in quantities capable of producing a worst case acute exposure to the public of no more than 2 mrem or 1,000 rem from prompt ionizing radiation, are considered a hazardous material, and if so, which category (hazard class and division) applies. You state that the antiprotons are intrinsically stable and would only emit radiation upon contact with residual gas within the bottle or the walls of the bottle. In my judgment it seems to me Hbar has asked for advice over a rather wide range of worst case doses. I suggest that DOT point that out and introduce early in this letter the possibility that several levels of stringency will be required at different points just like what is done for other ionizing radiation hazards.

Your letter does not provide sufficient information on the hazardous properties of your particular material, the amount of material to be transported, or the manner in which the material is packaged to provide you with specific guidance. Nevertheless, based upon the information you provided, we believe that sufficient quantities of antimatter offered for transportation would meet the defining criteria of a Class 1 (explosive), a Class 7 (radioactive), and perhaps other Class material. In my view, I would point out Class 7 first, as I think this the "exotic" issue. However, you should still list explosive hazard. I believe the latter hazard is more likely to present itself due to the nature of the technology used to create the bottle than from the antiproton annihilations themselves for the quantities of antiprotons they are talking about transporting. See comments below concerning other hazards. For example, a dose of 1,000 rem of prompt ionizing radiation to the public is significantly greater than the defining annual dose criteria for Class 7 (radioactive) material. Again, the worst case dose is crucial to determining what DOT might require, I suggest.

Deleted:

We recognize that antimatter is not specifically listed in the HMR and the need for possible future rulemaking on this emerging technology. In order to complete our review of your proposed single transport of antiprotons later this year from the Fermi National Accelerator

Laboratory in Batavia, IL to the NASA Marshall Space Flight Center in Huntsville, AL, we have identified the following issues pertaining to your request to determine if the proposed quantity meets the defining criteria for hazard classes and divisions in the HMR.

Material

1) Provide information on the material purity as well as the method and accuracy of measuring the quantities of antiprotons proposed to be transported. This is a good issue. They should be able to describe to you how they will know how many antiprotons they have in the bottle as I imagine it will make a difference in what requirements will be prescribed.

2) Provide the quantities of antiprotons that you may desire to transport, based on your evaluation of the information requested in this letter. They did, indeed, as for a big range!

Containment System

3) Describe the antimatter transport bottle, including design features such as materials of construction, barriers, shielding, vacuum system, cryogenics, superconducting magnets, and detection systems for loss of design feature functions or annihilation of the antiprotons.

4) Provide information on magnetic fields produced by the bottle system. Yes, there will be stray magnetic fields. In my limited expertise with DOT, I cannot recall any requirements pertaining to magnetic fields.

5) Describe any other hazardous materials present, such as helium. Is helium really a hazardous material per DOT (pardon my ignorance!). Under some situations it can be an asphysixiant.

Failure Modes

6) Detail the processes, such as shock, prolonged or rapid loss of vacuum, cryogenics, or electromagnetic containment in the transport bottle that could cause annihilation of the antiprotons with matter, as well as information on any steady state annihilation. Good issue to raise, you have brought up the 2 key problems that can cause annihilations; loss of vacuum and loss of electromagnetic containment. You might want to ask about backup systems, if any, that might be present to assure this does not happen. I doubt if steady-state annihilation is a problem but they should address this.

7) Provide information on any past experience with planned or unplanned stored antiproton annihilation.

Transport

8) Provide details on the truck and any design features, such as shielding or barriers, to be used for the transport. Good.

9) Provide details on any operational controls or contingency planning to be used during transport. Good.

10) Provide details on any personnel or environmental monitoring for any hazardous materials during transport. I suggest restating this point to cover personnel or environmental monitoring for possible prompt radiation hazards. I don't believe other hazardous materials are a significant issue. However, if it is decided to require personnel monitoring badges, the choice of dosimetry badge is crucial. Due to the nature of the radiation fields, they would have to select dosimeter that is capable of seeing fast neutrons as well as gamma-rays. I would insist on a NVLAP-accreditated badge inclusive of fast-neutron capability.

Consequences

11) Provide the supporting information for the ionizing radiation exposure determination you provided from antiproton annihilation with matter, specifying contributions from all products and processes, including energies and decay times. Provide information on the total effective dose equivalent, deep dose equivalent, committed effective dose equivalent if any, committed dose equivalent if any, shallow dose equivalent, and lens dose equivalent; and quality factors used. Include contribution from decay chain daughter products. Provide spatial and time data. I think this is nearly all a "prompt" situation with insignificant decay products, but let them tell you that. From my own work, it will all be deep dose equivalent as all of the major components of the radiation field have sizeable mean-free paths in tissue. At one point a crude calculation had been done by one of G. Jackson's partners. However, it left out some effects that my paper didn't and generally underestimated the doses. We'll see what they submit here.

12) Provide an analysis of the level of safety of the bottle under normal and accident conditions during transport that could lead to annihilation of the antiprotons with matter. See my comment about failures above.

13) Provide information on possible fission caused by antiproton annihilation with matter, such as caused by pions or high-energy gamma rays, on transuranic and fissile material that may be impacted. Fission won't be a problem unless they shield the bottle with uranium! However, should they, for some reason not obvious to me, choose depleted uranium as a shield to make the thing compact, fission would have to be considered.

14) Provide information on airborne radioactivity, radioactive material contamination, and induced activation caused by the antiproton annihilation. These should be non-issues for the quantities envisioned here. However, they should state their conclusions on this.

15) Your memo provides data for a single prompt dose to the public. Provide the quantity of antiprotons that would cause this dose and the assumptions used. Provide the total, and not just prompt dose, if the total dose is different. Provide estimated total doses to any transport workers and the assumptions, such as distance, utilized. Provide a time and spatial plot of total doses estimated. See comment above concerning calculations that might be outdated.

16) Provide data on heat generated and the explosive potential of the antiprotons annihilating with matter.

17) Explain the correlation of effects based on the quantity of antiprotons, e.g., linearity, or any phenomena that would cause non-linear or threshold effects based on the quantity of antiprotons. I don't think there are any such effects but they should be able to demonstrate that.

General

18) Estimate the margin of error in any calculations or experimental data you provide.

19) Provide references used and details on any computer codes used to provide information relevant to these issues, and any verification and validation performed.

20) Provide details on the credentials and backgrounds of personnel involved in providing information relevant to the issues, including peer reviewers. I realize that I will have to be careful here as G. Jackson might come back to me on this! Since I have already agreed to help DOT on this, I will recuse myself from assisting Jackson unless you see this different.

21) Provide any test data that substantiates calculated data, or of any physical testing that is planned to be conducted to corroborate any calculated data.

Should you have further questions on this matter, please contact Mr. Jim Williams, Office of Hazardous Materials Technology, (202) 366-4545.

Sincerely,

Robert A. McGuire
Associate Administrator for
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