ASPIRATION REQUIREMENTS FOR THE TRANSPORTATION OF RETRIEVABLY STORED WASTE IN THE TRUPACT-II PACKAGE*

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ABSTRACT

The Transuranic Package Transporter-II (TRUPACT-II) is the shipping package to be used for the transportation of contact-handled transuranic (CH TRU) waste between the various U.S. Department of Energy (DOE) sites, and to the Waste Isolation Pilot Plant (WIPP) located near Carlsbad, New Mexico. Waste (payload) containers to be transported in the TRUPACT-II package are required to be vented prior to being shipped (2). "Venting" refers to the installation of one or more carbon composite filters in the lid of the container, and the puncturing of a rigid liner (if present). This is a transportation requirement for a payload in TRUPACT-II package (2). Stored payload containers need to be aspirated for a sufficient period of time, so that under theoretical worst-case conditions, acceptably low gas concentrations are achieved. The period of time for which a payload container needs to be in a vented condition before qualifying for transport in a TRUPACT-II package is defined as the "aspiration time."

This paper presents the basis for evaluating the minimum aspiration time for a payload container that has been in unvented storage. Three different options available to the DOE sites for meeting the aspiration requirements are described in this paper.

INTRODUCTION

The TRUPACT-II is the shipping package designed for the transportation of CH TRU waste. TRU waste is defined as waste contaminated to greater than 100 nanocuries per gram with predominantly alpha emitting radionuclides of atomic numbers greater than 92 and half lives greater than 20 years (4). CH TRU waste is TRU waste with an external dose rate less than 200 mrem/hr at the container's surface. A detailed description of the TRUPACT-II package and its payload contents is provided in the Safety Analysis Report (SAR) submitted to the Nuclear Regulatory Commission (NRC) (2). Based on the analysis presented in the SAR, the NRC issued a Certificate of Compliance for the TRUPACT-II package in August 1989.

One of the transportation requirements for payload containers in the TRUPACT-II package is that they be vented prior to transport. Venting involves the installation of one or more carbon composite filters in the lid of the containers, and the puncturing of any rigid liners present. The carbon composite filters are High-Efficiency Particulate Air (HEPA-Grade) and act as barriers for particulates while allowing equilibration of gases with the air volume outside the payload container. The properties of these filters are described in detail elsewhere (2). When retrievably-stored waste is present in an unvented condition, there is a potential for gases to accumulate within the different confinement layers. Examples of these confinement layers are plastic bags that contain the waste, and void volumes within the rigid liner and drum. Drums have been shown to be stored under perfectly safe conditions, without being vented for prolonged periods of time (3). The venting and aspiration provide an added margin of safety preventing any potential gas accumulation. When the payload container is vented, a certain period of time (equal to the aspiration time) has to elapse before the payload container can be shown to meet the transportation requirements.

CONCEPTUAL MODEL FOR PAYLOAD CONTAINER ASPIRATION

A schematic of a typical packaging configuration for CH TRU waste at the DOE sites is presented in Fig. 1. As shown in the figure, the waste is placed inside one or more plastic bags which are then closed by twisting and taping at the end. Currently, the twist and tape closure is a requirement of the TRUPACT-II SAR. The bags are then usually placed inside a 90-mil polyethylene rigid liner (optional), which is then placed in a 208-liter drum. The bags, the rigid liner, and the drum constitute the different layers of con-

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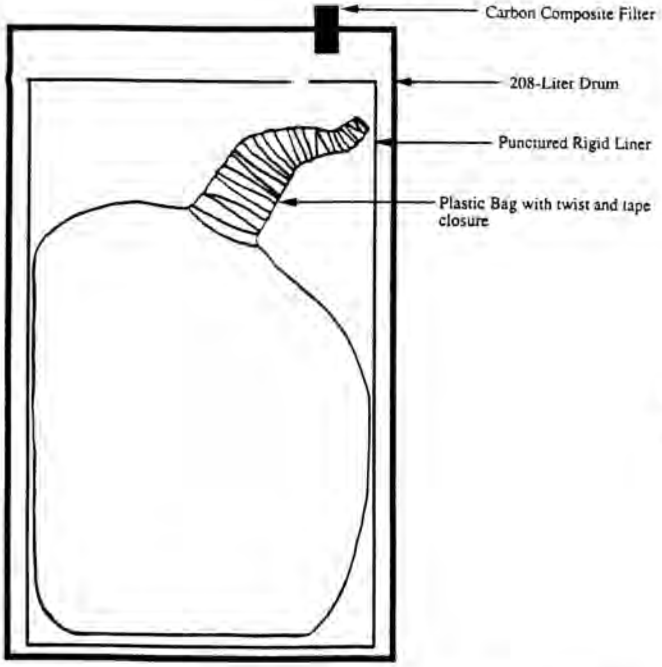

Fig. 1. Example of Packaging Configuration For 208-Liter Drums.

finement for the waste. The drum must be fitted with a carbon composite filter prior to transport. The rigid liner must be punctured or provided with a filter.

The waste in the bags is either solidified or solid material, examples being cemented sludges, glass, metal, paper, plastic and other organics. Radiolysis of these waste materials can result in the generation of hydrogen inside the plastic bags, with the generation rates depending on the material being irradiated. Bounding values of these generation rates have been estimated for the different waste forms to provide conservative estimates of their gas generation potential (2). Release of the hydrogen from the bags occurs by diffusion through the twist and tape closure (which is the only allowable method of closure for the bags) and by permeation through the bag material. Release of hydrogen through the rigid liner and drum occur through the puncture in the liner and the carbon composite filter in the drum. All of these release rates have been conservatively estimated and quantified by experiments (2). Once steady-state conditions are reached, the generation rate of hydrogen, and the release rates of hydrogen across the different confinement layers are equal, and the concentrations of hydrogen in the different confinement layers remain constant. The amount of radioactive material (or decay heat) present per payload container is restricted such that, given the bounding generation and release rates, the concentrations of hydrogen remain below five mole percent in any layer of confinement during a 60-day shipping period. The methodology of arriving at these limits, and the margins of safety involved are described in detail in the TRUPACT-II SAR (2).

Knowing the hydrogen generation and release rates, and related parameters, the accumulation of hydrogen during storage, and subsequent aspiration during venting, can be simulated by performing a mass balance on hydrogen for each confinement layer.

ASSUMPTIONS AND PARAMETERS GOVERNING ASPIRATION TIMES

This section describes the parameters and assumptions used for determining the aspiration times for retrievably-stored waste.

1. Pressure and Temperature: The pressure and temperature are assumed to be 1 atmosphere and 294 K, respectively.
2. Hydrogen Generation and Release Rates: As mentioned earlier, bounding values have been established for hydrogen generation rates for the different waste forms, and for release rates for different packaging configurations. The methodology for arriving at these is presented in the TRUPACT-II SAR (2). No credit is taken for decreasing hydrogen generation rates due to depletion of the waste matrix.
3. Void Volumes in Confinement Layers: The void volumes in each confinement layer determine the concentrations of hydrogen (mass of hydrogen divided by the volume of the layer) in each of the layers. Total void volumes used in determining the aspiration times were based on data obtained from a sampling program conducted at the Idaho National Engineering Laboratories (INEL) (3). These volumes were distributed between the different confinement layers based on data obtained from actual measurements, and aspiration studies conducted at the INEL (1). For packaging configurations with multiple bag layers, an effective void volume was obtained by treating all of the bags as one layer. By attributing all of the available void volume in the bags to the innermost layer, the most conservative aspiration times were obtained. The mathematical analysis governing this parameter as well as the overall mass balances will be presented elsewhere. A theoretical discussion of the behavior of an aspirating drum is presented below, along with the different options by which the proper aspiration time can be determined.

HYDROGEN CONCENTRATION PROFILES IN A RETRIEVABLY-STORED PAYLOAD CONTAINER

Figure 2 is a plot of the hydrogen concentration in the different confinement layers in the payload container as a

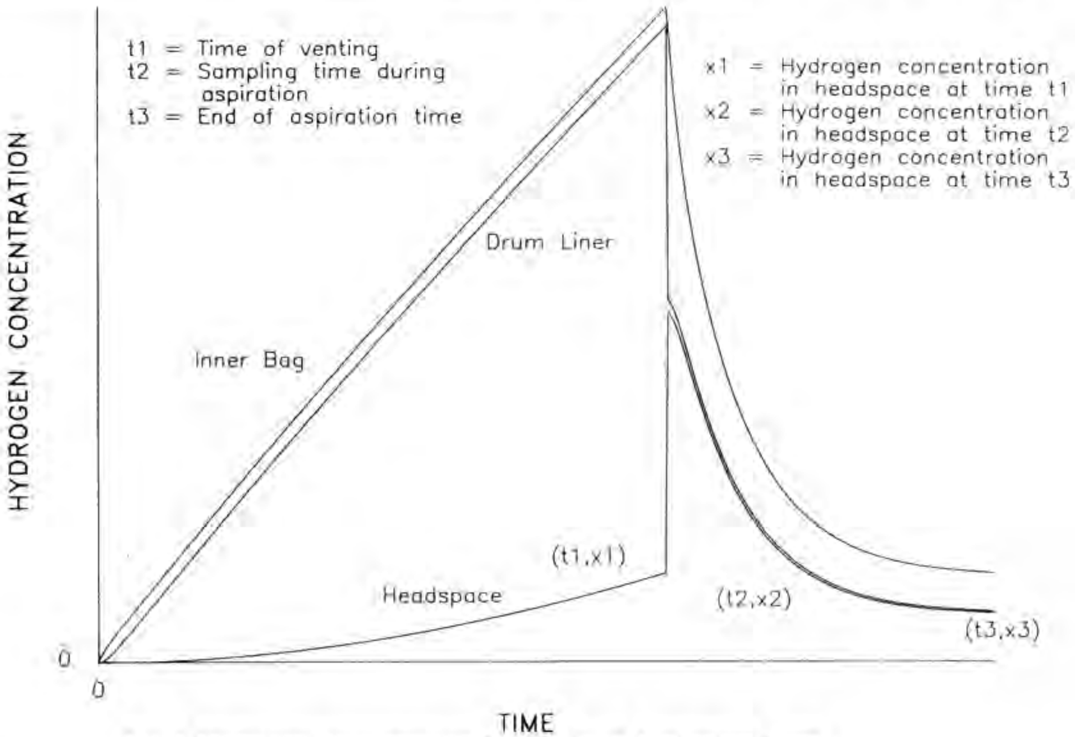

Fig. 2. Hydrogen Concentration Profiles in an Aspirating Drum.

function of time. As mentioned earlier, the void volumes in the layers of bags are combined into one single void volume; hence only three concentration profiles are shown in Fig. 2. The curve labeled "inner bag" represents the hydrogen concentration profile in the bag layer. The curve labeled "liner" denotes the hydrogen concentration profile in the void space between the bag and the rigid drum liner. The curve labeled "headspace" denotes the hydrogen concentration profile in the annular space between the rigid liner and the drum. Waste is placed inside the container, and the container is closed at time t = 0. From time t = 0 to time t = t1 in the figure, the container is closed and hydrogen accumulates in the different layers, as shown. During this time, hydrogen is generated in the container by radiolysis, and it is assumed that there is no release of hydrogen from the container. The container is vented at time t1, with the drum liner punctured and the drum fitted with a carbon composite filter. The sharp increase in the headspace hydrogen concentration at this point is due to equilibration of the gases between the drum head space and the void volume in the liner. The drum starts to aspirate at time t1, and approaches the steady-state concentration in all layers at time t3. The drum can be part of a payload after time t3 and will comply with the five mole percent limit on the hydrogen concentration at the end of the 60-day shipping period in any layer of confinement.

From an operation point of view, the aspiration time can be determined by three different methods. The method of arriving at the aspiration times under each of the three options is described below for the case of this payload container. The mathematical basis for the three options is the same.

Aspiration Time from Option 1 Based on Date of Container Closure: Under Option 1, the aspiration time is determined from the storage time of the waste. This is the period for which the container has been in an unvented condition. This storage time is indicated in Fig. 2 as time t1. The aspiration time required is (t3 - t1). The aspiration times for different storage periods can be derived similarly. Plots of aspiration time as a function of the storage time can be obtained, and knowing the storage time for a payload container, the aspiration time can be determined.

Aspiration Time from Option 2 Based on Headspace Gas Sampling at the Time of Venting: Under Option 2, the aspiration time is determined from the headspace hydrogen concentration at the time of venting. That is, a gas sample from the headspace is taken at the time of venting, and the hydrogen concentration determined. From Fig. 2, the time of venting is t1, and the corresponding hydrogen concentration is X1. The aspiration time for this headspace concentration is again (t3 - t1). The aspiration times for different headspace concentrations can be derived similarly. Hence, under Option 2, aspiration times are derived as a function of the headspace hydrogen concentration at the time of venting. The advantage of actual sampling in Option 2 over Option 1 is that it accounts for realistic hydrogen generation rates (as opposed to the bounding case), and allows credit for any leakage of hydrogen from the payload container during storage.

Aspiration Time from Option 3 Based on Headspace Gas Sampling During Aspiration: From Option 3, the aspiration time is determined from the headspace hydrogen concentration, measured after venting and during aspiration. In Fig. 2, this sampling time is indicated by t2, with a corresponding headspace hydrogen concentration of X2. The aspiration time required is (t3 - t2). The aspiration times for different samples of the headspace concentration can be derived similarly. The aspiration time under this option is a function of the headspace hydrogen concentration measured during the aspiration process. This option accounts for actual hydrogen generation and release rates (as opposed to bounding values) up to the time of sampling.

The sites with retrievably-stored waste can implement one of these three options to determine the aspiration requirements for the waste.

SUMMARY

Aspiration requirements for retrievably-stored waste arise from the possible accumulation of hydrogen in the waste containers during storage. The time for which a container needs to be aspirated can be determined knowing the properties of the waste container, and by performing a mass balance on hydrogen within the container. Three options are presented here for the sites to determine the aspiration times for the waste containers. Implementation of these aspiration requirements will ensure safe transport conditions for the containers.

REFERENCES

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