Idaho National Engineering and Environmental Laboratory

INEEL/EXT-99-0987
Revision 1

October 1999

TRUPACT-II Matrix Depletion Program Final Report

Program Participants

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Rocky Flats Environmental Technology Site

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INEL/EXT-98-00987
Rev. 1

TRUPACT-II Matrix Depletion Program
Final Report

October 1999

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Developed in conjunction with
Benchmark Environmental Corporation
Under Subcontract No. C90-132787

Prepared for the
U.S. Department of Energy, Assistant Secretary for
Environmental Restoration and Waste Management
Under DOE-Idaho Operations Office
Contract No. DE-AC07-99ID13727

ABSTRACT

This final report documents the three-year long Matrix Depletion Program (MDP), a cooperative effort performed by representatives of the Idaho National Engineering and Environmental Laboratory, Los Alamos National Laboratory, and the Rocky Flats Environmental Technology Site for the U.S. Department of Energy Carlsbad Area Office. The MDP determined the dose-dependent gas generating potential, or G-value, for material types defined in the *Safety Analysis Report for the TRUPACT-II Shipping Package* (SARP). The MDP was designed with three integral components; laboratory experiments to determine effective G-value with respect to dose for several material matrices, comparisons to hydrogen gas generation measurements in real waste drums, and theoretical modeling to confirm the current understanding of matrix depletion mechanisms. The MDP determined that the dose dependent G-values ("G" value decreases with accumulated dose) for waste types II and III are substantially lower than the initial bounding G-values used in the TRUPACT-II SARP.

EXECUTIVE SUMMARY

The Transuranic Package Transporter-II (TRUPACT-II) Matrix Depletion Program (MDP) was established as a joint venture of the U.S. Department of Energy (DOE) National Transuranic (TRU) Program and the DOE Mixed Waste Focus Area, with the objective of investigating the phenomenon of matrix depletion and arriving at dose dependent G-values for contact-handled (CH) TRU waste material types. Matrix depletion is the reduction in the gas generating potential, or effective G-value, of a target material. Effective G-value is the gas generation potential of a specific material or matrix due to exposure to ionizing radiation. From experimental and empirical results available prior to the MDP, it was known that matrix depletion decreases the rate of hydrogen gas generation inside CH TRU waste containers. Quantification of the dose-dependent behavior of the effective G-values (i.e., hydrogen gas generation rates within waste containers) is expected to support justifications for greater wattage limits for CH TRU waste and, ultimately, a revised TRUPACT-II *Safety Analysis Report for the TRUPACT-II Shipping Package* (TRUPACT-II SARP) (U.S. Nuclear Regulatory Commission [NRC] 1996). Increased wattage limits will allow shipment of a much greater portion of the current TRU waste inventory.

This report documents TRUPACT-II MDP activities completed during the three-year duration of the program. To confirm earlier reports of the dose dependency of effective G-values, the MDP comprised three major elements:

- Laboratory experiments for the assessment of effective G-value as a function of dose for several matrices and the effects of experimental conditions, including isotope and heating. These results are used to determine a dose dependent G-value that is a statistically derived conservative estimate on effective G-value by waste material type.

- Measurements of effective G-values and hydrogen concentrations in real waste and comparisons with MDP effective G-values. These data are used to show that the MDP dose dependent G-values are conservative estimators of actual waste material type effective G-values.

- Theoretical analyses using a numerical model that calculates effective G-value as a function of dose by explicitly incorporating fundamental nuclear and molecular mechanisms that result in the generation of hydrogen. The analyses are used to show that the current understanding of these mechanisms, which result in hydrogen generation and matrix depletion, yields results that are consistent with experimental measurements.

Supporting programs that provided data for comparison with the MDP experiment results, which are the Idaho National Engineering and Environmental Laboratory (INEEL) Gas Generation Test Program (GGTP), the Rocky Flats Environmental Technology Site (RFETS) GGTP, and the TRU Waste Characterization Program (TWCP), are also described.

The MDP was successful in quantifying the dose dependent G-values of waste materials as a result of matrix depletion. The matrix depletion experiments comprised test cylinders containing polyethylene (PE), wet and dry cellulose, polyvinyl chloride (PVC), and Envirostone matrices impregnated with either ^{238}Pu or ^{239}Pu radioactive source material. Some cylinders were heated to simulate conditions encountered during CH TRU waste transportation and handling. Several sets of cylinders with stable effective G-values and reduced oxygen concentrations were evacuated and backfilled to ambient air oxygen concentrations to simulate conditions in actual vented drums. Data were collected over a 24-month period, at approximately biweekly intervals, totaling 34 sampling episodes.

The dose dependent G-values were compared with results from other experimental programs and with current TRUPACT-II SARP initial bounding G-values. To enhance the understanding of the matrix depletion phenomenon, provide input to experimental procedures, and support comparisons to other experimental programs, an approach for conducting an uncertainty analysis of effective G-value calculations, as well as two computer models, were developed. One computer model, based on theoretical radiolytic processes, illustrates matrix depletion and gas generation in target matrices. The other computer model was used to simulate hydrogen and methane generation, accumulation, and transport across layers of confinement in waste containers using MDP effective G-values.

Analyses of MDP experimental data indicate that dose dependent G-values lie between 14% (UCL_{95} value for wet cellulose) and 38% (UTL_{95} value for PE) of the applicable TRUPACT-II SARP values, depending on the waste material, including those calculated from heated cylinders (e.g., wet cellulose is comparable to waste material type III-1, solid organic materials). In general, the data patterns are consistent with theoretical expectations for G-value behavior over time for different waste materials. Mass spectrometer analyses conducted periodically are in agreement with gas chromatograph analyses used in the experiments.

The MDP effects analysis indicated that only the waste matrix has a significant effect on the effective G-value. At the 95% confidence level, isotope and temperature (i.e., heating) did not have significant effects on the effective G-values. G-value statistics for each waste matrix tested were obtained. Comparisons with actual drum data demonstrate that the MDP G-values are, in fact, greater than the G-values measured in real waste.

The information and results presented in this report may be used to support applications to revise the appropriate sections of the TRUPACT-II SARP and TRUPACT-II Authorized Methods of Packaging (TRAMPAC) to explain and account for the matrix depletion phenomenon. The original TRUPACT-II SARP initial bounding G-values will be used to establish the wattage limits for newly generated containers. When a container has attained an adequate dose level (in Watt · yr), the lower G-values resulting from the MDP would be used to establish the allowable wattage for dose-dependent effective containers.

In summary, the MDP testing has demonstrated matrix depletion in simulated TRU waste materials, and the effects of key parameters have been quantified. A theoretical model of the matrix depletion phenomenon has been validated with experimental data. The dose dependent G-values are reproducible, consistent with earlier results, and fall within theoretically predicted bounds. The data demonstrate consistency with TRUPACT-II SARP limits for waste type I. Reduced effective G-values can be supported for waste types II and III after an adequate dose has been received and can be used to support a revision to the TRUPACT-II SARP.

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ACRONYMS

ALARA	as low as reasonably achievable
CAO	Carlsbad Area Office
CFR	*Code of Federal Regulations*
CH TRU	contact-handled transuranic
CMR	Chemistry and Metallurgy Research
COC	Certificate of Compliance
DOE	U. S. Department of Energy
DQO	data quality objective
EPA	U.S. Environmental Protection Agency
eV	electron volt(s)
FY	fiscal year
GC	gas chromatograph
GGMD	Gas Generation Matrix Depletion
GGTC	Gas Generation Test Canister
GGTP	Gas Generation Test Program
GUI	graphical user interface
HDPE	high-density polyethylene
IDC	item description code
INEEL	Idaho National Engineering and Environmental Laboratory
LANL	Los Alamos National Laboratory
LDPE	low-density polyethylene
LEL	lower explosive limit
MDL	method detection limit
MDP	Matrix Depletion Program
MDP QAPP	TRUPACT-II Matrix Depletion Program Quality Assurance Program Plan (Connolly et al. 1997a)
MDP Test Plan	*TRUPACT-II Matrix Depletion Program Test Plan* (Connolly et al. 1997b)
MS	mass spectrometry
MT	Material Type
NRC	U.S. Nuclear Regulatory Commission
PC	personal computer
PE	polyethylene
ppm	part(s) per million
PVC	polyvinyl chloride
QA	quality assurance
QAO	quality assurance objective
QAPjP	quality assurance project plan
QAPP	quality assurance program plan
QC	quality control
RFETS	Rocky Flats Environmental Technology Site
RH TRU	remote-handled transuranic
SOP	standard operating procedure
TA	Technical Area
TARMATDEP	target matrix depletion computer simulation code
TRU	transuranic
TRUPACT-II	Transuranic Package Transporter-II
TRUPACT-II SARP	*Safety Analysis Report for the TRUPACT-II Shipping Package* (NRC 1996)

TWCP	TRU Waste Characterization Program
UCL_{95}	95% upper confidence limit
UTL_{95}	95% upper tolerance limit
WIPP	Waste Isolation Pilot Plant

DEFINITIONS

Dose	The product of the ionizing radiation or energy emission rate in a test cylinder and the elapsed time since the cylinder's loading. This is expressed in terms of Watt · yr.
Dose-dependent G-value	A steady state effective G-value that is dependent on the total amount of energy absorbed by a waste matrix. The total amount of energy absorbed is assumed to equal the total amount of energy emitted by the radionuclides within the waste matrix. These are the final statistically derived values calculated from the steady state effective G-values measured during the MDP experiments.
Effective G-value	The number of molecular or ionic products (usually gaseous) generated or consumed per 100 electron-volts (eV) of ionizing radiation emitted. Because the actual amount of energy that is absorbed by the matrix cannot be directly measured, this is a material parameter that is based on the amount of energy emitted by the particle on the matrix. These are the individual G-values that were calculated for each sampling event.
Hydrogenous	Hydrogen containing.
Initial bounding G-value	A G-value that is assumed for a waste matrix that is based on the most hydrogenous material within that waste matrix and does not account for any matrix depletion effects. These are the values used in the current TRUPACT-II Shipping Package (NRC 1996) (TRUPACT-II SARP).
Intrinsic G-value	The number of molecular or ionic products (usually gaseous) generated or consumed per 100 electron-volts (eV) of ionizing radiation absorbed by the matrix. This is a material parameter that is based on the actual amount of energy absorbed by the matrix.
Matrix depletion	The phenomenon by which the G-value changes (i.e., gets smaller) as the amount of energy deposited on a matrix depletes the hydrogen bonds in the surrounding material.
Non-hydrogenous	Not hydrogen containing.
Steady state	Effective G-values are approaching asymptotic values with dose as determined through statistical tests for significance of slopes in effective G-values versus dose.
Waste material	An individual type of material contained within a waste matrix (e.g., plastic, paper, etc.).
Waste material type	A category describing the general make up of waste as defined by the Safety Analysis Report for the TRUPACT-II SARP TRUPACT-II Shipping Package (NRC 1996).
Waste matrix	The waste contained within a container. One waste matrix may contain many waste materials.

1.0 INTRODUCTION

This report describes Transuranic Package Transporter-II (TRUPACT-II) Matrix Depletion Program (MDP) activities that were completed over the three-year duration of the program. These activities included program development, test design and implementation, experimental setup modifications, quality assurance (QA) documentation revisions, data collection, data management and analysis, computer models development, and program interfaces.

A concern in the packaging and transportation of radioactive waste materials is the formation of hydrogen gases due to radiolytic breakdown of hydrogen bonds in the waste matrix. The cause of radiolytic breakdown of these chemical bonds is thought to be primarily due to alpha particle interactions with the target material. Therefore, the generation of hydrogen gas is of particular concern in waste contaminated with transuranic (TRU) isotopes, which are primarily alpha-emitters. The gas generation potential of a target material can be characterized by its *intrinsic G-value*, which is defined as the number of molecular or ionic products (usually gaseous) generated or consumed per 100 electron-volts (eV) of ionizing radiation absorbed by the material. However, because the energy that is absorbed (i.e., the absorbed dose) by a material cannot be measured directly, an *effective G-value* based on energy emitted (i.e., the emitted dose), which can be measured, is normally used in analysis. Dose from this perspective is the equivalent of energy emission rate multiplied by the time elapsed since packaging.

The phenomenon of matrix depletion accounts for the gradual reduction in the rate of hydrogen gas generation (i.e., effective G-value) from a material over time and constant exposure to radiation. Hydrogen is removed from the matrix, thus decreasing the number of hydrogen bonds available for radiolytic breakdown. When the alpha-generating source is dispersed in or on the target material in a particulate form, it will affect only that portion of the target material in a small spherical volume surrounding the source particle. Additionally, some energy is lost within the source particle itself, and some is absorbed by nonhydrogenous materials (such as air) that are part of the waste matrix. Because over time the amount of available hydrogen is reduced, the phenomenon of matrix depletion causes the effective G-value to decrease asymptotically with increasing dose to a limit that is characteristic of the matrix affected. This asymptote limit is termed the dose dependent G-value. This phenomenon was verified from experimental and empirical results available prior to the MDP, but it was not studied in sufficient detail to predict the impact on the long-term G-value for a specific material matrix.

The MDP was established as a joint venture by the U.S. Department of Energy (DOE) National Transuranic Program and the DOE Mixed Waste Focus Area, with the objective of investigating the phenomenon of matrix depletion and arriving at dose-dependent G-values for contact-handled (CH) TRU waste material types. To confirm earlier reports of the dose dependency of G-values, the MDP comprised three major elements:

- Laboratory experiments for the assessment of effective G-value as a function of dose for several matrices and the effects of experimental conditions, including isotope and heating. These results are used to place a statistically derived conservative estimate on the effective G-value by waste material type (i.e., dose dependent G-value).

- Measurements of effective G-values and hydrogen concentrations in real waste and comparisons with dose dependent effective G-values. These data are used to show that the dose dependent G-values are conservative estimators of actual waste material type effective G-values.

- Theoretical analyses using a numerical model that calculates effective G-value as a function of dose by explicitly incorporating fundamental nuclear and molecular mechanisms that result in the generation of hydrogen. The analyses are used to show that the current understanding of these mechanisms, which result in hydrogen generation and matrix depletion, yields results that are consistent with experimental measurements.

1.1 Background

The inventory of CH TRU waste currently in retrievable storage at DOE sites is planned for shipment to, and disposal at, the Waste Isolation Pilot Plant (WIPP) facility. The TRUPACT-II is a reusable shipping container designed for the transportation of CH TRU waste containers to the WIPP facility. Waste containers are 55-gal. drums, standard waste boxes, and ten-drum overpacks.

The TRUPACT-II was designed in accordance with the requirements for Type B packaging found in Title 10 *Code of Federal Regulations* Part 71 (10 CFR 71). Upon completion of the design and required testing, the *Safety Analysis Report for the TRUPACT-II Shipping Package* (U.S. Nuclear Regulatory Commission [NRC] 1996) (TRUPACT-II SARP) was submitted to the NRC in 1989. Based on the analyses presented in the TRUPACT-II SARP, the NRC issued Certificate of Compliance (COC) No. 9218 for the package in August 1989. Subsequently the NRC has approved nine revisions to the TRUPACT-II COC.

A major transportation requirement for the TRUPACT-II is that the concentration of potentially flammable gases must not exceed 5% (by volume) in the package or the payload during a 60-day shipping period after the TRUPACT-II is sealed. Decomposition of materials caused by radiation (or radiolysis) is the predominant mechanism of gas generation during transport.

CH TRU waste is classified into four major waste types (I, II, III, and IV) based on chemical and physical characteristics, and is further subdivided into waste material types (I.1, I.2, I.3, II.1, II.2, and III.1) based on bounding flammable gas generation potential, as shown in Tables 1-1 and 1-2 (NRC 1996). Each CH TRU waste container is assigned a TRUPACT-II shipping category, which is based on a combination of waste material type and the packaging (number and type of plastic layers of confinement) of the waste materials within the waste container. To demonstrate compliance with the flammable gas requirement, the TRUPACT-II SARP uses theoretical worst-case calculations with initial bounding G-values to establish allowable wattage (decay heat) limits for each TRUPACT-II shipping category. Initial bounding G-values are the theoretical or assumed maximum for newly-generated wastes.

The maximum allowable wattage limits for each shipping category and for the TRUPACT-II were, therefore, based on the initial effective G-values observed during experiments on the irradiation of materials found in TRU waste. The wattage limit calculations assumed a constant effective G-value from the time the waste was packaged until emplacement at the WIPP facility. The calculations made no allowance for decreases of the effective G-value with dose, a phenomenon observed by many experimenters (Kazanjian 1976; Kosiewicz 1981; Zerwekh 1979; Zerwekh and Warren 1986; Zerwekh et al. 1993; Smith et al. 1994; Marshall et al. 1994; and Smith et al. 1997).

Considering the existing TRUPACT-II wattage limits, it is currently estimated that a large portion of the CH TRU waste container inventory cannot be shipped. A joint effort was conducted at the Idaho National Engineering and Environmental Laboratory (INEEL), Los Alamos National Laboratory (LANL), and Rocky Flats Environmental Technology Site (RFETS) to determine the impact of existing wattage limits on the shippability of CH TRU waste stored at those sites. Of the total volume of CH TRU waste, it was determined that approximately 34% of the waste would not be shippable based on its failure to meet TRUPACT-II wattage limits. Although the effort was performed at the three named sites, the results are applicable to all DOE sites that plan to ship CH TRU waste to the WIPP facility. The TRUPACT-II SARP contains a Gas Generation Test Program (GGTP) that allows for individual drum testing for those drums that exceed the applicable wattage limit. However, implementing the plan for 34% of the CH TRU waste would be prohibitively expensive and time consuming.

Table 1-1. Summary of CH TRU payload waste types.

Waste type	Description and examples
I	Solidified Aqueous or Homogeneous Inorganic Solids (<1% organics–not including packaging) • Absorbed, adsorbed, or solidified inorganic liquid • Soils, solidified particulates, or sludges formed from precipitates • Concreted inorganic particulate waste
II	Solid Inorganics • Glass, metal, crucibles • Other solid inorganics
III	Solid Organics • Plastics (e.g., polyethylene [PE], polyvinyl chloride [PVC]) • Cellulose (e.g., paper, cloth, wood) • Cemented organic solids • Other solid organics
IV	Solidified Organics • Cemented or immobilized organic liquids and solids

Source: NRC 1996.

Table 1-2. Summary of CH TRU waste material types.

Waste type	Waste material type	Description and examples
I	I.1	Absorbed, adsorbed, or solidified inorganic liquids
I	I.2	Soils, solidified particulates, or sludges formed from precipitation
I	I.3	Concreted inorganic particulate waste
II	II.1	Solid inorganic materials in plastic bags
II	II.2	Solid inorganic materials in metal cans
III	III.1	Solid organic materials

Source: NRC 1996.

All TRU waste will ultimately have to be transported to the WIPP facility; therefore, a method to provide for its acceptance for shipment in the TRUPACT-II is needed. A solution for a portion of the waste may lie in determining effective G-values as a function of dose and, thus, more realistic TRUPACT-II wattage limits, primarily by accounting for dose-dependence of the effective G-values. Matrix depletion testing was a cost-effective method for arriving at dose-dependent G-values that would support higher TRUPACT-II wattage limits.

1.2 Objectives

The MDP was established with the objective of investigating the phenomenon of matrix depletion and arriving at dose-dependent G-values for each material matrix tested. To specify data quality for MDP data collection activities, a formal procedure based on U.S. Environmental Protection Agency (EPA) guidance was used to formulate data quality objectives (DQOs). The procedure includes formulating a problem statement, a decision, and inputs to the decision; defining study boundaries; formulating the decision rule; establishing tolerable limits on decision errors; and optimizing the design. Appendix A of the *TRUPACT-II Matrix Depletion Program Test Plan* (MDP Test Plan) (Connolly et al. 1997b) provides details. The primary DQO for the MDP was to ensure with 95% confidence that the true mean effective G-values for simulated waste materials, when estimated with 10% relative error, will not exceed the dose dependent G-values.

The secondary DQOs of the MDP were:

- To determine with 95% confidence whether or not the effects (e.g., isotope, heating) significantly influence the effective G-values observed in the matrix depletion experiments

- To determine with 95% confidence whether or not the dose dependent G-values are conservative based on the results of testing on real waste. This implies that a 5% chance of determining that matrix depletion experiment results are lower than the real waste testing results when the reverse is actually true.

1.3 Program Description

The MDP was funded based on an INEEL white paper that provided a historical perspective, rationale, approach, and expected benefits. Table 1-3 summarizes assigned program participants and responsibilities.

Table 1-3. Matrix of MDP participants and responsibilities.

Participant	Responsibilities
CAO	Overall management; performance of audits; approval of documents; funding
INEEL TRU Waste Program Manager	Primary interface between the CAO and the MDP Coordinator; document review and approval; interface
INEEL MDP Coordinator	Providing technical direction and coordination; review and approval of data, reports, and other documents; resolution of technical issues; determination of future direction; forwarding recommendations to the CAO; documentation preparation; interface
INEEL/Benchmark Environmental Corporation	Preparation of MDP Test Plan, procedures, annual status reports, QA documentation, and MDP Final Report; development of computer models; data reduction and analysis; performance of audits; documentation review and approval; interface
INEEL	Data collection under the GGTP; data collection under the TWCP
RFETS	GGTP data collection; TWCP data collection; preparation, review and approval of documents; interface
LANL	Design and construction of MDP testing apparatus; preparation of test matrices; collection and validation of MDP experimental data; preparation of procedures and other documentation; document review and approval; interface
Westinghouse – Waste Isolation Division (Packaging and Transportation)	MDP documentation review; preparation of TRUPACT-II SARP revision applications; technical guidance; interface

MDP activities were grouped into the following areas:

- *Documentation and QA*. Documents were prepared, reviewed, and approved for the MDP, as well as for programs that will support revisions to the TRUPACT-II SARP. The *TRUPACT-II Matrix Depletion Program Quality Assurance Program Plan* (MDP QAPP) (Connolly et al. 1997a) and the MDP Test Plan provide the program test framework and associated QA requirements. The MDP QAPP also specified the performance-based QA/quality control (QC) requirements that had to be met by each facility participating in the MDP. Based on the requirements of the MDP QAPP, LANL prepared a QA project plan (QAPjP) for the MDP experiments, and developed, reviewed, and finalized associated procedures. Documentation of model development and application was prepared for both computer models. Annual status reports were prepared for the program in fiscal years (FYs) 1995, 1996, and mid-1997. The MDP QA Officer and the DOE Carlsbad Area Office

(CAO) staff audited the program, and the results of the audit and corrective actions were documented.

- *Matrix Depletion Testing*. Matrix depletion experimental design, implementation, testing, and data collection. The testing was performed at LANL using test cylinders loaded with simulated TRU waste materials impregnated with one of two different isotopes of plutonium.

- *Headspace Sampling of TRU Waste Drums*. Headspace samples were collected and analyzed from a representative subpopulation of existing TRU waste containers at ambient temperatures to determine hydrogen gas concentrations in drums. Samples were taken from both drum and inner confinement layers. These activities were performed by the INEEL and RFETS under the WIPP Transuranic Waste Characterization Program (TWCP).

- *Drum Testing to Determine Actual Waste G-values*. Fifty-five-gal. CH TRU waste drums were tested to quantify hydrogen gas generation rates and effective G-values for comparison to the values derived from the MDP testing. This effort was performed at the INEEL and the RFETS under the TRUPACT-II GGTP.

- *Data Management*. Data from the matrix depletion testing were validated, reduced, and analyzed to establish dose dependent G-values for each waste matrix tested.

- *Computer Models Development and Application*. Two computer models were developed to enhance the understanding of the matrix depletion phenomenon and to support comparisons to other experimental programs. The target matrix depletion model (TARMATDEP), which simulated theoretical radiolytic processes, was used to illustrate matrix depletion and gas generation in target matrices. The TRU waste container model (NEWGVALS) was used to simulate hydrogen gas generation, accumulation, and transport across layers of confinement in waste containers using dose dependent G-values.

- *Statistical Analyses*. Statistical analyses compared the dose dependent G-values with container data, model predictions, and current TRUPACT-II SARP values. Statistical comparisons were made of dose dependent G-values derived from the matrix depletion experiments with the measurements from actual TRU waste drums (i.e., TWCP and GGTP) to justify that the dose dependent G-values from the matrix depletion experiments are, in fact, conservative.

- *Program Interfaces*. During the three-year duration of the MDP, participants interfaced extensively with each other, as well as with participants in other TRU transportation program initiatives. MDP personnel participated in a number of meetings on TRUPACT-II transportation initiatives, including three annual GGTP meetings. The objective of these meetings was to familiarize participants with ongoing initiatives and discuss integration of the initiatives.

To obtain dose dependent G-values representative of the TRU waste inventory, the matrix depletion experimental design was developed to quantify the effects of the following variables:

- Dose
- Matrix
- Moisture
- Temperature
- Agitation

- Particle size distribution
- Isotopic composition
- Initial versus dose-dependent G-values.

The following sections provide discussions of how each variable was addressed in the experimental design.

1.3.1 Dose

The effects of dose were evaluated by conducting the experiments over a period of two years to allow the effective G-values for the various matrices to achieve asymptotic (i.e., stabilized) values over time. The dose is the product of the ionizing radiation or energy emission rate in each test cylinder (wattage) and the elapsed time from cylinder loading. This is true because of the primary assumptions that all energy emitted is absorbed by the matrix. Dose is expressed in units of Watt · yr.

1.3.2 Matrix Materials

PE was chosen for the tests because it is commonly found in TRU waste. Additionally, because of its high effective G-value observed in previous studies, it is the bounding material for hydrogen gas generation in waste types II and III. PVC was selected because it, along with PE, is abundant in CH TRU waste.

Cellulosics were chosen because they are the bounding material for overall gas generation (i.e., combined total of hydrogen, methane, oxygen, carbon dioxide, and other gases) for waste type III. As a result of the higher activation energy of cellulose, the potential for flammable gas generation of cellulosics approaches that of PE at higher temperatures.

Envirostone (representative of a "cement" matrix) was chosen because of the extensive presence of water, which is the bounding material for both flammable and overall gas generation in waste type I. Envirostone was tested to confirm that effective G-values obtained for one specific waste type I material are consistent with current TRUPACT-II SARP initial bounding G-values.

1.3.3 Moisture

The effects of moisture were evaluated by having cylinders with both wet and dry cellulosics. The objective was to ascertain whether the presence of water affected effective G-values.

1.3.4 Temperature

The effects of temperature were evaluated by heating selected test cylinders. Heating was intended to simulate potential over-the-road transportation of waste containers where the temperature within the TRUPACT-II may rise to as high as 146°F during a 60-day transport period.

1.3.5 Agitation

Agitation effects were previously investigated using test cylinders and materials similar to those used in the MDP. Those experiments indicated no effect on G-values due to agitation (Zerwekh, 1979; Zerwekh er al., 1993; Smith et al., 1997). Agitation of specified test cylinders was planned after steady state G-values had been established. The agitation was to be performed on a one-time basis to simulate transportation of waste containers, while heating was conducted over time. As described later in this report, the effects of agitation were not evaluated because the proposed agitation of test cylinders did not represent the conditions of actual 55-gal. drums during movement and transport.

1.3.6 Particle Size Distribution

The effects of particle size distribution were evaluated by having two radioactive source materials with significantly different particle size distributions. In one case, the particle sizes were approximately 16.6 microns in diameter and relatively monodisperse while, for other test cylinders, the spread in particle diameter was very broad, with a mean particle diameter of around 33 microns. Earlier testing used a mean particle diameter of 3.61 microns (Smith et al. 1997).

1.3.7 Isotopic Composition

The isotopes ^{239}Pu and ^{238}Pu were chosen because of their prevalence in TRU waste and high specific activity, respectively. ^{238}Pu, which is frequently used as a heat source, provides the majority of the decay heat in TRU waste, while ^{239}Pu is the predominant plutonium isotope present in the TRU waste inventory. Approximately 0.014 g of Material Type (MT)-83, a plutonium isotope blend that is predominately $^{238}PuO_2$, and 2.3 g of MT-52, a blend that is predominately $^{239}PuO_2$, were chosen for the tests. These amounts were chosen because they provided equal decay heats in the tests.

1.3.8 Initial Bounding versus Dose Dependent G-values

The initial bounding G-value for both waste types II and III in the TRUPACT-II SARP was based on gamma irradiation of high-density PE (HDPE) at room temperature based on testing performed in 1959. The MDP experiments were conducted over adequate dose to allow the effective G-values for the various matrices to achieve asymptotic (i.e., steady-state) values. Thus, the MDP testing allowed comparisons of final, dose dependent G-values with initial bounding G-values documented in the TRUPACT-II SARP.

2.0 MATRIX DEPLETION PROGRAM

This section documents the three major elements of the MDP: laboratory experiments; real waste measurements; and theoretical analyses. This section also discusses QA activities related to the elements and various program interfaces of MDP personnel both internally and with personnel involved in other TRUPACT-II transportation-related initiatives.

2.1 Laboratory Experiments

The first major element of the MDP involved design and implementation of the experimental program to determine dose dependent G-values for various material matrices. The experimental program consisted of selecting four representative material matrices, factorial experiment design, apparatus procurement and assembly, data collection, and QA activities.

2.1.1 Experimental Design

Matrix depletion experiments were conducted at LANL. The experimental design was an aggregate of several designs, each with two replicates. The first was a 3×2^3 in 24 units, which was a full factorial involving PE, and wet and dry cellulose. Results from this portion of testing were used to determine the effective G-values and evaluate the effects of isotope, matrix, and heating. The second portion of the design involved PVC testing under limited conditions to facilitate comparisons with other materials and to test the hypothesis that dose dependent G-values based on PVC would not be conservative. The third portion of the design was a 2^2 factorial in four units for Envirostone, which had a reduced number of factors because agitation was not relevant. Results from Envirostone would be used to determine dose dependent G-values and factor effects to confirm that MDP G-values were consistent with the current TRUPACT-II SARP initial bounding G-values for waste type I.

The total number of test cylinders (60) containing the simulated TRU waste matrix materials was determined based on DQOs developed for the MDP (Connolly et al. 1997b). Table 2-1 shows the breakdown of the number of test cylinders in each experimental setting depicted in the test matrix.

Table 2-1. Test matrix (number of cylinders of each experimental setting).

	^{238}Pu				^{239}Pu			
Matrix	Normal	Agitated	Heated	Heated and agitated	Normal	Agitated	Heated	Heated and agitated
PE	2	2	2	2	2	2	2	2
Dry cellulosics	2	2	2	2	2	2	2	2
Wet cellulosics	2	2	2	2	2	2	2	2
Cement (Envirostone)	2	—	2	—	2	—	2	—
PVC	2	—	—	—	—	—	—	2

The apparatus for conducting the matrix depletion tests consisted of two major components: (a) a series of 1-L test cylinders designed to contain the simulated waste material, and (b) a series of valves, tubing, and measurement apparatus for sampling generated gases and quantitatively measuring constituents. To maintain sample integrity and validity, the experimental apparatus was designed to prevent sample cross-contamination. Overall, 64 cylinders in four groups were used. Within a group, one test cylinder contained standard calibration gases for QC purposes (for a total of four QC cylinders). Figure 2-1 presents a schematic of the MDP experimental setup.

The entire matrix depletion testing apparatus was controlled by a single IBM-compatible personal computer (PC) through LabVIEW software. The PC was configured to allow remote access by other selected PCs. Three LabVIEW virtual instruments were developed initially for the operation of the MDP experiments: manual controller, autosequencer, and volume autosequencer. This allowed computerized sampling and associated data acquisition of the test cylinders. The manual controller provided operator manual control and data acquisition for nonsequenced operation of the experiment. The autosequencer provided system control, data acquisition, and data recording for fully automated sampling operation of the experiment. The volume autosequencer provided fully automated measurement and reporting of the sample line volumes for each test cylinder in the experiment. The purge (evacuation) and backfill autosequencer provided fully automated evacuation of test cylinders and backfilling of the cylinders with room air at ambient atmospheric pressure.

All major hardware components were received by October 20, 1995. Initial fabrication of the experiment in the cold area of the LANL Chemistry and Metallurgy Research (CMR) facility, Wing 3, SM-29, Technical Area (TA)-3 was completed in early January 1996. The experiment was moved to its permanent location in a radiologically controlled area of LANL Wing 5, SM-29, TA-3 in April 1996. The heated cylinders were placed in support racks incorporating an oven to maintain elevated temperatures of 140 °F ± 5 °F. The heated group of cylinders was placed in a support rack that was mounted firmly on the floor, while the heated/agitated group was placed in a support rack that was mounted on springs. (Note that cylinders were not agitated, as mentioned previously in this report.)

2.1.2 Implementation

The plastic and cellulosic matrix configurations were prepared by sprinkling the radioactive isotope powders over the matrix materials, folding the matrix materials over the contaminated surfaces, securing them, then placing them in the test cylinders. For the cement matrix, Envirostone was mixed with a solution of dissolved plutonium oxide, water, and a small amount of sodium hydroxide to adjust the pH. Each cylinder was loaded with approximately 450 g of Envirostone, 300 g water, and 20 ml of sodium hydroxide. The loaded cylinders were allowed to cure for 24 hours. All plutonium operations were performed in a glove box to contain the plutonium and ascribe to as low as reasonably achievable (ALARA) guidelines. Preparation of test matrices and loading of test cylinders were documented on videotapes. Loaded test cylinders were prepared in late May 1996, and leak checked by early June 1996.

Manual sampling of the test cylinders was initiated on June 10, 1996. During the following two months, changes in both the mechanical and electrical systems and in the sampling procedure were incorporated into the LabVIEW data acquisition software. The first fully automated sampling run began in mid-August 1996. A total of six sampling episodes were completed in FY 1996. Heating of cylinders occurred after the fourth episode; data for the fifth episode reflect cylinder heating.

All data collection and validation activities associated with the MDP testing at LANL were completed by June 30, 1998. Biweekly data that contained rack temperatures, concentrations of hydrogen and oxygen in each test cylinder, absolute pressure in each test cylinder, and time of cylinder sampling were collected over a 24-month period, totaling 34 sampling episodes or cycles (seven in FY 1996, 22 in FY 1997, and five in FY 1998). Data from the MDP experimental setup were not collected between September 1997, and February 1998, because of an CMR facility shutdown.

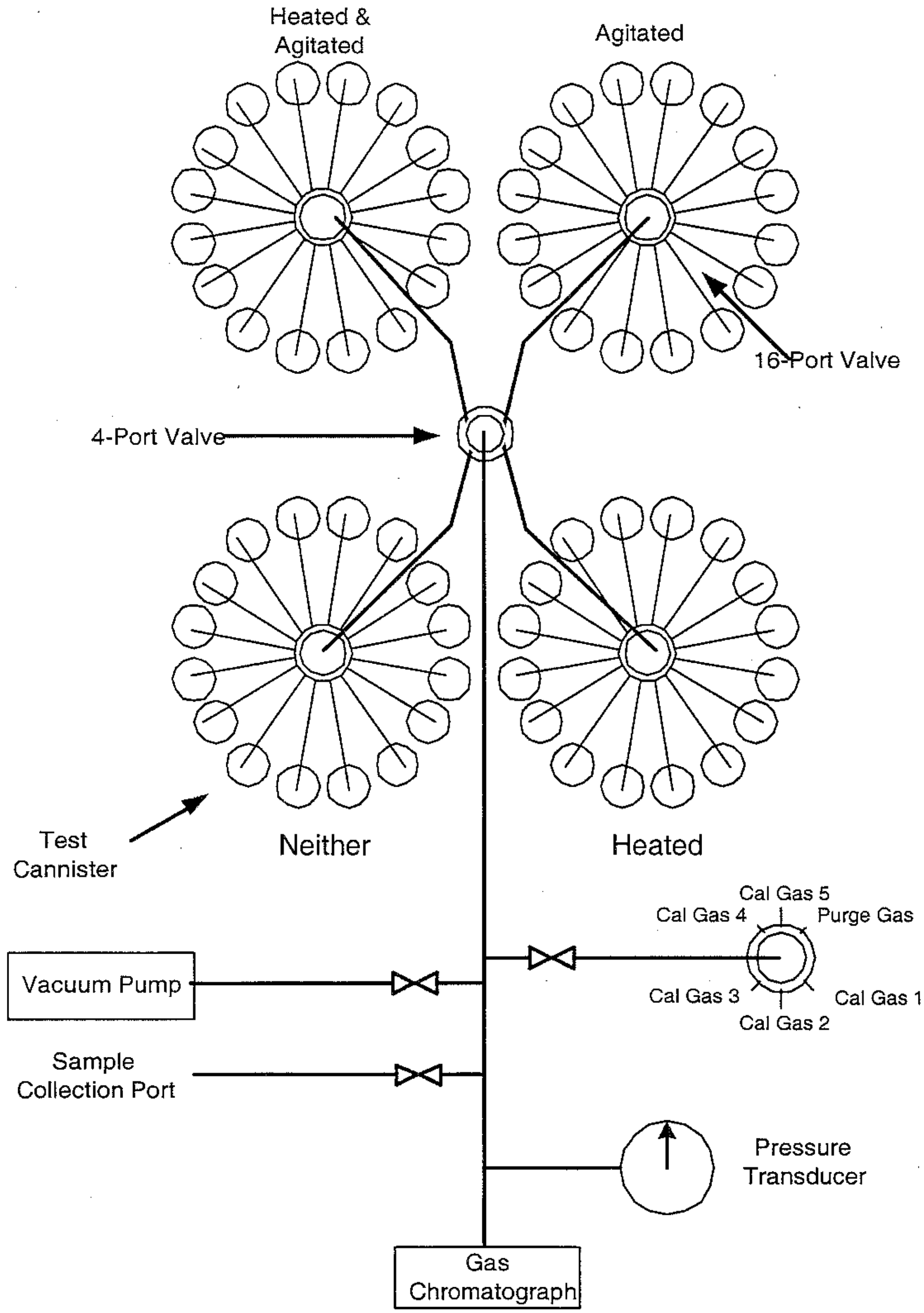

Figure 2-1. Schematic of the MDP experimental setup.

The following measurements were made for each sampling cycle:

- *Pressure Measurements.* The absolute pressure in each test cylinder was established biweekly (every two weeks) before and after withdrawing a gas sample to determine concentration. Cylinder pressure was monitored for safety. Pressure measurements before and after gas sample withdrawal were needed to quantify the number of moles of gas taken from the test cylinder for sampling. This information was used to calculate effective G-values.

- *Temperature Measurements.* The temperature of each heated rack was measured biweekly. This information was used to calculate effective G-values.

- *Concentration Measurements.* The concentrations of hydrogen and oxygen were established within each test cylinder biweekly using a gas chromatograph (GC). The purge gas and blank gas used in the experiments was nitrogen. Hydrogen and oxygen were the critical analytes of interest in the experiments and for the calculation of effective G-values. Sampling for oxygen was initiated during sampling episode 9. Argon, carbon monoxide, carbon dioxide, and nitrogen were also monitored over the course of the experiments. Hydrogen, oxygen, and methane concentrations were confirmed periodically using a mass spectrometer. This information was used to calculate effective G-values, timing the purging and backfilling of cylinders to ambient air oxygen concentrations, validating GC results, demonstrating that methane generation is insignificant compared to hydrogen generation, and supporting mass balance and cylinder leakage evaluations.

For each test cylinder, three additional parameters were quantified to calculate the effective G-value for each sampling cycle.

- *Void Volume.* The void volume within each test cylinder after placement of the target and radioactive source materials was estimated by subtracting the volume occupied by solid material from the measured inside volume of an empty test cylinder. The volume occupied by the solid portions of each waste matrix was estimated by dividing the mass of test matrix in each cylinder by the density of the waste matrix material.

- *Decay Heat.* The isotopic ratios of the radioactive source material were combined with the mass of radioactive source material added to each test cylinder to arrive at the decay heat (wattage) for each cylinder.

- *Sample line volume.* The sample line volume associated with each test cylinder was recorded to track the amount of gas removed for sampling during each cycle.

To simulate venting of the containers and introduction of oxygen into actual containers, test cylinders were evacuated (i.e., purged) and backfilled to ambient air oxygen concentrations ±5% when the cylinders had become significantly depleted of oxygen. The objective of the purging and backfilling was to evaluate whether reintroduction of oxygen would impact the effective G-values. Two conditions had to be met before the purge and backfill procedure was performed on a test cylinder: (a) the oxygen concentrations had to be less than 1.0 volume percent; and (b) the G-values must have reached steady state. The statistical tests were performed at the 95% confidence level and assessed whether the slopes of individual cylinder G-values are all equal to zero and the regression model error associated with modeling effective G-value behavior is less than 0.1. Cylinder purging and backfilling with ambient air oxygen concentrations were performed on 21 test cylinders. Nine cylinders were purged and backfilled after cycle 25, and 12 were purged and backfilled after cycle 27 (Appendix A). During testing for cylinder purging and backfilling, the timing between cylinder sampling was adjusted. The test cylinders were sampled and analyzed for oxygen and hydrogen immediately prior to and following the procedure.

Agitation of specified test cylinders was to be performed at some point after it had been established that effective G-values had again reached steady state following evacuation and backfilling to ambient air oxygen concentrations. The agitation method was intended to simulate over-the-road transportation of waste containers and was to be performed on a one-time basis. Based on extensive discussions among participants of the MDP, it was concluded that the agitation of test cylinders as designed for the MDP would not represent the agitation experienced by real TRU waste containers during movement and transport. In addition, previous laboratory-scale testing of test cylinders, to evaluate the effects of agitation through vigorous manual agitation, indicated no impact to effective G-values (Zerwekh 1979; Zerwekh et al., 1993; Smith et al. 1997).

Test cylinder sampling results suggested that substantial depletion may have occurred within the first 40 days of the experiment (approximately up to 0.0007 Watt • yr). However, the temporal resolution of the measurements specified as biweekly in the MDP Test Plan was too infrequent, and unavoidable delays in initiating the first sampling cycle resulted in data that did not capture the phenomena. Therefore, G-initial experiments were undertaken to quantify the matrix depletion effect in simulated CH TRU waste during initial exposure. The activities included loading four cylinders with fresh source and target matrix material; procuring and assembling new equipment; revising the MDP Test Plan and related documentation; leak testing cylinders; revising the LabVIEW autosequencer software to accommodate more frequent sampling (daily initially); and data analysis and management. The four empty test cylinders that resided in the QC positions on the racks were refitted for the G-initial experiments by adding pressure transducers. All four cylinders were loaded with PE and the same amount of simulated waste material and ^{239}Pu as in the existing test cylinders. The loaded cylinders were placed within 24 hours of loading into rack positions A01, A04, A16, and N01. Two of the cylinders were heated.

2.1.3 Quality Control

The MDP QAPP (Connolly et al. 1997a) defines the QA objectives (QAOs) associated with these experiments in terms of precision, accuracy, representativeness, completeness, and comparability. The MDP QAPP also discusses sampling and analysis procedures that were used to meet the QAOs set for the program. Specific QA measures were also followed for sample custody, calibration of equipment, data reporting, and data reduction.

At the MDP data generation level, data were validated both automatically and manually. The autosequencer software was checked to ensure that the concentrations of gases in the QC cylinders were within 10% of the certified concentrations. If the data were not within this range, the autosequencer program halted program execution. Concentration data were manually checked for completeness; integration parameters for hydrogen were checked to ensure that they had been set correctly; integration parameters were checked for correctness through the entire analysis cycle and concentration range; and argon and oxygen chromatogram peaks were checked to ensure that they had been correctly separated and integrated. Data passing these checks were then transferred to a FileMaker® Pro database, which automatically performed additional checks. In addition, the data from mass spectrometry (MS) analyses of hydrogen were compared to those determined by GC. If the two analyses differed by more than 25%, an occurrence was noted and examined for trends. LANL project leader performed a final review of the data before releasing them for additional data reduction. Appendix A contains a detailed description of QC sample results.

2.2 Real Waste Measurements

The second major element of the MDP involved hydrogen measurements of actual TRU waste drums under the TRUPACT-II GGTP and under the TWCP. The TRUPACT-II GGTP consists of performing controlled tests with actual containers of CH TRU waste to quantify the gas generation properties of the waste under simulated transportation conditions. Whether or not containers of CH TRU waste are tested is based on their hydrogen gas generation potential. Containers of CH TRU waste that can be shipped without the need for testing are qualified for shipment based on set decay heat limits determined from theoretical worst-case calculations, as required by the TRUPACT-II SARP. GGTP testing is intended to (a) facilitate the shipment of waste containers that exceed the decay heat limits or that do not have established theoretical upper bounds for gas generation potential by showing compliance with applicable hydrogen and total gas generation rate limits; and (b) for specific populations of waste, increase the quantity of waste that can be shipped by redefining decay heat limits.

The GGTP testing procedure is described conceptually in Appendix 1.3.7 of the TRUPACT-II SARP. One gas generation test system has been implemented at the INEEL. Another gas generation testing system has been developed and tested by the RFETS GGTP.

Headspace gas sampling of TRU waste containers is conducted under the TWCP at the INEEL and RFETS. The sampling includes the drum headspace and the headspace of inner layers of confinement. Headspace gas analytes of interest to the MDP are hydrogen and methane.

2.2.1 Gas Generation Testing Program at the Idaho National Engineering and Environmental Laboratory

The testing apparatus used at this facility is based on the general procedure outlined in Attachment 2 of Appendix 1.3.7 of the TRUPACT-II SARP. The primary purpose of the test setup is to provide a system for the reproducible measurement of total gas flow rate for the test period, during which the gas generation properties of the waste drum are monitored by sampling and analyses. The hydrogen gas generation rate is calculated by multiplying the time-averaged net gas generation rate by the sampled concentration of hydrogen. The effective G-value for each drum was calculated by combining the measured hydrogen gas generation with the wattage of the drum. Individual drums were tested under elevated temperature conditions that simulate worst-case thermal conditions expected in a 14-drum TRUPACT-II payload during normal transport conditions for the specific shipping category of the drum.

As of the end of July 1998, 114 drums had been tested and data on 83 drums had been evaluated. Of the 83 drums, 54 passed TRUPACT-II SARP limits for total gas release and flammable gas generation rate. None of the 83 drums failed the hydrogen gas generation rate. Twenty-nine drums failed the total gas release limit, even though the container decay heats are below the allowable decay heat limits. Because of the uncertainty in experimental results, INEEL GGTP results were not used for the MDP analyses. The experimental design and resulting data are currently undergoing independent technical review.

2.2.2 Gas Generation Testing Program at the Rocky Flats Environmental Technology Site

The RFETS testing system consists of a stainless steel bell jar, a lower explosive limit (LEL) detector, a SUMMA® canister gas sampling connection, and an MS for analysis of gases in the bell jar headspace. To conduct a test, a drum is first placed in the Gas Generation Test Canister (GGTC) and isolated. Initial and final (after approximately two weeks) gas samples are then drawn into evacuated and cleaned SUMMA® canisters. The SUMMA® canister samples are analyzed using an MS. Then, the concentrations of hydrogen and other inorganic gas species in the void space of the GGTC are determined analytically. The change in concentration versus the change in time is used to determine the hydrogen generation rate. The effective hydrogen G-value was calculated for each drum using the measured hydrogen gas generation rate and the mean wattage of the drum.

The first 27 drums tested were sampled using an on-line hydrogen analyzer, which was essentially a combustible gas detector calibrated from zero to 50% LEL for hydrogen. This detector is susceptible to interference by other gases. Due to concern that other gases may be interfering with the measurements of hydrogen, the remainder of the gas generation tests have been accomplished by means of obtaining batch samples with SUMMA® canisters and analyzing these on a highly sensitive and accurate sector-scan MS. In general, the on-line analyzer yielded higher calculated effective G-values than the MS. The assays of radioactive materials in the drums (used to calculate the effective G-value) were performed using either passive-active drum counters or segmented drum counters, both of which have accuracy limited to ±25%. As a result, the calculated effective G-value is only as accurate as the assay of the drum.

The gas generation testing system developed by RFETS in 1995, has been used to test 117 drums as of the end of July 1998. Elevated temperature testing at 63 °C was initiated on June 10, 1998. Effective G-values for 83 of the drums tested at the RFETS under the GGTP were used for comparison with the MDP dose dependent G-values. All of these containers were tested at ambient temperatures. Table 2-2 presents a breakdown of these drums by waste type. Appendix D presents the individual drum effective G-values and other relevant data.

Table 2-2. Number of RFETS GGTP drums used in the MDP analyses.

Waste type	Number of drums
II.1	16
III.1	67
Total	83

2.2.3 Transuranic Waste Characterization Program

The TWCP is a CAO-established program that must be implemented at DOE sites planning to send waste to the WIPP facility. The INEEL instituted its TWCP in 1991, and the RFETS instituted its TWCP in 1993. Headspace samples were collected and analyzed for hydrogen and methane from a representative subpopulation of existing TRU waste containers at ambient temperatures. Samples were taken from the headspace gases of all CH TRU waste drums, and certain drums underwent innermost layers of confinement sampling. The MDP QAPP describes QA requirements specific to the MDP, which are consistent with the TWCP requirements.

A total of 457 samples collected by the RFETS under the TWCP was used for the MDP analyses. A total of 428 samples collected by the INEEL under the TWCP were used for the MDP analyses. Table 2-3 presents a breakdown of the number of samples by waste type and by site. In addition, other container data including drum identifier, shipping category, dates of container packaging, container venting, and container sampling, and wattage, were collected and used as input to the NEWGVALS code (Section 2.2.4).

These data, along with dose dependent G-values determined from the MDP laboratory experiments, were used to predict the concentrations of hydrogen in various confinement layers at the time of sampling for comparison to the sampled concentrations. Appendix C provides detailed information on the samples and drum data that were used in the MDP analyses. The objective was to demonstrate that the dose dependent G-values predict concentrations of hydrogen in drums that is higher than the corresponding measured hydrogen concentrations.

Table 2-3. Number of TWCP samples used in the MDP analyses.

Waste Type	Number of INEEL samples	Number of RFETS samples
I	94	113
II	137	87
III	197	257
Total	428	457

2.2.4 NEWGVALS

NEWGVALS was developed to predict drum headspace hydrogen gas concentrations based on the dose dependent G-values and the measured effective G-values of actual drums. The predicted gas concentrations using NEWGVALS were compared with the respective actual waste drum flammable gas concentrations (sum of hydrogen and methane) to show that dose dependent G-values predict drum hydrogen concentrations that are greater than measured concentrations. The model mathematically simulates the generation of flammable gas and subsequent transport across layers of confinement in a TRU waste drum. The code uses a step function in effective G-values and actual TRU waste container decay heat or wattages to predict flammable gas concentrations within actual TRU waste containers at any dose up to the cumulative dose when the container was sampled for flammable gas under the TWCP. Effective G-values supplied to the model were determined from the MDP laboratory experiments conducted at LANL.

NEWGVALS is based on the aspiration model documented in Appendix 3.6.11 of the TRUPACT-II SARP (NRC 1998). To account for the various packaging configurations and container conditions, four sets of ordinary differential equations are solved along with the appropriate initial conditions that represent the initial state of a container. The four sets represent: (a) a sealed container with two void volumes, (b) an aspirating container with two void volumes, (c) a sealed container with three void volumes, and (d) an aspirating container with three void volumes. The concentrations predicted in a sealed container at the time of venting serve as initial conditions for the differential equations that describe an aspirating container. Appendix C provides a more detailed technical description of the NEWGVALS model.

2.3 Theoretical Analyses

The third major element of the MDP is the theoretical analysis, which was conducted primarily through development and use of the target matrix depletion (TARMATDEP) computer simulation code. The TARMATDEP model was developed to theoretically analyze hydrogen gas generation in TRU. The model tracks alpha radiation propagation through a source and target material and determines the effects on target molecules. Based on user-input dimensions and initial energies, TARMATDEP determines the alpha energy loss profile in two PuO_2 source materials: (a) ^{238}Pu, and (b) ^{239}Pu, as well as in five candidate target materials, simulating the contents of TRU waste: PE, PVC, wet and dry cellulose, and cement. The program calculates the instantaneous number of hydrogen bonds broken, running sum of hydrogen bonds broken, and effective G-value. The model allows for user specification of both the total duration of modeling, as well as the time interval between recording of the calculated data. A number of preliminary sensitivity simulations were made to predict the effective G-value as a function of dose rate and to evaluate the effects of changing bond breakage probabilities. Section 4 and Appendix B present results of model simulations; in addition, Appendix B provides a more detailed and technical description of the TARMATDEP model.

2.4 Quality Assurance

The MDP QAPP and the MDP Test Plan provide the program test framework and associated QA requirements for the experimental program, as well as for the validation/verification of the theoretical model, NEWGVALS, and the LabVIEW control software. The MDP Test Plan establishes the scope of the MDP; defines the different MDP components and the relationship between them; describes the selection of the test matrices, experimental design, and test methodology; and documents methods for data management and analysis of results.

The MDP QAPP specifies the quality of data required to meet program objectives, waste parameters that must be characterized prior to testing, analytical methods, instrument calibration, and administrative QC. The MDP QAPP also specifies the performance-based QA/QC requirements that must be met by each facility participating in the MDP. The INEEL prepared several procedures for data management, as well as documentation of model development and application also for the NEWGVALS and TARMATDEP computer models.

Revision 1.0 of the MDP QAPP (Connolly et al. 1997a) was issued in June 1997, and Revision 1.0 of the MDP Test Plan (Connolly et al. 1997b) was issued in January 1997. These documents were revised to reflect the changes in the implementation of the TRUPACT-II MDP, the experiments being performed at LANL, and the TWCP.

2.4.1 LANL Matrix Depletion Experiments

LANL matrix depletion experiments were conducted under the *Gas Generation Matrix Depletion Quality Assurance Project Plan* (GGMD QAPjP) (LANL 1998). The GGMD QAPjP identifies the quality of the data and the techniques required to ensure that the specific DQOs associated with the program were met. It follows the guidelines of the TWCP QAPP. In addition, the following procedures were prepared, reviewed, approved, and implemented:

- GGMD Training and Qualification Plan
- GGMD Corrective Action and Quality Improvement Plan
- GGMD Document Control Plan
- GGMD Records Management Plan
- GGMD Design Procedure
- GGMD Procurement Procedure
- GGMD Inspection and Acceptance Plan
- GGMD Notebook and Logbook Maintenance Procedure
- GGMD Management Assessment Procedure
- Verification and Validation of LabVIEW for GGMD
- Documentation of LabVIEW for GGMD
- Procedure for Loading Test Chambers for ^{238}Pu and ^{239}Pu
- Procedure for the Analysis of QC Verification Samples by Gas MS

- Test Container Reload Procedure
- GGMD Cold test Procedure
- Sampling and Quality Control Procedure
- Data Generation Level Validation Procedure

The LabVIEW software used to control the experimental apparatus at LANL was extensively verified and documented.

2.4.2 INEEL and RFETS TWCP and GGTP

For TWCP activities at the RFETS and the INEEL, the TWCP QAPP (DOE 1996) identifies the quality of data necessary and techniques designed to attain and ensure the required quality to meet the specific DQOs associated with the TWCP. The TWCP QAPP follows the guidelines recommended by EPA in QA/R-5 (EPA, 1994). The INEEL and the RFETS conducted headspace gas hydrogen and methane measurements under approved QAPjPs that provide the QA/QC requirements of the TWCP. The INEEL implemented the requirements of the *Idaho National Engineering and Environmental Laboratory Quality Assurance Project Plan for the TRU Waste Characterization Program* (LMITCO 1997). RFETS implemented the requirements of the *RFETS Quality Assurance Project Plan for the TRU Waste Characterization Program* (RFETS 1998b). These QAPjPs were supplemented by site-specific standard operating procedures (SOPs) that detailed the implementation of headspace gas sampling and analysis.

For the GGTP, the following documents were prepared:

- GGTP QAPP (Westinghouse 1996)
- GGTP Test Plan (Attachment to Appendix 1.3.7 of NRC 1996)
- Test Standard Operating Procedure (Westinghouse 1995)
- INEEL site-specific GGTP QAPjP (Edinborough 1996)
- RFETS site-specific GGTP QAPjP (RFETS 1997)
- RFETS site-specific GGTP test procedure (RFETS 1998a)
- Site-specific SOPs

2.4.3 Program Interfaces

During the course of the MDP, participants interfaced extensively with each other and with participants in other TRU transportation program initiatives. The MDP coordinator and the MDP QA officer met with MDP participants in October 1996 and February 1997, to discuss and resolve outstanding QA issues.

A TRUPACT-II transportation initiatives meeting was held in February 1997, to familiarize participants with the ongoing initiatives and discuss integration of the initiatives. The agenda included overviews of the RFETS GGTP, the MDP, the *Hydrogen Gas Getters Project* (Weinrach 1997), the *Flammability Assessment Methodology Program* (Loehr et al. 1997), the *Mixing of TRUPACT-II Shipping Categories* (Djordjevic et al. 1996), and the *Use of Headspace Flammable Gas Sampling as an Alternative Method of Certifying TRU Waste Containers Project* (Djordjevic et al. 1997). The major outcome of the meeting for the MDP was the decision to use the effective G-values determined by the RFETS GGTP in the MDP in the same way as the INEEL GGTP derived effective G-values.

A meeting held in April 1997 identified activities that would facilitate shipments of RH and CH TRU wastes in the 72-B Cask and TRUPACT-II shipping packages, respectively. A coordination meeting of MDP participants was held in July 1997, to plan the G-initial experiments with respect to tasks, responsibilities, and schedules. MDP participants agreed that additional cylinders, absolute pressure gauges, and pneumatic valves should be procured for any future G-initial experiments. MDP personnel also participated in annual TRUPACT-II GGTP meetings that were held in Idaho Falls, Idaho, in July 1996; and in Albuquerque, New Mexico, in August 1997 and July 1998.

3.0 RELATED STUDIES

In addition to the activities performed under the MDP, the phenomena of matrix depletion have been studied by various researchers over the past 20 years. Most of the experimental work has been related to matrix depletion and understanding the effects and behavior of effective G-values was conducted at LANL. The following sections summarize relevant portions of this research and provide a brief description of their results.

3.1 The Zerwekh/Kosiewicz Experiments

Early experiments conducted at LANL, using plastic matrices and $^{238}PuO_2$, resulted in the first substantive proof that matrix depletion has an effect on gas generation rates. In 1979, Zerwekh reported on a series of experiments begun in 1977, to explore variables affecting TRU waste gas generation (Zerwekh 1979). The experiments focused on low-density polyethylene (LDPE) contaminated with ^{238}Pu, which provided a maximum estimated experimental effective hydrogen G-value of 1.7 molecule/100 eV.

In 1981, Kosiewicz reported on a series of experiments conducted with $^{238}PuO_2$ and $^{239}PuO_2$ powders and under simulated geologic repository conditions. The matrices consisted of PE, PVC, wet and dry cellulosics, Teflon®, hypalon, neoprene, bitumen, polyurethane, Lucite®, and a composite waste matrix. The resultant effective G-value for PE ranged from 2.0 to 2.4 (Kosiewicz 1990, 1981), and a conclusive reduction in gas generation rates with increasing dose was observed.

3.2 The Marshall/Smith/Cappis Experiments

A new set of experiments focusing on alpha radiolysis was conducted by Marshall, Smith and Cappis (Smith et al. 1997) with the goal of evaluating conditions for safe on-site storage and the applicability of the TRUPACT-II wattage limits for ^{238}Pu-contaminated combustible waste (Smith et al. 1997). Two different experiments were performed under this investigation to determine the gas generation characteristics of ^{238}Pu-contaminated waste at LANL: (a) six test canisters were loaded with cellulosics or PE (three each), contaminated with $^{238}PuO_2$ powder, and then analyzed for gas constituents and quantities over prolonged periods of time; and (b) 50 drums containing ^{238}Pu-contaminated wastes were sampled for headspace hydrogen concentration to determine the Effective G-value for actual wastes being generated at LANL.

3.2.1 Test Canisters

The six 2.06-L test cylinders were made of stainless steel, and sampling was performed on evacuated 5-mL volumes. The first pair of canisters contained matrices that were contaminated with approximately 25 mg of $^{238}PuO_2$, which were exposed for a total duration of 1,085 days, at a dose of roughly 12.96 W · days. The second pair of canisters contained matrices contaminated with approximately 17 mg of $^{238}PuO_2$, which were exposed for 945 days at a dose of roughly 7.41 W · days, The third pair of canisters contained matrices contaminated with approximately 14 mg of $^{238}PuO_2$, which were exposed for 795 days at a dose of roughly 5.56 W · days. The $^{238}PuO_2$ powder was characterized by a mean diameter of 3.61 microns.

The canisters were analyzed by MS for H_2, CH_4, N_2, O_2, CO, Ar, and H_2O. Samples were obtained every few days initially, decreasing to once every few months after the first 365 days. At the conclusion of the experiments, all six canisters showed H_2 gas generation to be slowing down with increasing dose. The Effective G-value for the cellulose simulated waste experiments started at a value of approximately 1.0 and decreased to 0.3 or below by the time doses reached $4x10^{24}$ eV. For the PE simulated waste, the effective G-value initially ranged from 0.8 to 1.8 and decreased to below 0.3 as doses approached $4x10^{24}$ eV. Figures 3-1 through 3-4 show the resultant effective G-values.

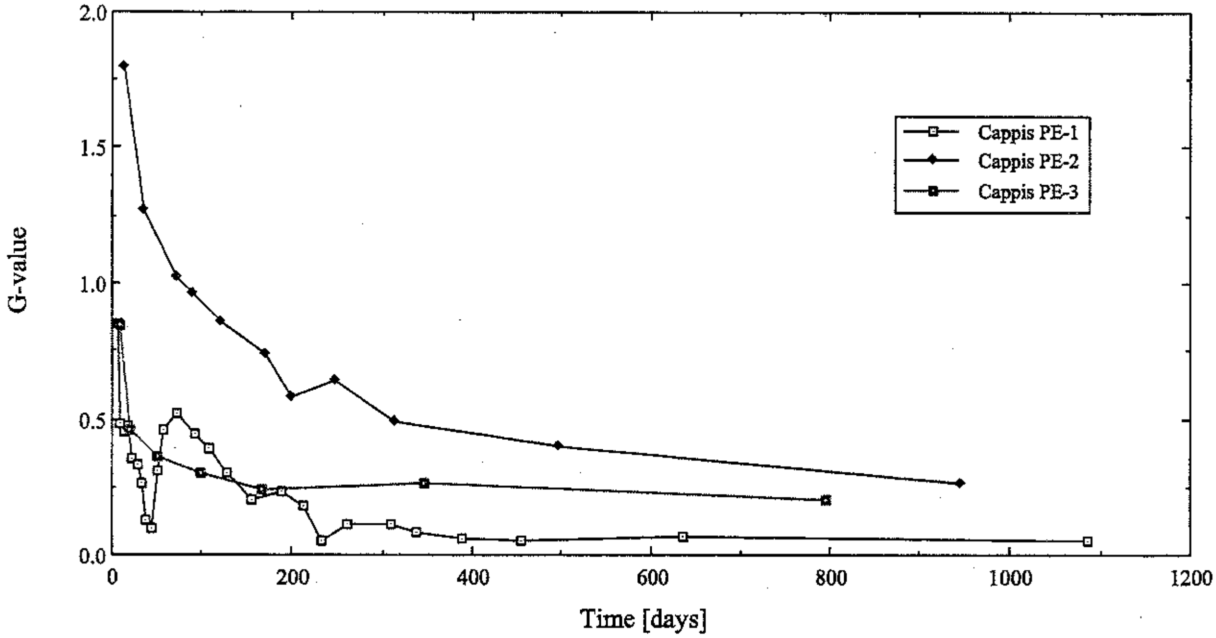

Figure 3-1. Marshall/Smith/Cappis experimental data (PE, G-value vs. time).

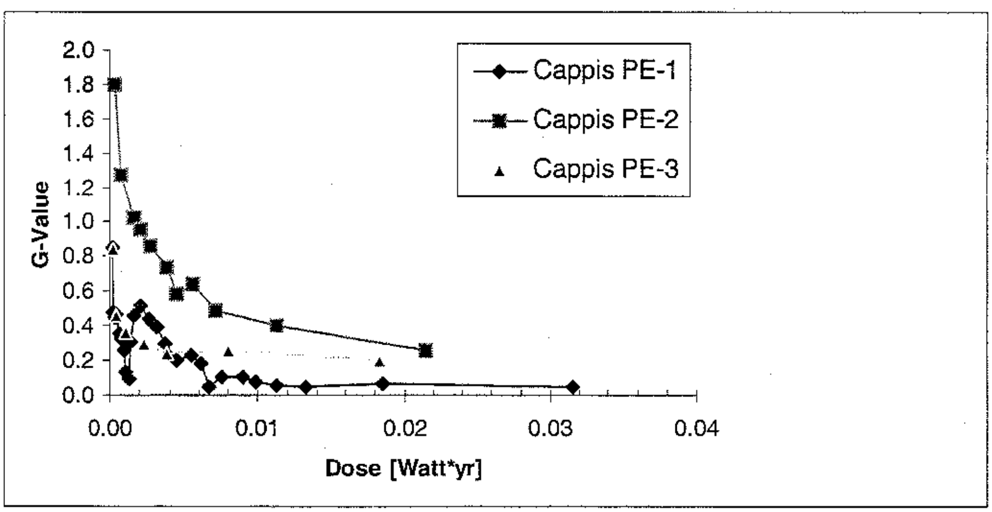

Figure 3-2. Marshall/Smith/Cappis experimental data (PE, G-value vs. dose).

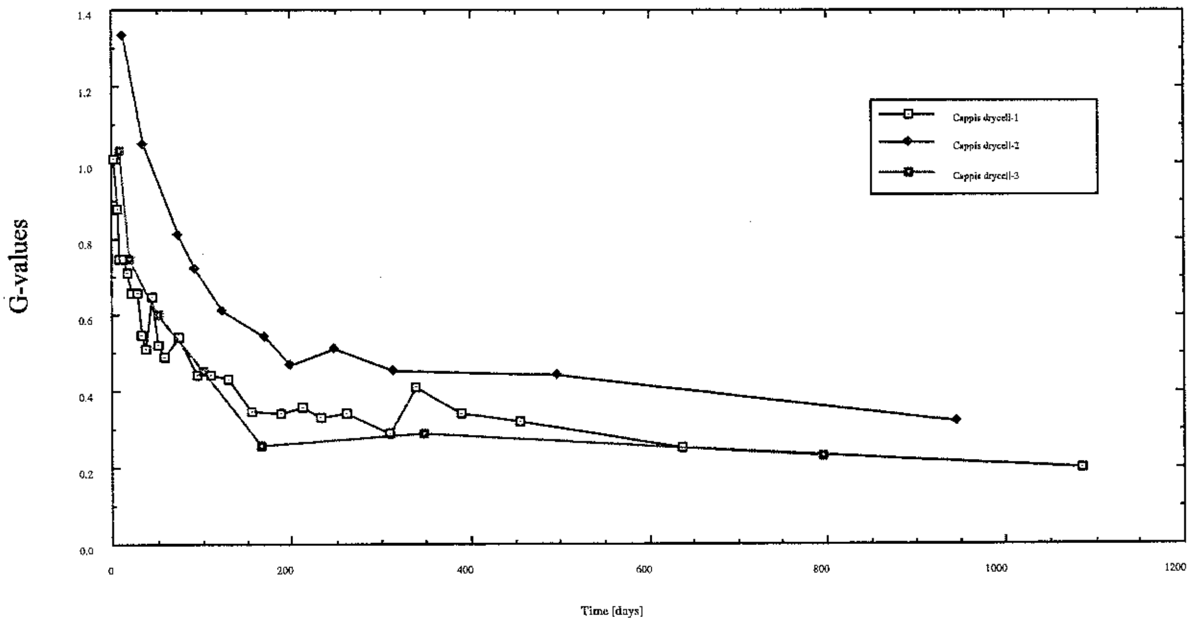

Figure 3-3. Marshall/Smith/Cappis experimental data (cellulose, G-value vs. time).

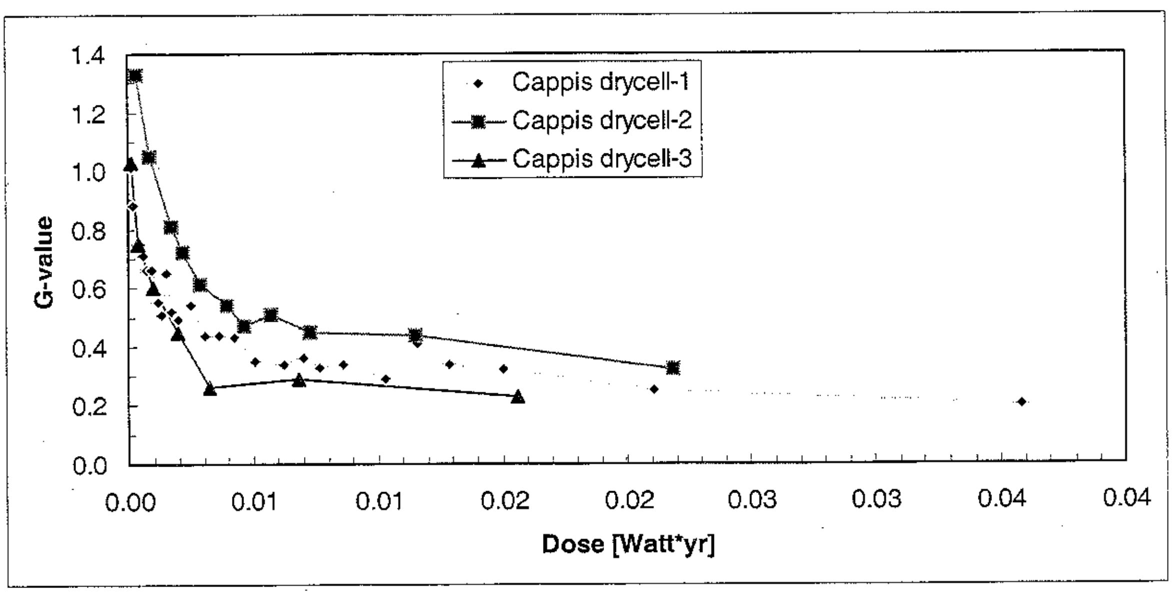

Figure 3-4. Marshall/Smith/Cappis experimental data (cellulose, G-value vs. dose).

3.2.2 TA-55 Waste Drums

The 50 drums of actual waste at LANL, containing waste contaminated with ^{238}Pu, were sampled using a custom-made drum sampling device that evacuated a 25-mL sample volume. The waste had been loaded into the drums six months to two years prior to sampling. The effective G-value was calculated for each drum using a mathematical model that simulates hydrogen generation and diffusion through multiple containment layers in 55-gal. drums.

All drum lids were fitted with a single NFT 013-type carbon composite filter, through which gas samples were collected. Overall, hydrogen concentrations in mole percent were measured to range from <0.001 to 2.06%. The effective G-value calculated for each drum was consistent with the effective G-value derived from the six test canisters, and generally fell well below 1.0. The most notable exception found was a waste drum containing discarded gloves, which had a effective G-value of 1.7.

4.0 MDP RESULTS

This section provides the results of the three major elements of the MDP: laboratory experiments to determine effective G-values for simulated waste materials; comparisons of experimentally derived effective G-values with real waste measurements; and theoretical analyses. This section provides a synthesis of the three elements of the MDP and compares the dose dependent G-values to current TRUPACT-II initial bounding G-values. In addition, a postirradiation examination was performed on two of the test cylinders. The results of this examination are detailed in Appendix E.

4.1 Laboratory Experiments

By the end of June 1998, data had been collected for 34 cycles in the MDP experiments. Appendix A presents an analysis of the data; describes the calculation of effective G-values, determination of data sets used to select effective G-values, analysis of effects on effective G-value, and statistical summaries of effective G-values; and presents effective G-value behavior and values for individual cylinders. Appendix A also summarizes purging episodes and QC data collected over the 34 cycles. In general, the data patterns are consistent with theoretical expectations for effective G-value behavior for different waste materials. MS data are in good agreement with GC data.

The effects analysis of MDP experimental results showed that only the waste matrix has a significant effect on effective G-value. Heating and isotope did not have significant effects. Effective G-values follow a normal distribution for each waste matrix. The individual effective G-values calculated for each sampling event were used to statistically calculate a dose dependent G-value for each waste matrix. Three statistical methods were used, which are: 1) the mean, 2) the 95% upper confidence limit (UCL_{95}), and 3) the 95% upper tolerance limit (UTL_{95}). Table 4-1 provides various statistics for the effective G-value for each waste matrix. The tabulated statistics include the number of observations, the mean effective G-value, the standard deviation of the effective G-values, the standard error of the mean, the UCL_{95} of the mean effective G-value, the 95th percentile effective G-value, and the UTL_{95}. The statistics are based on only steady state effective G-value data, which is determined by the effective G-value exhibiting a zero slope over time (tested at the 0.05 significance level) by experimental condition (e.g., unheated cylinders with PE and ^{239}Pu).

Table 4-1. Experimental G-value Statistics (molecules/100 eV).

Matrix	Number of observation s	Mean	Standard deviation	Standard error of mean	UCL_{95} of mean	95th percentile	UTL_{95}
Cement	202	0.25	0.18	0.01	0.27	0.49	0.58
Dry cellulose	302	0.27	0.18	0.01	0.29	0.49	0.59
PE	186	0.23	0.22	0.02	0.26	0.56	0.64
PVC	99	0.14	0.19	0.02	0.17	0.44	0.50
Wet cellulose	276	0.44	0.36	0.02	0.48	0.99	1.09

Depending on the experimental condition, zero slopes (i.e., stabilized or statistically constant effective

G-values with dose) were attained at different cycle numbers, as shown in Table A-4 (Appendix A). The lowest initial cycle numbers associated with the zero slopes are for cement and PVC matrices; these range from three to six, and correspond to doses ranging from 0.0009 to 0.002 Watt @ yr. The highest cycle numbers associated with zero slopes are typically PE and include some wet and dry cellulose data sets; the highest associated dose observed is 0.006 Watt @ yr.

Figures 4-1 through 4-5 show the calculated effective G-value versus dose for each test matrix. These graphs contain data for all of the cylinders for a specific matrix material (e.g., Figure 4-1 contains the data for all of the cylinders containing cement). Analyses were performed on the individual container data to determine the dose at which the effective G-value has statistically reached steady state. Each graph contains two types of data: (a) non-steady state (triangles) and (b) steady state (circles). Each graph contains a vertical dotted line that signifies the maximum dose in Watt @ yr required for the effective G-value in any container to reach steady state. Therefore, a few of the steady state data points (circles) may lie to the left of the vertical line and all of the non-steady state points (triangles) will lie to the left of the vertical line. In addition, to the vertical line, there are two horizontal lines on each graph. The solid horizontal line signifies the dose dependent G-value based on the UCL_{95}. The dashed horizontal line signifies the dose dependent G-value based on the UTL_{95}. The horizontal lines show how the dose dependent G-values compare to all of the calculated effective G-values.

4.2 Real Waste Measurements

Statistical comparisons were made of the dose dependent G-values derived from the matrix depletion experiments, with the measurements from actual TRU waste drums to demonstrate that the dose dependent G-values from the matrix depletion experiments are greater. Two types of comparisons were made using the dose dependent G-values derived from matrix depletion experiments. The first compared the dose dependent G-values with those of the GGTP results (Section 4.2.1), and the second compared predicted flammable gas concentrations using the dose dependent G-values with flammable gas concentrations measured in the TWCP (Section 4.2.2).

Because of the simulated waste materials used in the MDP, it was expected that headspace flammable gas concentrations predicted using the MDP dose dependent G-values would be greater than measured drum flammable gas concentrations. It was also expected that the dose dependent G-values measured in the MDP would be greater than the effective G-values calculated from gas generation testing of actual TRU waste containers. In both cases, MDP dose dependent G-values were greater due to the nature of the target material and the geometry of the cylinder contents. This is primarily because other non hydrogenous materials present in actual CH TRU waste are not included in the MDP. In addition, the target material was directly sprinkled with plutonium oxide, allowing the radioactive particles to come into direct contact with the target material. In actual CH TRU waste, the plutonium is dispersed and not always in such direct contact with hydrogenous materials.

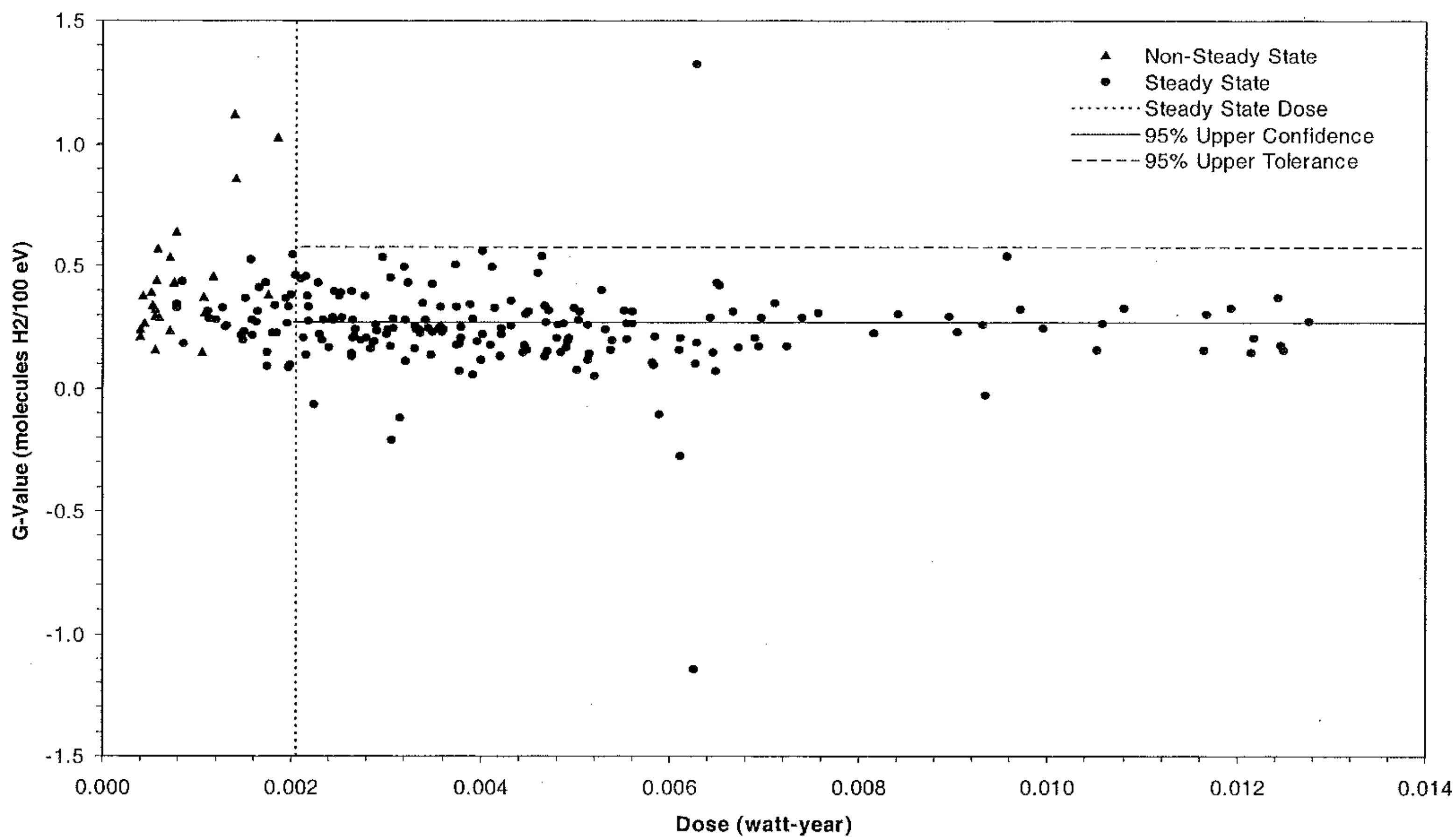

Figure 4-1. Graph of G-value versus accumulated dose for cement matrix.

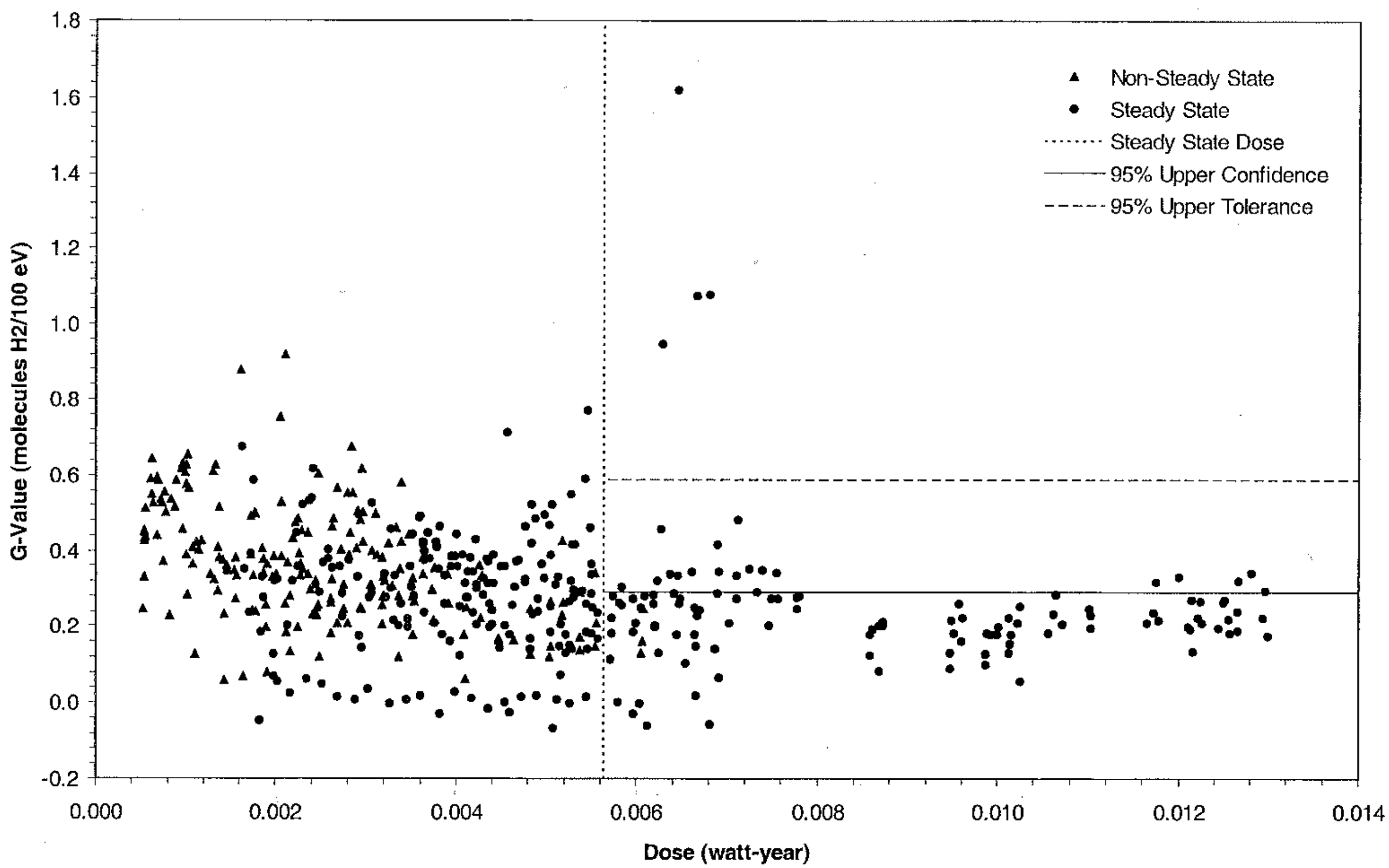

Figure 4-2. Graph of G-value versus accumulated dose for dry cellulose matrix.

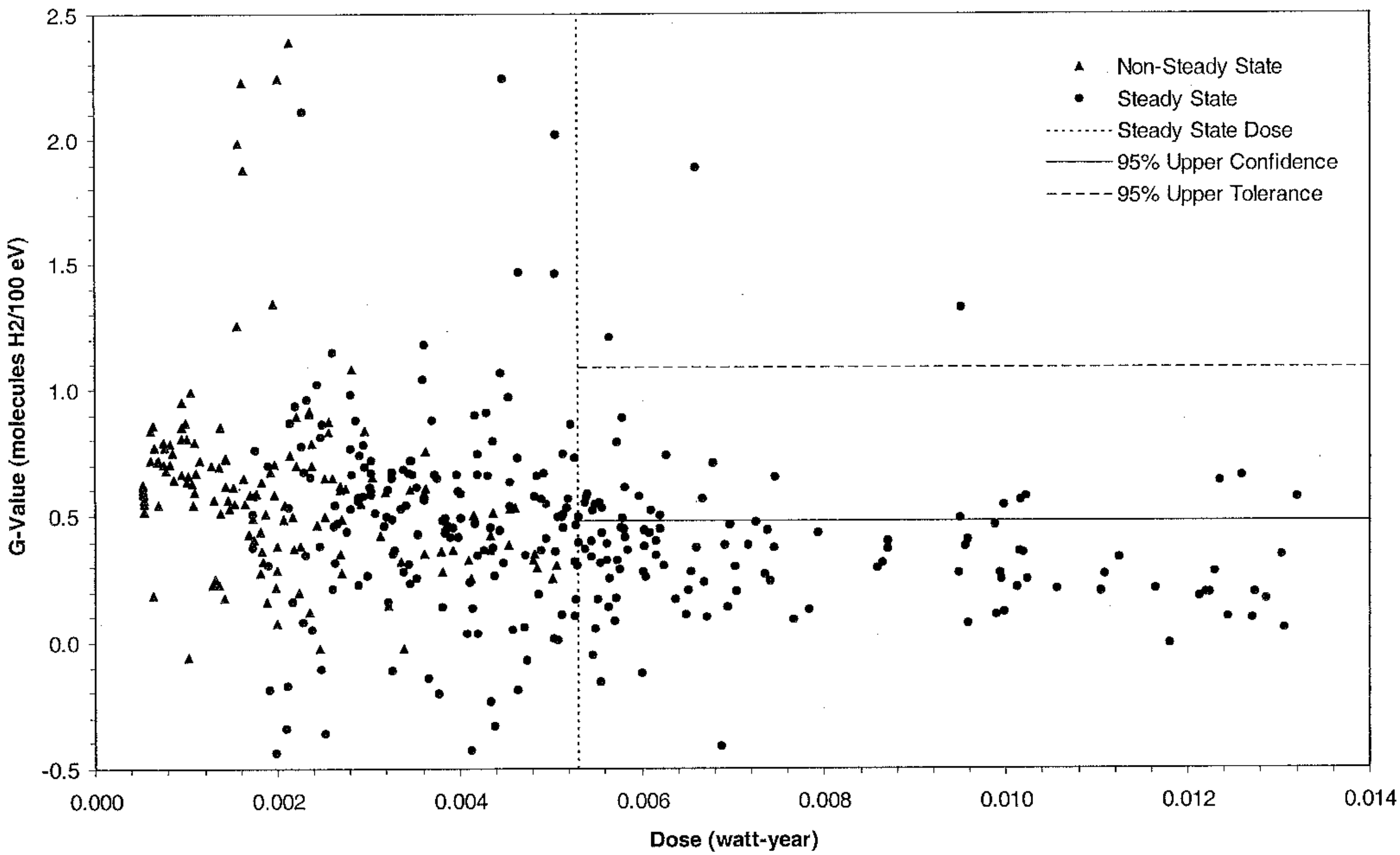

Figure 4-3. Graph of G-value versus accumulated dose for wet cellulose matrix.

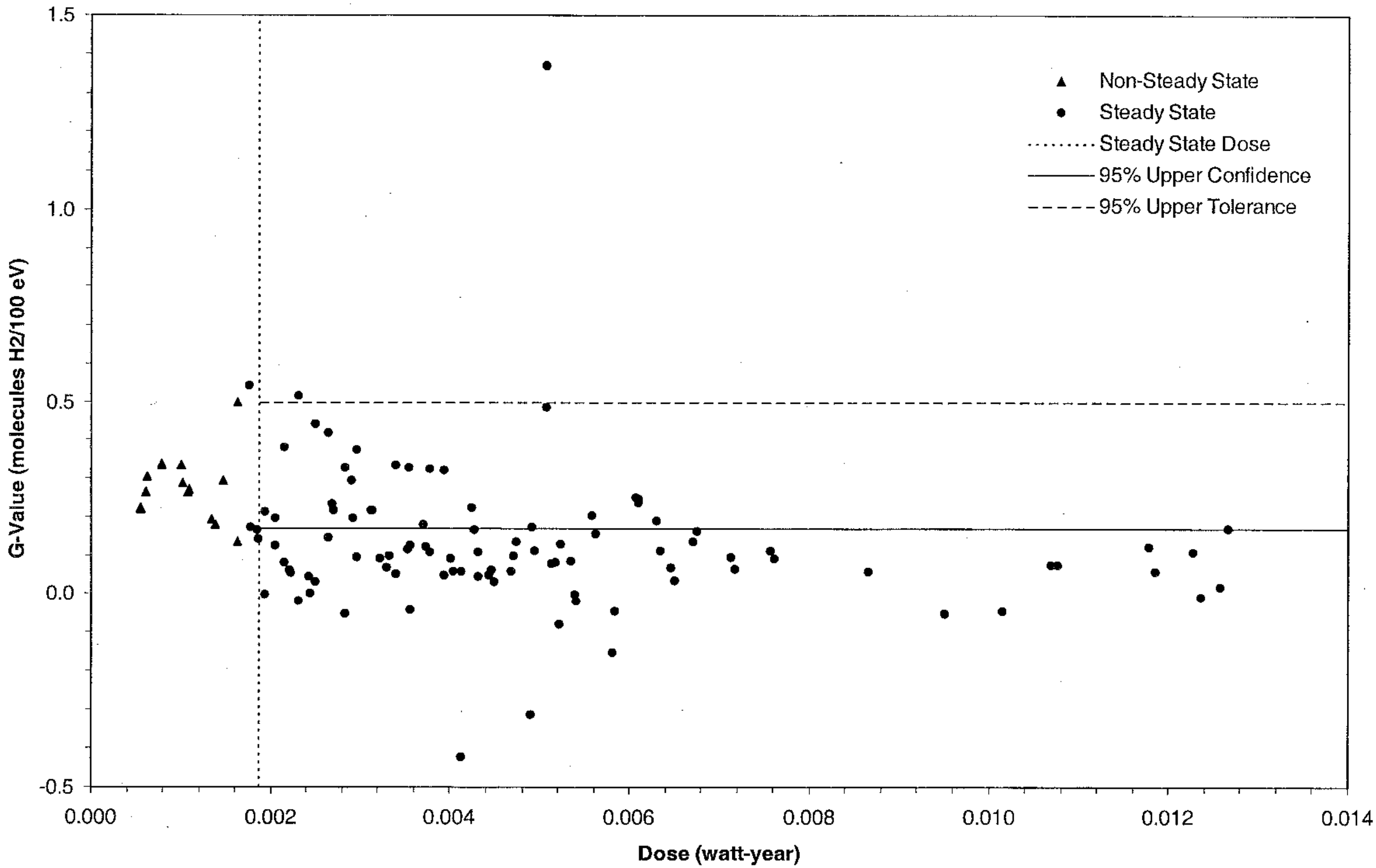

Figure 4-4. Graph of G-value versus accumulated dose for PVC matrix.

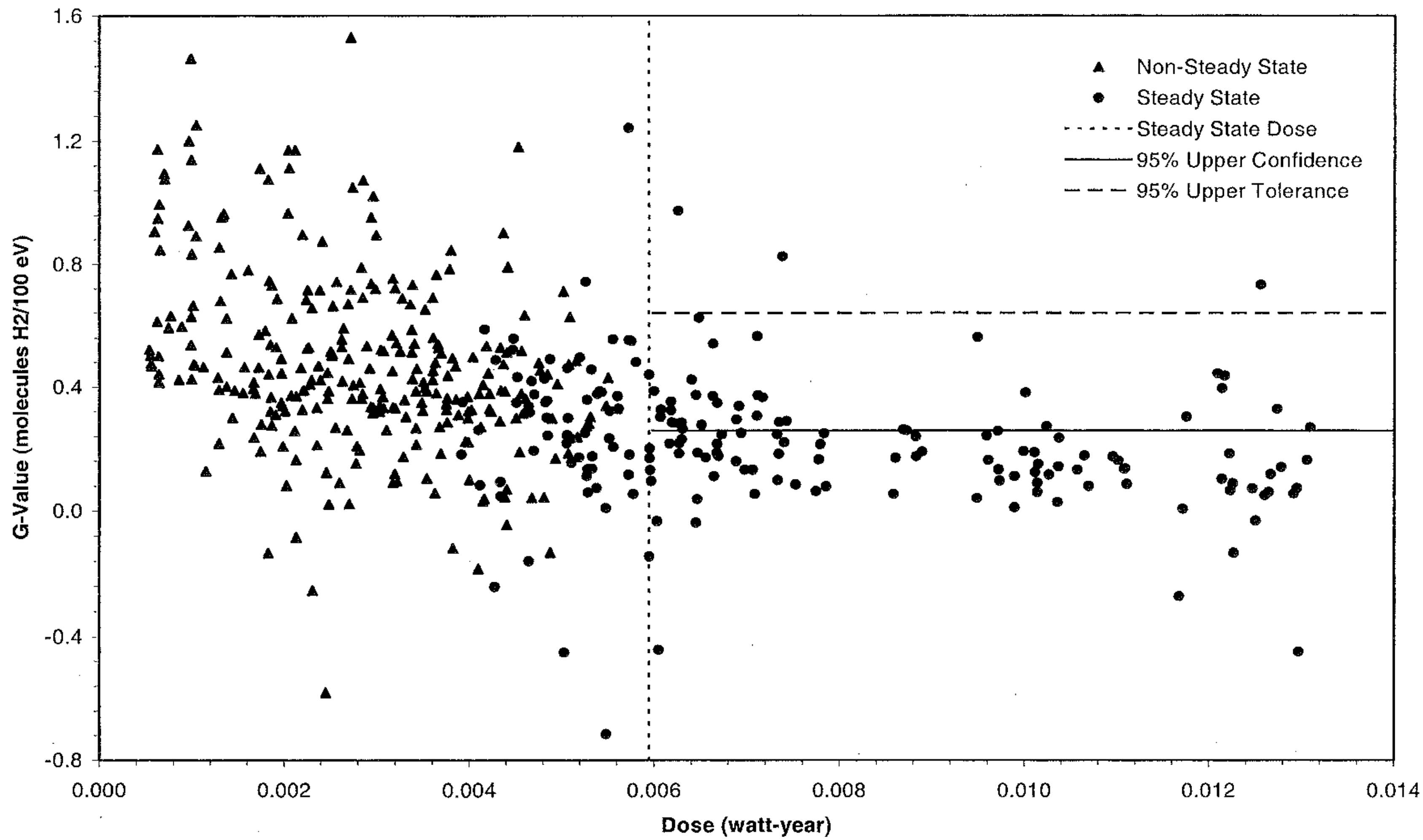

Figure 4-5 Graph of G-value versus accumulated dose for PE matrix.

4.2.1 GGTP Results

Hydrogen gas generation rates were determined for 83 drums under the RFETS GGTP program. The effective G-value was calculated for each drum using the measured hydrogen gas generation rate and the mean decay heat or wattage of the drum. The effective G-values for these 83 drums were used for comparison with the MDP dose dependent G-values. Appendix D is a summary of these testing results. Results for drums with item description codes (IDCs) 300, 442, and 480 (waste material type II.1) were compared to the MDP dose dependent G-values for the worst-case packaging material (i.e., PE). Results for drums with IDCs 330, 335, 336, 337, 338, 342, and 376 (waste material type III.1) were compared to MDP dose dependent G-values for the worst-case material found in waste material type III.1 wastes (i.e. wet cellulosics).

For each drum examined in the GGTP, the effective drum G-value was subtracted from the smallest appropriate dose dependent G-value (i.e., mean effective G-value) to give the difference shown in Equation 4-1:

$$D = G_{mean} - G_{drum} \tag{4-1}$$

The differences were tested at the 0.05 significance level using the **t** test. A dose dependent G-value of 0.23 molecule/100 eV based on PE was used in comparisons with waste material type II.1 drums, while a dose dependent G-value of 0.44 molecule/100 eV based on wet cellulosics was used in comparisons with waste material type III.1 drums. The hypotheses tested were:

$$H_o: D \geq 0 \tag{4-2}$$

and

$$H_a: D < 0 \tag{4-3}$$

Through the statistical analysis a determination could be made as to whether or not the MDP dose dependent G-values are conservative (i.e., greater) relative to effective G-values for actual waste drums. If the dose dependent G-values based on the mean effective G-value are shown to be greater compared to the effective actual drum G-values, then the dose dependent G-values based on the UCL_{95} of the means and UTL_{95} are even more conservative. The mean value of the 83 calculated differences was 0.138, while the standard deviation of the differences was 0.024. The corresponding **t** statistic for this comparison was 5.66. At a 0.05 significance level, the **t** test indicated that MDP dose dependent G-values are greater than the effective G-values of actual drums. Thus, the dose dependent G-values based on the UCL_{95} and UTL_{95} are also greater than the effective G-values of actual drums.

4.2.2 TWCP Results

A total of 885 gas samples (428 from the INEEL and 457 from the RFETS) were collected and analyzed for hydrogen and methane under the TWCP for use in MDP analyses. A total of 30 samples were taken from the innermost layer of confinement void volumes, 304 from rigid drum liner void volumes, and 551 samples from drum headspace void volumes. The concentrations of hydrogen and methane in each sample analyzed were added to provide the total flammable gas concentration for each sample. If the reported value was below detection limit, the detection limit was used in the summation. Concentrations in each void volume were predicted at the time of sampling using the NEWGVALS model and a step function in the G-value as described in Appendix C. The mean G-values for PE and wet cellulosics were used to represent the dose dependent effective G-values for waste material types II.1 and III.1, respectively. Using the dose dependent G-values based on the UCL_{95} of the means and UTL_{95} would have yielded even higher predicted flammable gas concentrations. Appendix C provides the specifics of the modeling, G-value step functions used, and drum and sample data supplied as input to NEWGVALS, as well as the predicted flammable gas concentrations in each layer of confinement for use in comparisons with sampled concentrations.

For each sample, the measured flammable gas concentration, C, was subtracted from the NEWGVALS predicted flammable gas concentration, C_B, as documented in Appendix C, to give the following difference:

$$D = C_B - C \tag{4-4}$$

The differences were tested at the 0.05 significance level using the **t** test. The hypotheses tested were:

$$H_o: D \geq 0 \tag{4-5}$$

and,

$$H_a: D < 0 \tag{4-6}$$

Through the statistical analysis, a determination could be made as to whether or not the MDP dose dependent G-values are conservative relative to actual waste drums. If the dose dependent G-values based on the mean used in the predictions are shown to be bounding, then the dose dependent G-values based on the UCL_{95} of the means and UTL_{95} are even more conservative. Table 4-2 summarizes the results of the hypothesis testing.

Table 4-2. Statistics for comparisons of TWCP headspace sampling data and predictions made using experimentally derived G-values.

Location of sampling	Number of observations	Mean of differences (vol% flammable gas)	Standard deviation of differences (vol% flammable gas)	**t** statistic value
Inner bag void	30	0.623	0.188	3.31
Rigid drum liner	304	2.429	0.375	6.48
Drum headspace	551	1.688	0.310	5.44

At a 0.05 significance level, the three **t** tests by sampling location indicated that the flammable gas concentrations predicted using the dose dependent G-values based on the mean are statistically greater than the sampled flammable gas concentrations in all three tests. Thus, the dose dependent G-values based on the UCL_{95} and UTL_{95} are also greater.

4.3 Theoretical Analyses

A major portion of the TARMATDEP work related to the MDP involved theoretical simulations of LANL matrix depletion experiments. The purpose of the theoretical simulations was to demonstrate that mathematical representations of the fundamental nuclear and molecular level mechanistic processes of matrix depletion and hydrogen production are consistent with experimental measurements. The TARMATDEP model was first executed as a simulation run of the G-initial or short-term testing LANL MDP experimental data (Section 2.1.2). Using the appropriate ^{239}Pu based nuclide data, with PE as the target matrix, TARMATDEP was executed for an 80-day simulation period. Figure 4-7 shows a comparison of the TARMATDEP prediction with the actual LANL MDP experimental data. It can be seen that the model prediction closely tracks LANL MDP experimental data, beginning with about day 1 and ending with day 80. The critical initial time period, corresponding to the first 15 days during which the effective G-value curve experiences its steepest drop, is especially accurately predicted with the TARMATDEP model.

A separate simulation run was carried out to investigate the benefits of establishing a "predictive range" of effective G-values using the TARMATDEP model. Because most experiments to date (i.e., LANL MDP, Zerwekh 1979, Kosiewicz 1981, Smith et al. 1997) involved PuO_2 powders sprinkled onto thin strips of target matrix, which were then folded over the powders multiple times, the experimental geometry in most cases was 4ð (i.e., complete encirclement of the PuO_2 particles by target matrix material). By using a less conservative assumption, namely that of a 2ð experimental geometry with respect to the PuO_2 particles, the predicted effective G-values would then represent a "lower limit" of the effective G-value range. The corresponding "upper limit" of the effective G-value range could then be obtained by doubling the effective G-values arising from the 2ð set. Figure 4-8 shows such a method and the resultant predictive range of G-values, plotted against LANL MDP short-term data. It can be seen that the predictive range approach is valid, as the majority of experimental data lie within the upper and lower limits. Because the actual experimental data is characterized by a 4ð geometry between the PuO_2 particles and the target matrix, it lies much closer to the 2*2ð-based upper limit than it does to the 2ð-based lower limit.

The TARMATDEP model was also run to simulate the long-term LANL MDP experiments. Using the appropriate Pu nuclide data, with PE as the target matrix, TARMATDEP was executed for an 80-day simulation period. Figure 4-9 shows a comparison of the TARMATDEP prediction with the actual LANL MDP experimental data from the "N" (neither-heated-nor-agitated) rack for a ^{239}Pu contaminant and a PE target matrix. The model tracks LANL experimental data very well, over the entire 80-day period, as shown in Figure 4-9.

Overall, the TARMATDEP modeling of the effective G-value versus dose behavior indicated that, while the effective G-value is independent of the dose rate (in Watts) incident on a particular target matrix, it is highly dependent on the total dose (in Watt @ yrs) applied to a particular target matrix. In other words, a finite and known effective G-value can be derived from knowing the properties of the contaminant, the properties of the target matrix material, and the total dose applied to the target matrix.

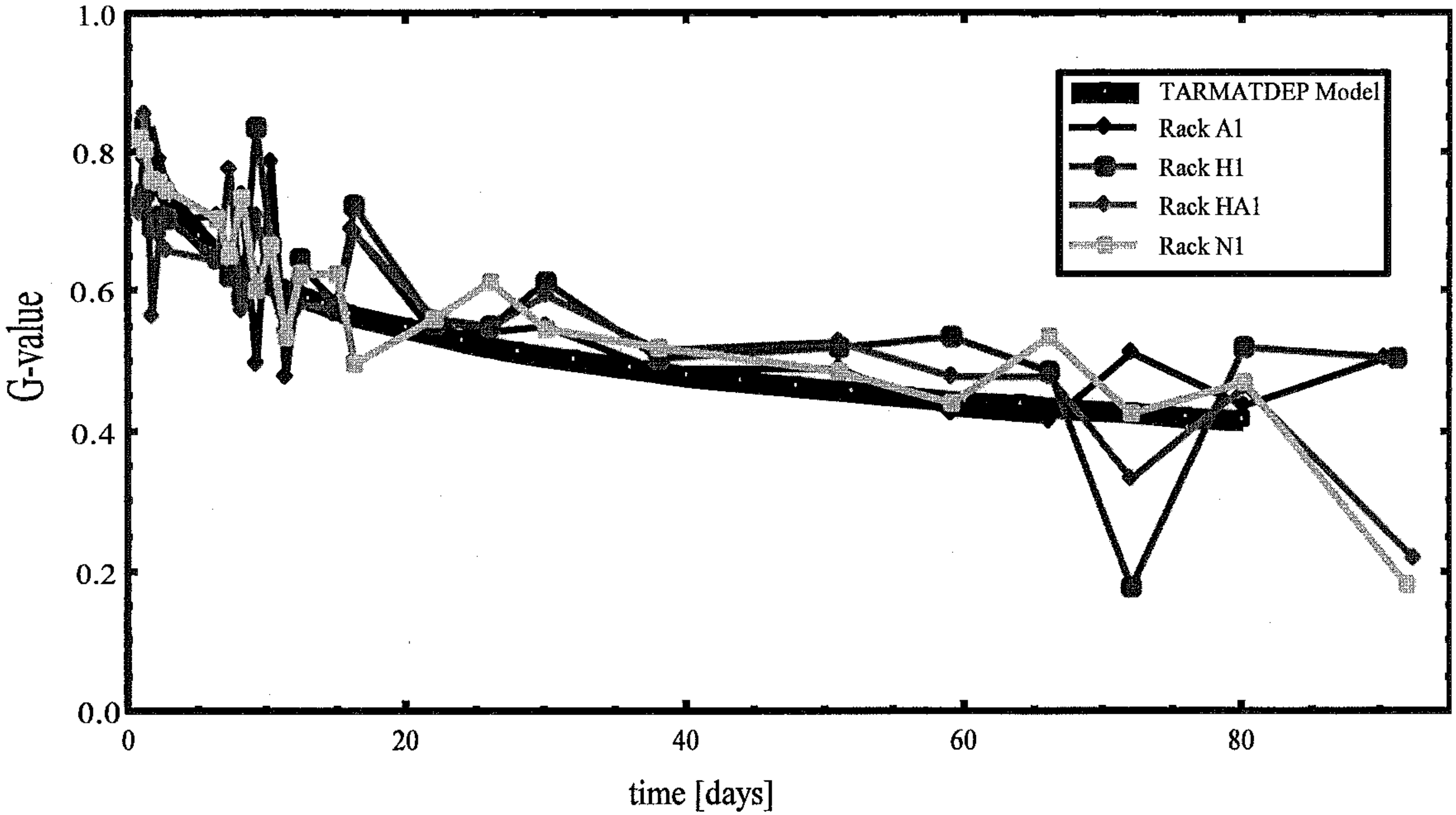

Figure 4-6. Comparison of LANL MDP short-term experimental data with TARMATDEP model.

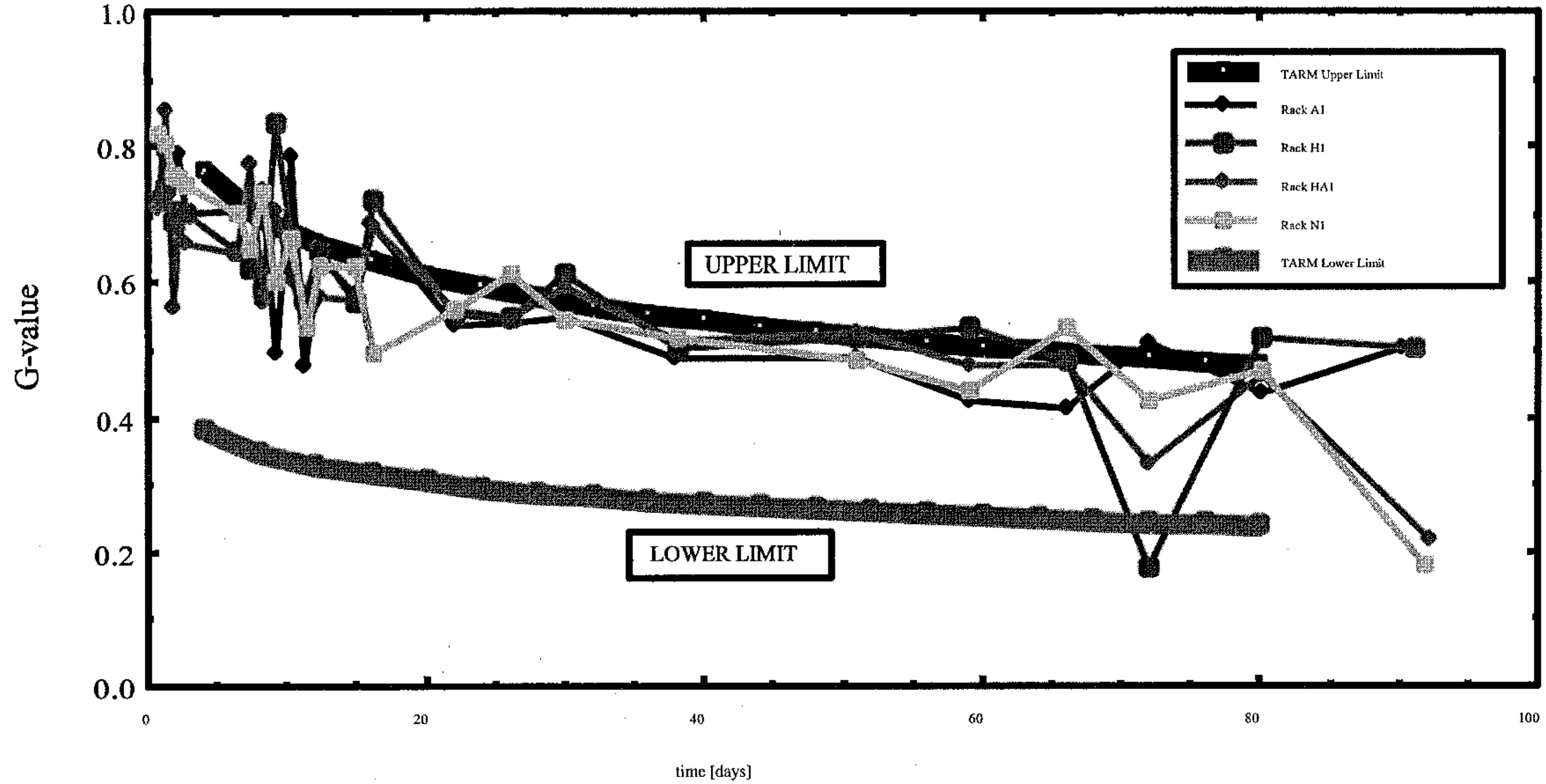

Figure 4-7. **Comparison of LANL MDP short-term experimental data with TARMATDEP predictive range.**

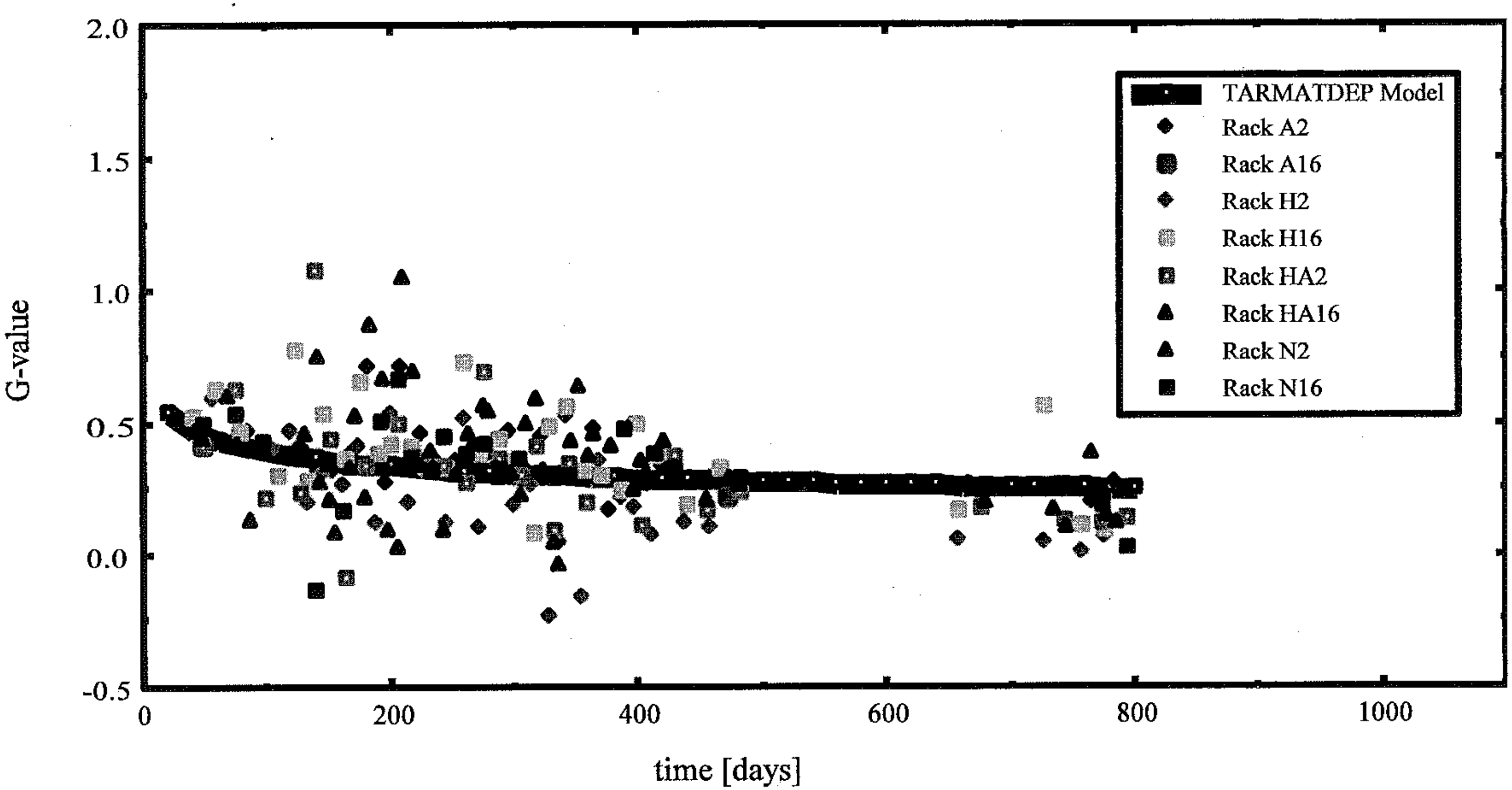

Figure 4-8. Comparison of LANL MDP long-term experimental data with TARMA TDEP model.

4.4 Synthesis and Comparison to TRUPACT-II SARP Values

Dose dependent G-values were experimentally derived for a number of simulated waste materials. The MDP dose dependent G-values are consistent with those obtained in previous studies. Statistical comparisons of the dose dependent G-values with hydrogen gas generation measurements on real waste drums have shown that the dose dependent values are larger and more conservative. Theoretical analyses using a first principles model that simulates the fundamental nuclear and molecular level mechanistic processes of hydrogen generation and matrix depletion are consistent with experimental measurements.

A comparison was made of the dose dependent G-values by waste material type to those in the current TRUPACT-II SARP, and the results are summarized in Table 4-3. Waste material types I.2, I.3, and IV.1 were not tested as part of the MDP. The current TRUPACT-II SARP initial bounding G-value for waste material type I.1 is that of water, with an effective G-value of 1.6 molecule/100 eV. The Envirostone matrix that was tested under the MDP was a waste form specific to LANL and may not represent waste material type I wastes at other sites. The testing of the Envirostone matrix was primarily performed to demonstrate that the dose dependent G-values are consistent with the current TRUPACT-II SARP values. Statistically based GGTP testing of waste type I.1 and I.2 containers may establish an effective G-value on a waste stream or IDC basis.

It appears that the critical parameter effecting the effective G-value of a particular waste stream of waste material type I.3 will be the weight percent water in the waste form. The TRUPACT-II SARP assumed a maximum of 30% water in establishing the initial bounding G-value of 0.4 molecule/100 eV for waste material type I.3. A statistically based sampling program to determine effective G-values for each waste stream or IDC may provide waste stream-specific effective G-values. An initial bounding G-value for waste material type IV.1 was not established in the TRUPACT-II SARP, and all containers of waste type IV fall into the test category. It is expected that statistically based GGTP testing of waste type IV containers will establish effective G-values on a waste stream or IDC basis.

The current TRUPACT-II SARP G-value for waste material type II.1 is based on the assumption that the surface-contaminated inorganic wastes will, on the average, absorb half of the alpha decay energy escaping from particulate contamination. The inorganic materials are considered to generate no gas. The remaining half of the alpha decay energy is assumed to be absorbed by the packaging materials. Because the worst-case packaging material from a hydrogen generation standpoint is PE, the initial bounding G-value (i.e. 3.4) defined in the TRUPACT-II SARP for waste material type II.1 is 50% of the value for PE, or 1.7 molecule/100 eV. MDP experiments have demonstrated that, for dose dependent G-values, PE is still the worst-case material, and the values for the dose dependent G-values listed in Table 4-3 (UCL_{95} G-value and UTL_{95} G-value) are those of PE. The dose dependent G-value based on the UCL_{95} (i.e., 0.26 molecule/100 eV) is approximately 15% (i.e. 8% of initial bounding PE G-value) of the current TRUPACT-II SARP initial bounding G-value, while the dose dependent G-value based on the UTL_{95} (i.e., 0.64 molecule/100 eV) is approximately 38% (i.e. 19% of initial bounding PE G-value) of the current TRUPACT-II SARP initial bounding G-value.

The current TRUPACT-II SARP initial bounding G-value for waste material type III.1 of 3.4 molecule/100 eV is based on the initial bounding G-value for the worst-case material that may be present in the waste, namely PE. However, the results of the MDP testing indicate that the worst-case hydrogen depleted material for this waste material type is wet cellulosics, and the values for the dose dependent G-values listed in Table 4-3 (UCL_{95} G-value and UTL_{95} G-value) are those of wet cellulosics. The dose dependent G-value based on the UCL_{95} (i.e., 0.48 molecule/100 eV) is approximately 14% of the current TRUPACT-II SARP initial bounding G-value, while the dose dependent G-value based on the UTL_{95} (i.e., 1.09 molecule/100 eV) is approximately 32% of the current TRUPACT-II SARP initial bounding G-value.

Table 4-3. Comparison of dose dependent G-values to TRUPACT-II SARP initial bounding G-values.

Waste type	Waste material type	Description and examples	TRUPACT-II SARP initial bounding G-value	Corresponding MDP test matrix[a]	MDP worst-case matrix material dose dependent G-value based on the UCL_{95} (molecule/ 100 eV)	MDP worst-case matrix material dose dependent G-value based on the UTL_{95} (molecule/ 100 eV)
I	I.1	Absorbed, adsorbed, or solidified inorganic liquids	1.6	Cement (Envirostone)	0.27	0.58
I	I.2	Soils, solidified particulates, or sludges formed from precipitation	1.3	—	Not tested	Not tested
I	I.3	Concreted inorganic particulate waste having a maximum of 30 weight percent unbound water	0.4	—	Not tested	Not tested
II	II.1	Solid inorganic materials in plastic bags	1.7[b]	PE	0.26	0.64
III	III.1	Solid organic materials	3.4	WC	0.48	1.09
IV	IV.1	Solidified organic materials (organic sludges)	Not established	—	Not tested	Not tested

a. PE=polyethylene; WC=wet cellulosics.
b. 50% of initial bounding PE G-value of 3.4.

5.0 CONCLUSIONS

The three-year MDP is the most comprehensive study of gas generation and matrix depletion phenomena of simulated TRU waste materials completed to date. The program was developed and implemented under a formal QA program. The matrix depletion experiments were designed using an EPA-established procedure in formulating DQOs that were met.

Validated gas generation data were collected for 34 sampling cycles using the experimental testing apparatus at LANL. Effective G-values were then calculated for each test cylinder for each of the 34 sampling cycles. Each cylinder contained one of five simulated TRU waste materials (i.e., PE, PVC, wet and dry cellulose, and cement represented by Envirostone) that were impregnated with one of two isotopic mixtures (one predominantly ^{238}Pu oxide and the other predominantly ^{239}Pu oxide). MDP testing has demonstrated matrix depletion in simulated waste materials, which is consistent with results from past research. The key parameters effecting the effective G-value have been identified and quantified through testing and analysis of results. The observed effects of each of the key variables is summarized below.

5.1 Dose

Increasing dose (defined as the product of the decay heat measured in a test cylinder and elapsed time from cylinder loading) decreases the effective flammable gas generation rate of hydrogenous materials (such as plastics and combustibles) due to depletion of the target material in the vicinity of an alpha-emitting radioactive source particle. This effect has been demonstrated through the current MDP testing, previous testing of similar materials with similar radioactive sources, and theoretical modeling of the matrix depletion phenomena.

5.2 Matrix Materials

The values of the dose dependent G-values are highly dependent on the material that is irradiated. Testing has demonstrated that wet cellulosics yield the highest dose dependent G-values. Wet cellulosics are typically found in containers containing predominantly combustible wastes (i.e. waste type III). PE is the bounding material for hydrogen gas generation in containers of inorganic solid wastes packaged within plastic bags (i.e., waste type II).

5.3 Moisture

The effects of moisture were evaluated by having cylinders with both wet and dry cellulosic materials. The dose dependent G-values for wet cellulosics are statistically higher than those of dry cellulosics because of the presence of water.

5.4 Temperature

The effects of temperature were evaluated by heating selected test cylinders continuously at 140 °F to simulate worst-case thermal transport conditions. At the 95% confidence level, there was no statistically significant effect of temperature on the dose dependent G-value.

5.5 Agitation

The effects of agitation were not evaluated because the proposed agitation of test cylinders was found not to represent the conditions of actual 55-gal. drums during movement and transport. Previous experiments that included agitation of cylinders similar to those used in the MDP indicated that agitation did not affect effective G-values.

5.6 Particle Size Distribution

The effects of particle size distribution were evaluated by having two radioactive source materials with significantly different particle size distributions. In one case, the particle sizes were approximately 16.6 microns in diameter and relatively monodisperse, while for other test cylinders, the spread in particle diameter was very broad, with a mean particle diameter of around 33 microns. Experimental results as well as theoretical simulations indicate that smaller particle diameters yield higher initial G-values. However, for all particle diameters tested, the effective G-values for individual test cylinders are substantially lower than the dose dependent G-values based on the UCL_{95} and UTL_{95} for the worst-case materials tested under the MDP.

5.7 Isotopic Composition

Two different isotopes of Pu (^{238}Pu and ^{239}Pu) were tested at equivalent decay heats for each test cylinder. At the 95% confidence level, isotopic composition did not have a significant effect on the dose dependent G-value.

5.8 Initial versus Dose Dependent G-values

Initial effective G-values were higher than the dose dependent G-values for all waste matrices except Envirostone, thus supporting the concept of matrix depletion. The dose dependent G-values for PE are considerably lower than the initial bounding G-value of 3.4 molecule/100 eV used in the TRUPACT-II SARP. The TRUPACT-II SARP value is based on gamma irradiation experiments conducted in 1959. The credibility of experiments conducted prior to 1962 is questionable. More recent data collected since that time indicate that the maximum initial bounding G-value for alpha irradiation of PE in air is 2.4 molecule/100eV. The dose dependent G-values for PE, PVC, and cellulosics are several times lower than the corresponding initial bounding G-values.

5.9 The Path Forward

Revision 17 of the TRUPACT-II SARP, through the proposed revised numeric shipping category notation, has provided a framework for readily incorporating dose dependent G-values. The new shipping category notation uses 10 numeric characters, as shown in the following example:

Example: XX YYYY ZZZZ

where

XX = Waste Type (10=waste type I, 20=waste type II, 30=waste type III, and 40=waste type IV)

YYYY = G-value (x 100)

ZZZZ = Resistance to hydrogen release (x 10^{-4})

Thus the dose dependent G-values can be readily represented by the YYYY portion of the shipping category notation. The calculation of maximum allowable wattage for a container is calculated through a three-step process:

Step 1: Determine effective G-value for waste material type from look-up table in TRAMPAC (thus MDP dose dependent G-values can readily be added to this look-up table).

Step 2: Determine resistance to hydrogen release by a worksheet.

Step 3: Determine maximum allowable wattage as a function of effective G-value and total resistance to hydrogen release.

Appropriate sections of the TRUPACT-II SARP (including Appendix 3.6.7, "Effective G-values for TRUPACT-II Waste Types") and the TRAMPAC may be revised to explain the matrix depletion phenomenon; provide a rationale for dose dependent G-values; document the MDP testing and related experimental programs; and summarize MDP results.

5.10 Summary

The dose dependent G-values are reproducible, consistent with earlier results, and fall within theoretically predicted bounds. Dose dependent G-values have been derived for each waste material tested. Comparisons with actual drum data have demonstrated that the dose dependent G-values for worst-case materials by waste type (i.e., PE for type II, and wet cellulosics for type III) are, in fact, greater than those for actual wastes and are, therefore, good conservative estimators for each respective waste type.

MDP effects analyses indicated that only the waste matrix has a significant effect on the dose dependent G-value. At the 95% confidence level, isotope and temperature (i.e., heating) did not have significant effects on the dose dependent G-values. In addition, the data demonstrate consistency with TRUPACT-II SARP limits for waste type I. Analyses of MDP experimental data indicate that dose dependent G-values lie between 14% (UCL_{95} value for wet cellulose) and 38% (UTL_{95} value for PE) of the applicable TRUPACT-II SARP initial bounding values, depending on the waste material, and including effective G-values calculated from heated cylinders (e.g., wet cellulose is comparable to waste material type III-1, solid organic materials). In general, the data patterns are consistent with theoretical expectations for effective G-value behavior over time for different waste materials.

Appropriate sections of the TRUPACT-II SARP and TRAMPAC should be revised to explain and account for the matrix depletion phenomenon. The original TRUPACT-II SARP initial bounding G-values may be used to establish the wattage limits for newly generated containers. When a container has attained an adequate dose level, the lower dose dependent G-values may be used to establish the allowable wattage for the containers (i.e., a step function in G-value from initial high to depleted low).

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Appendix A

Results of TRUPACT-II Matrix Depletion Program Experiments

RESULTS OF TRUPACT-II MATRIX DEPLETION PROGRAM EXPERIMENTS

A.1 G-value Calculations

(NOTE: All tables and figures referenced in Appendix A are provided at the end of this appendix.)

Effective G-values based on Matrix Depletion Program experimental results through August 1997, were calculated according to the following equations, in accordance with the *Data Reduction, Validation, and Reporting Procedure for the TRUPACT-II Matrix Depletion Program*, Revision 1 (INEEL 1997):

$$G_i = \frac{\Delta n \, N_A}{0.01 \, m \, DH_{avg} \, \Delta t \, k} \tag{A-1}$$

where

G_i = effective G-value of target waste material at sampling period i (molecules/100 eV)

Δn = moles of flammable gas generated during the time period t_i - t_{i-1} (mole)

N_A = Avogadro's number (6.022045 x 10^{23} molecules/mol)

m = mass of radioactive source material (g)

k = conversion factor (1 eV/1.602 x 10^{-19} W·s)

Δt = t_i - t_{i-1}, which is the elapsed time between successive sampling periods (s)

DH_{avg} = average decay heat of radioactive source material (W/g).

The moles of flammable gas generated during the time period t_i - t_{i-1}, Δn, accounting for displacement of gas in the sampling line, is calculated as follows:

$$\Delta n = \frac{MF_i P_i V}{RT_i} + \frac{MF_i P_i L}{RT_{i,amb}} - \frac{MF_{i-1} P_{i-1} V}{RT_{i-1}} \tag{A-2}$$

where

L = sampling line volume (l)

MF_i = mole fraction flammable gas concentration in test cylinder at sampling period i (dimensionless)

MF_{i-1} = mole fraction flammable gas concentration in test cylinder at sampling period i-1 (dimensionless)

T_i = absolute temperature on rack at sampling time i (K)

$T_{i\text{-}1}$ = absolute temperature on rack at sampling time i-1 (K)

$T_{i,\,amb}$ = absolute ambient temperature at sampling time i (K)

P_i = absolute final pressure in test chamber at sampling period i prior to gas sample withdrawal for concentration determination (atm)

$P_{i\text{-}1}$ = absolute final pressure in test chamber at sampling period i-1 after gas sample withdrawal for concentration determination (atm)

V = void volume in test chamber (l)

R = universal gas constant (0.08206 atm l/mol K).

A.2 G-value Data Sets

Experimental data validated according to Los Alamos National Laboratory procedures were used to calculate G-values according to the above equations for cycles 1-34 of original test cylinders and for cycles 1-25 of restart cylinders. Cylinder characteristics are described in Table A-1.

Cylinder purging and backfilling with ambient air oxygen concentrations was performed on 21 original test cylinders. Nine cylinders were purged and backfilled after cycle 25, and 12 were purged and backfilled after cycle 27. All cylinders were inadvertently opened to the atmosphere during an unauthorized intrusion into the computer network at cycle 31. Those cylinders that were at sub-atmospheric pressure conditions were brought back to the ambient pressure with air, whereas those cylinders that were above atmospheric pressure were depressurized back to the ambient pressure. Table A-1 identifies purged cylinders and cycles. Cycles are renumbered in analysis data set to reflect sampling before and after each planned purge; the total number of cycles in the resulting original test cylinder data set is 38.

For the first cycle(s) after the purging until the cycle with the next available validated hydrogen measurement, G-values for purged cylinders were not computed. Also, G-values were not computed across pressure discontinuities. Ambient temperatures for calculations are taken as the average of unheated rack temperature measurements for each cycle, except cycle 0 is taken as 25 °C. Cylinder void volumes are used for the calculations. Data for cylinders designated as heated, but collected prior to heating, and data from a leaking cylinder (A04) are omitted from analysis data sets. Tables A-2 and A-3 provide input measurements and calculated G-values for original and restart cylinders, respectively.

Table A-1. Cylinder characteristics for original and restart cylinders.

Cylinder code	Pu isotope	Matrix[a]	Heated/ unheated	Purge cycle	Original/ restart
N02	239	PE	Unheated	30/31	Original
N03	238	CEM	Unheated	26/27	Original
N04	239	DC	Unheated	26/27	Original
N05	238	PE	Unheated		Original
N06	239	WC	Unheated		Original
N07	238	PE	Unheated		Original
N08	238	PVC	Unheated		Original
N09	238	WC	Unheated		Original
N10	238	PVC	Unheated		Original
N11	238	WC	Unheated		Original
N12	239	WC	Unheated		Original
N13	238	DC	Unheated	26/27	Original
N14	239	DC	Unheated	26/27	Original
N15	238	DC	Unheated	26/27	Original
N16	239	PE	Unheated	30/31	Original
A02	239	PE	Unheated	30/31	Original
A03	238	CEM	Unheated	26/27	Original
A04	239	DC	Unheated		Original
A05	238	WC	Unheated		Original
A06	239	WC	Unheated		Original
A07	238	WC	Unheated		Original
A08	239	CEM	Unheated		Original
A09	238	DC	Unheated	26/27	Original
A10	239	CEM	Unheated		Original
A11	238	DC	Unheated	26/27	Original
A12	239	WC	Unheated		Original
A13	238	PE	Unheated		Original
A14	239	DC	Unheated	26/27	Original
A15	238	PE	Unheated		Original
A16	239	PE	Unheated		Original
H02	239	PE	Heated		Original
H03	238	CEM	Heated		Original
H04	239	DC	Heated	30/31	Original
H05	238	PE	Heated		Original
H06	239	WC	Heated		Original
H07	238	PE	Heated		Original
H08	239	CEM	Heated		Original
H09	238	WC	Heated		Original
H10	239	CEM	Heated		Original
H11	238	WC	Heated		Original

Table A-1. (continued).

Cylinder Code	Pu Isotope	Matrix[a]	Heated/ Unheated	Purge Cycle	Original/ Restart
H12	239	WC	Heated		Original
H13	238	DC	Heated	30/31	Original
H14	239	DC	Heated	30/31	Original
H15	238	DC	Heated	30/31	Original
H16	239	PE	Heated		Original
HA02	239	PE	Heated		Original
HA03	238	CEM	Heated		Original
HA04	239	DC	Heated	30/31	Original
HA05	238	WC	Heated		Original
HA06	239	WC	Heated		Original
HA07	238	WC	Heated		Original
HA08	239	PVC	Heated	30/31	Original
HA09	238	DC	Heated	30/31	Original
HA10	239	PVC	Heated	30/31	Original
HA11	238	DC	Heated	30/31	Original
HA12	239	WC	Heated		Original
HA13	238	PE	Heated		Original
HA14	239	DC	Heated		Original
HA15	238	PE	Heated		Original
HA16	239	PE	Heated		Original
N01	—	QC	—		Original
A01	—	QC	—		Original
H01	—	QC	—		Original
HA01	—	QC	—		Original
N01	239	PE	Unheated		Restart
A01	239	PE	Unheated		Restart
H01	239	PE	Heated		Restart
HA01	239	PE	Heated		Restart

a. CEM = Cement
DC = Dry Cellulose
PE = Polyethylene
PVC = Polyvinyl Chloride
QC = Quality Control
WC = Wet Cellulose

Table A-2. Measured parameters and calculated G-values for original cylinders.

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
A01	0		0.0				
A01	2		4935.0	25.00			
A01	3		5325.0	25.00			
A01	4		5165.0	25.00			
A01	5		5199.0				
A01	6	0.9061	4736.0	24.20			
A01	7	1.0361	4715.0	24.62			
A01	8	1.0272	4807.0	23.98			
A01	9	1.0687	4660.0	23.50			
A01	10	1.0776	4892.8	22.88			
A01	11	0.9293	4884.3	23.08			
A01	12	0.8776	4766.1	23.92			
A01	13	0.9204	4877.1	22.50			
A01	14	0.9204	4889.9	22.81			
A01	15	0.9136	4919.7	23.19			
A01	16	0.9177	4844.4	23.44			
A01	17	0.9190	4958.7	23.85			
A01	33	1.0014	4954.8	56.64			
A01	34	0.9694	4975.0	56.44			
A01	35	0.9755	4977.9	56.68			
A01	36	0.9673	5024.3	56.46			
A01	37	0.9714	4986.1	56.24			
A01	38	0.9755	5055.3	56.47			
A02	0	0.7672	0.0	25.00		0.0000	
A02	1	0.6536	32498.1	25.00	0.4761	0.0006	
A02	2	0.6685	46527.0	25.00	0.4234	0.0009	
A02	3	0.6535	62122.8	25.00	0.4645	0.0011	
A02	4	0.6612	76587.0	25.00	0.3881	0.0015	
A02	5	0.6660	85587.4	25.00	0.4150	0.0017	
A02	6	0.6531	93237.5	24.36	0.3199	0.0019	
A02	7	0.6687	96171.2	24.92	0.3222	0.0020	
A02	8	0.6660	104292.0	24.13	0.3873	0.0022	
A02	9	0.6646	118801.7	23.53	0.7149	0.0024	
A02	10	0.6639	122761.4	22.96	0.2674	0.0026	
A02	11	0.6660	135549.7	23.17	0.7167	0.0027	
A02	12	0.6694	144589.5	23.86	0.4605	0.0029	
A02	13	0.6639	149692.4	22.62	0.3683	0.0031	
A02	14	0.6660	157738.5	22.89	0.3579	0.0033	
A02	15	0.6673	163533.7	23.30	0.3499	0.0035	
A02	16	0.6667	169039.7	23.50	0.3795	0.0036	

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
A02	17	0.6694	178120.7	23.76	0.4667	0.0039	
A02	18	0.6667	183597.2	23.79	0.3263	0.0040	
A02	19	0.6680	191158.7	24.32	0.4449	0.0042	
A02	20	0.6476	195209.3	23.13	0.0458	0.0044	
A02	21	0.6660	194576.0	22.52	0.3144	0.0046	
A02	22	0.6728	201268.7	24.16	0.4787	0.0048	
A02	23	0.6667	203804.6	23.13	0.1691	0.0049	
A02	24	0.6714	213973.0	24.53	0.4845	0.0052	
A02	25	0.6612	218173.0	22.57	0.2824	0.0053	
A02	28	0.6653	222616.1	23.46	0.3399	0.0055	
A02	32	0.7354	27765.4	24.97		0.0058	
A02	33	0.7048	36706.7	24.95	0.3034	0.0061	
A02	34	0.7551	107060.3	25.48	0.2630	0.0087	
A02	35	0.7259	120873.8	25.69		0.0092	
A02	36	0.7279	128995.1	25.84	0.2428	0.0096	
A02	37	0.7340	135166.2	26.70	0.1927	0.0100	
A02	38	0.7286	142179.1	26.78	0.2735	0.0102	
A03	0	0.7631	0.0	25.00		0.0000	
A03	1	0.8542	10335.0	25.00	0.1563	0.0006	
A03	2	0.9785	12693.0	25.00	0.2340	0.0007	
A03	3	0.9204	18849.0	25.00	0.1474	0.0011	
A03	4	1.0204	25453.0	25.00	0.2119	0.0015	
A03	5	1.0136	29058.0	25.00	0.1456	0.0017	
A03	6	1.0061	30740.0	24.44	0.0844	0.0020	
A03	7	1.0184	32587.0	25.06	0.1340	0.0022	
A03	8	1.0238	35868.0	24.13	0.1663	0.0024	
A03	9	1.0170	38731.0	23.51	0.1413	0.0026	
A03	10	1.0204	41351.8	23.00	0.1617	0.0028	
A03	11	1.0306	43867.5	23.18	0.1685	0.0031	
A03	12	1.0469	46493.2	23.72	0.1599	0.0033	
A03	13	1.0442	48033.3	22.58	0.1340	0.0035	
A03	14	1.0660	51457.9	22.85	0.1810	0.0038	
A03	15	1.0735	52968.8	23.34	0.1163	0.0040	
A03	16	1.0844	54092.4	23.54	0.1302	0.0042	
A03	17	1.0993	56894.6	23.79	0.1764	0.0045	
A03	18	1.1102	58033.8	23.76	0.1293	0.0047	
A03	19	1.1224	60029.4	24.26	0.1633	0.0049	
A03	20	1.1238	61255.9	23.15	0.1176	0.0051	
A03	21	1.0095	62388.3	22.51			D
A03	22	1.0299	64352.8	24.16		0.0056	

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
A03	23	1.0272	65716.4	23.05	0.1055	0.0058	
A03	24	1.0605	67267.9	24.68	0.1556	0.0061	
A03	25	1.0442	68590.6	22.55	0.1021	0.0063	
A03	26	1.0313	69811.3	22.10	0.0713	0.0065	
A03	27	0.7571	3156.1	22.00		0.0065	
A03	28	0.7565	4221.3	23.46	0.4330	0.0065	
A03	29	0.7844	8827.2	24.51	0.1651	0.0067	
A03	32	0.8048	13011.7	25.08	0.1694	0.0069	
A03	33	0.8354	18398.6	24.84	0.1703	0.0072	
A03	34	1.2857	52536.0	25.52	0.1573	0.0105	
A03	35	0.8388	56991.3	25.76		0.0112	
A03	36	0.8844	61526.3	25.92	0.1567	0.0117	
A03	37	0.9449	64722.0	26.79	0.1465	0.0121	
A03	38	0.9762	67484.1	26.76	0.1769	0.0125	
A04	0	0.7649	0.0	25.00		0.0000	
A04	1	0.6670	28903.7	25.00	0.2468	0.0005	
A04	2	0.7700	37691.1	25.00	0.2284	0.0008	
A04	3	0.7534	44605.7	25.00	0.1259	0.0011	
A04	4	0.7551	47509.2	25.00	0.0586	0.0014	
A04	5	0.7619	49015.8	25.00	0.0688	0.0016	
A04	6	0.7286	48495.1	24.44	-0.0463	0.0018	
A04	7	0.7639	47591.5	25.11	0.0695	0.0020	
A04	8	0.7639	47523.0	24.19	0.0252	0.0022	
A04	9	0.7537	49403.5	23.63	0.0616	0.0024	
A04	10	0.7619	49500.3	23.10	0.0494	0.0025	
A04	11	0.7571	49398.2	23.22	0.0148	0.0027	
A04	12	0.7612	48610.0	23.63	0.0082	0.0029	
A04	13	0.7571	48709.5	22.57	0.0335	0.0030	
A04	14	0.7558	47830.7	22.81	-0.0022	0.0033	
A04	15	0.7605	47030.5	23.39	0.0080	0.0035	
A04	16	0.7612	46691.2	23.52	0.0182	0.0036	
A04	17	0.7299	46522.4	23.83	-0.0309	0.0038	
A04	18	0.7537	45089.1	23.73	0.0265	0.0040	
A04	19	0.7605	44343.1	24.26	0.0114	0.0042	
A04	20	0.7585	42896.5	23.11	-0.0164	0.0044	
A04	21	0.7537	42242.0	22.48	-0.0010	0.0045	
A04	22	0.7660	41546.8	24.13	0.0157	0.0047	
A04	23	0.7653	41286.7	22.98	0.0180	0.0049	
A04	24	0.7680	40897.6	24.67	0.0066	0.0051	
A04	25	0.7578	40311.1	22.52	-0.0028	0.0053	

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
A04	28	0.7667	39707.2	23.46	0.0132	0.0054	
A04	32	0.7667	39254.5	25.05	0.0011	0.0058	
A04	33	0.7701	38171.6	24.73	-0.0033	0.0060	
A05	0	0.7654	0.0	25.00		0.0000	
A05	1	0.6978	44200.2	25.00	0.5424	0.0007	
A05	2	0.8105	55583.0	25.00	0.6650	0.0010	
A05	3	0.8113	75017.0	25.00	0.5631	0.0013	
A05	4	0.8163	91664.0	25.00	0.4064	0.0017	
A05	5	0.8095	101400.0	25.00	0.3833	0.0020	
A05	6	0.7714	109999.7	24.46	0.1997	0.0022	
A05	7	0.8088	113433.0	25.19	0.4653	0.0024	
A05	8	0.8048	121376.0	24.20	0.3516	0.0027	
A05	9	0.8000	133740.0	23.65	0.5480	0.0029	
A05	10	0.7966	142044.4	23.19	0.4240	0.0031	
A05	11	0.7959	147666.1	23.10	0.3197	0.0034	
A05	12	0.7980	155179.6	23.57	0.3539	0.0036	
A05	13	0.7912	160973.6	22.54	0.3639	0.0038	
A05	14	0.7946	168720.8	22.81	0.3241	0.0041	
A05	15	0.7952	175947.6	23.35	0.3681	0.0043	
A05	16	0.7939	182364.2	23.51	0.3867	0.0045	
A05	17	0.7952	189322.0	23.84	0.3272	0.0048	
A05	18	0.7932	193285.6	23.69	0.2527	0.0050	
A05	19	0.7939	199141.4	24.25	0.3238	0.0053	
A05	20	0.7850	199727.8	23.14	0.0566	0.0055	
A05	21	0.7707	219152.5	22.46			D
A05	22	0.7789	215588.1	24.13		0.0060	
A05	23	0.7694	226084.4	22.95	0.4495	0.0062	
A05	24	0.7803	225107.5	24.62	0.1134	0.0065	
A05	25	0.7612	237622.9	22.70	0.5663	0.0067	
A05	28	0.7653	244270.2	23.50	0.3889	0.0069	
A05	32	0.7707	254099.3	25.00	0.2722	0.0074	
A05	33	0.7687	254593.8	24.65	0.0922	0.0077	
A05	34	0.8408	299008.0	25.52	0.2058	0.0110	
A05	35	0.7748	307859.6	25.84		0.0117	
A05	36	0.7755	314153.3	25.95	0.1990	0.0122	
A05	37	0.7762	316325.1	26.78	0.0946	0.0127	
A05	38	0.7762	324541.3	26.76	0.3463	0.0130	
A06	0	0.7646	0.0	25.00		0.0000	
A06	1	0.7061	38145.5	25.00	0.6240	0.0005	
A06	2	0.8156	56208.0	25.00	0.7841	0.0008	

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
A06	3	0.7876	74470.0	25.00	0.5916	0.0011	
A06	4	0.8367	93754.0	25.00	0.7295	0.0014	
A06	5	0.8367	105437.0	25.00	0.6495	0.0016	
A06	6	0.8163	111596.0	24.25	0.2734	0.0018	
A06	7	0.8313	119499.0	25.21	0.7038	0.0020	
A06	8	0.8293	127622.0	24.24	0.4940	0.0022	
A06	9	0.8265	142756.0	23.66	0.9026	0.0024	
A06	10	0.8245	152170.2	23.39	0.6455	0.0025	
A06	11	0.8252	160286.3	23.12	0.6023	0.0027	
A06	12	0.8286	168996.5	23.57	0.5542	0.0029	
A06	13	0.8238	175908.5	22.51	0.6101	0.0030	
A06	14	0.8156	187298.8	22.78	0.4838	0.0033	
A06	15	0.8306	187781.2	23.32	0.3114	0.0035	
A06	16	0.8313	201634.4	23.50	1.0406	0.0036	
A06	17	0.8333	209045.8	23.83	0.4818	0.0038	
A06	18	0.8347	216243.2	23.68	0.5987	0.0040	
A06	19	0.8367	222023.2	24.22	0.4680	0.0042	
A06	20	0.8306	228340.6	23.15	0.4520	0.0043	
A06	21	0.8095	232051.1	22.48			D
A06	22	0.8190	238467.8	24.09		0.0047	
A06	23	0.8109	247618.2	22.94	0.5683	0.0049	
A06	24	0.8245	253287.6	24.64	0.4963	0.0051	
A06	28	0.8129	264150.7	23.49	0.3394	0.0054	
A06	29	0.8177	267648.7	24.53	0.3911	0.0056	
A06	32	0.8204	272447.9	24.98	0.4894	0.0058	
A06	33	0.8197	279772.9	24.63	0.4454	0.0060	
A06	35	0.7925	347569.5	25.94		0.0092	
A06	36	0.7946	357253.9	26.06	0.3804	0.0096	
A06	37	0.8088	357971.1	26.80	0.2508	0.0100	
A06	38	0.8088	363106.7	26.84	0.3588	0.0102	
A07	0	0.7660	0.0	25.00		0.0000	
A07	1	0.6910	61524.4	25.00	0.8381	0.0006	
A07	2	0.7919	83006.0	25.00	0.8535	0.0010	
A07	3	0.6890	103740.9	25.00	0.2310	0.0013	
A08	0	0.7607	0.0	25.00		0.0000	
A08	1	0.7276	10394.5	25.00	0.2088	0.0004	
A08	2	0.8160	14450.0	25.00	0.3897	0.0005	
A08	3	0.8126	24057.0	25.00	0.3278	0.0008	
A08	4	0.8163	35117.0	25.00	0.3117	0.0011	
A08	5	0.8095	40397.0	25.00	0.2500	0.0013	

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
A08	6	0.7973	44338.0	24.42	0.1948	0.0015	
A08	7	0.7973	48517.0	25.24	0.2677	0.0016	
A08	8	0.7891	55513.0	24.28	0.3354	0.0018	
A08	9	0.7810	63178.0	23.61	0.3841	0.0020	
A08	10	0.7741	71576.0	23.40	0.4552	0.0022	
A08	11	0.7476	76947.8	23.09	0.1928	0.0023	
A08	12	0.7646	82921.8	23.50	0.3755	0.0025	
A08	13	0.7565	87027.9	22.54	0.2805	0.0027	
A08	14	0.7578	91051.3	22.81	0.1902	0.0029	
A08	15	0.7592	99428.4	23.26	0.4526	0.0031	
A08	16	0.7571	103575.5	23.51	0.2795	0.0032	
A08	17	0.7599	108895.3	23.76	0.2761	0.0034	
A08	18	0.7565	112644.6	23.64	0.2469	0.0036	
A08	19	0.7571	118371.6	24.17	0.3337	0.0037	
A08	20	0.7483	119062.2	23.19	0.0569	0.0039	
A08	21	0.7340	126047.5	22.50			D
A08	22	0.7435	130572.9	24.41		0.0043	
A08	23	0.7374	132417.2	22.95	0.1429	0.0045	
A08	24	0.7483	138478.5	24.68	0.3358	0.0047	
A08	25	0.7354	141582.7	22.65	0.2038	0.0048	
A08	28	0.7422	146077.9	23.53	0.3260	0.0050	
A08	32	0.7483	153531.7	24.99	0.2373	0.0053	
A08	33	0.7578	156714.0	24.57	0.2654	0.0055	
A08	35	0.7925	195816.5	25.76		0.0086	
A08	36	0.8027	202840.0	26.14	0.2927	0.0090	
A08	37	0.8095	197910.9	26.80	-0.0262	0.0093	
A08	38	0.8095	210088.2	26.80	0.5398	0.0096	
A09	0	0.7659	0.0	25.00		0.0000	
A09	1	0.7093	78007.8	25.00	0.6424	0.0006	
A09	2	0.8352	101339.0	25.00	0.6063	0.0010	
A09	3	0.8521	132525.0	25.00	0.6263	0.0013	
A09	4	0.8776	160097.0	25.00	0.4998	0.0018	
A09	5	0.8776	170416.0	25.00	0.3365	0.0020	
A09	6	0.8830	183198.0	24.43	0.4835	0.0022	
A09	7	0.8939	187754.0	25.18	0.3202	0.0024	
A09	8	0.9082	201878.0	24.32	0.5666	0.0027	
A09	9	0.9129	214142.0	23.58	0.5045	0.0029	
A09	10	0.9177	221209.4	23.36	0.3874	0.0031	
A09	11	0.9265	229466.6	23.19	0.4595	0.0033	
A09	12	0.9401	239805.1	23.42	0.4857	0.0036	

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
A09	13	0.9415	245144.7	22.53	0.4236	0.0038	
A09	14	0.9633	251751.0	22.80	0.3870	0.0041	
A09	15	0.9714	254492.3	23.24	0.2819	0.0043	
A09	16	0.9789	257927.7	23.51	0.3581	0.0045	
A09	17	0.9891	268319.8	23.77	0.4641	0.0048	
A09	18	0.9966	275244.9	23.68	0.4925	0.0050	
A09	19	0.9884	276941.7	24.04	0.1307	0.0052	
A09	20	1.0014	285226.9	23.24	0.5891	0.0054	
A09	21	0.9354	287023.1	22.51			D
A09	23	0.9361	293007.9	23.02	-0.0608	0.0061	
A09	27	0.7612	39466.7	22.50		0.0068	
A09	28	0.7558	42177.9	23.56	1.0789	0.0068	
A09	32	0.7320	72304.1	25.05	0.3526	0.0073	
A09	33	0.7435	88406.5	24.59	0.3402	0.0076	
A09	35	0.8088	209760.9	25.70		0.0115	
A09	36	0.8422	222848.9	26.26	0.3290	0.0120	
A09	37	0.8741	231837.1	26.86	0.2624	0.0125	
A09	38	0.8830	241904.2	26.82	0.3395	0.0128	
A10	0	0.7607	0.0	25.00		0.0000	
A10	1	0.7147	12277.9	25.00	0.2376	0.0004	
A10	2	0.7985	15627.0	25.00	0.3358	0.0005	
A10	3	0.7942	26176.0	25.00	0.3441	0.0008	
A10	4	0.7959	36709.0	25.00	0.2831	0.0011	
A10	5	0.7823	42708.0	25.00	0.2542	0.0013	
A10	6	0.7762	47278.0	24.40	0.2311	0.0015	
A10	7	0.7762	52416.0	25.17	0.3105	0.0016	
A10	8	0.7354	59935.9	24.13	0.2219	0.0018	
A10	9	0.7551	68777.1	23.56	0.5434	0.0020	
A10	10	0.7517	74816.5	23.36	0.3310	0.0022	
A10	11	0.7456	80084.4	23.16	0.2770	0.0023	
A10	12	0.7435	86192.3	23.41	0.2869	0.0025	
A10	13	0.7306	90431.4	22.54	0.2380	0.0027	
A10	14	0.7361	95402.8	22.76	0.2337	0.0029	
A10	15	0.7374	99609.1	23.23	0.2451	0.0031	
A10	16	0.7367	106672.8	23.52	0.4289	0.0032	
A10	17	0.7381	111665.8	23.75	0.2453	0.0034	
A10	18	0.7347	115493.4	23.67	0.2381	0.0036	
A10	19	0.7313	120449.9	24.01	0.2497	0.0038	
A10	20	0.7265	123520.4	23.26	0.1918	0.0040	
A10	21	0.7306	128737.5	22.53	0.3270	0.0041	

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
A10	22	0.7415	133463.3	24.33	0.3562	0.0043	
A10	23	0.7354	135748.4	23.05	0.1565	0.0045	
A10	24	0.7456	141572.0	24.64	0.3198	0.0047	
A10	25	0.7327	143812.6	22.66	0.1463	0.0048	
A10	28	0.7415	146954.9	23.59	0.2768	0.0050	
A10	32	0.7347	153755.4	25.11	0.1531	0.0054	
A10	33	0.7469	156545.4	24.60	0.2645	0.0056	
A10	34	0.8721	193034.0	25.62	0.2219	0.0082	
A10	35	0.7884	196815.1	25.62		0.0087	
A10	36	0.7925	203204.8	26.31	0.2278	0.0090	
A11	0	0.7661	0.0	25.00		0.0000	
A11	1	0.7115	71539.0	25.00	0.5897	0.0006	
A11	2	0.8315	97611.0	25.00	0.6313	0.0010	
A11	3	0.8468	128277.0	25.00	0.6103	0.0013	
A11	4	0.8776	154484.0	25.00	0.4890	0.0017	
A11	5	0.8707	165790.0	25.00	0.3296	0.0020	
A11	6	0.8796	176208.0	24.41	0.4335	0.0022	
A11	7	0.8898	180258.0	25.14	0.2953	0.0024	
A11	8	0.9048	192173.0	24.15	0.4852	0.0026	
A11	9	0.9088	205550.0	23.45	0.5524	0.0029	
A11	10	0.9136	213124.2	23.27	0.3981	0.0031	
A11	11	0.9224	221508.1	23.11	0.4578	0.0033	
A11	12	0.9374	230118.6	23.41	0.4415	0.0035	
A11	13	0.9415	235649.4	22.68	0.4473	0.0037	
A11	14	0.9605	242927.6	22.79	0.3837	0.0040	
A11	15	0.9701	250218.5	23.22	0.4285	0.0042	
A11	16	0.9748	255618.3	23.42	0.3893	0.0044	
A11	17	0.9850	262031.5	23.75	0.3698	0.0047	
A11	18	0.9932	268580.0	23.65	0.4829	0.0049	
A11	19	0.9966	273002.8	24.05	0.3098	0.0051	
A11	20	1.0034	277650.7	23.26	0.4144	0.0053	
A11	21	0.9429	281317.8	22.52			D
A11	22	0.9524	284220.6	24.31		0.0058	
A11	23	0.9429	287292.8	23.04	0.2086	0.0060	
A11	24	0.9660	294915.7	24.60	0.4567	0.0063	
A11	25	0.9476	297498.3	22.63	0.1792	0.0064	
A11	26	0.9293	298007.0	22.50	0.0176	0.0067	
A11	27	0.7612	25122.5	22.60		0.0067	
A11	28	0.7565	26868.4	23.57	1.0768	0.0067	
A11	32	0.7293	55331.0	25.14	0.3343	0.0071	

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
A11	33	0.7395	72490.0	24.62	0.3464	0.0074	
A11	34	1.0109	180361.0	25.65	0.2835	0.0106	
A11	35	0.8088	196546.8	25.62		0.0113	
A11	36	0.8422	209341.7	26.28	0.3166	0.0118	
A11	37	0.8667	221352.8	26.63	0.2652	0.0123	
A11	38	0.8769	225319.6	26.62	0.2192	0.0126	
A12	0	0.7633	0.0	25.00		0.0000	
A12	1	0.6862	37817.5	25.00	0.6030	0.0005	
A12	2	0.7868	54641.0	25.00	0.7035	0.0008	
A12	3	0.7692	78432.6	25.00	0.7902	0.0011	
A12	4	0.7687	100150.7	25.00	0.6149	0.0014	
A12	5	0.7619	111974.7	25.00	0.5453	0.0016	
A12	6	0.7605	119045.6	24.38	0.4387	0.0018	
A12	7	0.7653	127072.0	25.14	0.5834	0.0020	
A12	8	0.7639	133551.1	24.16	0.3705	0.0022	
A12	9	0.7626	149074.1	23.39	0.9124	0.0024	
A12	10	0.7660	155585.0	23.26	0.4934	0.0025	
A12	11	0.7646	165260.5	23.06	0.6177	0.0027	
A12	12	0.7626	168939.2	23.41	0.2305	0.0029	
A12	13	0.7639	176431.2	22.75	0.6699	0.0030	
A12	14	0.7694	170348.6	22.77	-0.1146	0.0033	
A12	15	0.7449	187650.2	23.21	0.6676	0.0035	
A12	16	0.7531	193847.0	23.47	0.5737	0.0036	
A12	17	0.7721	190277.1	23.73	0.1421	0.0038	
A12	18	0.7701	195942.9	23.68	0.4201	0.0040	
A12	19	0.7687	212322.1	24.05	0.8969	0.0042	
A12	20	0.7687	205013.3	23.30	-0.2370	0.0044	
A12	21	0.7612	224374.8	22.57	0.9678	0.0045	
A12	22	0.7667	222654.0	24.30	0.0587	0.0047	
A12	23	0.7626	227626.8	23.13	0.3691	0.0049	
A12	24	0.7551	230849.8	24.04	0.1137	0.0051	
A12	25	0.7592	236598.3	22.65	0.7307	0.0053	
A12	28	0.7578	243192.2	23.57	0.4034	0.0055	
A12	29	0.7612	242892.0	24.49	0.1406	0.0056	
A12	32	0.7578	250000.5	25.16	0.4492	0.0058	
A12	33	0.7633	254747.0	24.66	0.3838	0.0060	
A12	35	0.7925	308358.0	25.24		0.0092	
A13	0	0.7675	0.0	25.00		0.0000	
A13	1	0.6697	64307.4	25.00	0.9063	0.0006	
A13	2	0.7814	89145.0	25.00	0.9260	0.0010	

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
A13	3	0.7995	114793.0	25.00	0.8542	0.0013	
A13	4	0.8163	135110.0	25.00	0.5701	0.0017	
A13	5	0.8095	146504.0	25.00	0.4918	0.0020	
A13	6	0.8122	153884.0	24.36	0.4610	0.0022	
A13	7	0.8170	160468.0	25.11	0.4684	0.0024	
A13	8	0.8163	171834.0	24.13	0.5554	0.0026	
A13	9	0.8075	188015.0	23.36	0.7893	0.0028	
A13	10	0.8054	196977.1	23.20	0.5211	0.0030	
A13	11	0.8020	206240.0	23.05	0.5165	0.0033	
A13	12	0.8034	211620.0	23.34	0.3236	0.0035	
A13	13	0.7959	219889.2	22.71	0.5278	0.0037	
A13	14	0.7973	223623.1	22.75	0.2237	0.0040	
A13	15	0.7952	234073.9	23.21	0.5344	0.0042	
A13	16	0.7918	240449.2	23.45	0.3860	0.0044	
A13	17	0.7918	246835.1	23.76	0.3379	0.0046	
A13	18	0.7878	252562.8	23.65	0.3559	0.0048	
A13	19	0.7837	258487.9	24.04	0.3002	0.0051	
A13	20	0.7796	259325.5	23.30	0.1346	0.0053	
A13	21	0.7599	279891.8	22.55			D
A13	22	0.7639	283416.9	24.28		0.0057	
A13	23	0.7571	284916.0	23.20	0.1318	0.0060	
A13	24	0.7585	290506.1	24.04	0.2829	0.0062	
A13	25	0.7510	296329.0	22.69	0.4241	0.0064	
A13	28	0.7565	300795.9	23.61	0.3711	0.0066	
A13	32	0.7531	306541.5	25.19	0.1331	0.0071	
A13	33	0.7599	308726.6	24.71	0.2872	0.0073	
A13	34	0.7993	333960.0	25.56	0.1329	0.0106	
A13	35	0.7687	360222.3	25.24		0.0113	
A13	36	0.7721	344838.6	26.40	-0.2701	0.0117	
A13	37	0.7633	367960.3	26.53	0.4369	0.0122	
A13	38	0.7592	368318.0	26.53	0.0734	0.0125	
A14	0	0.7647	0.0	25.00		0.0000	
A14	1	0.6911	47909.3	25.00	0.4314	0.0005	
A14	2	0.7998	69174.0	25.00	0.5332	0.0008	
A14	3	0.8021	88158.0	25.00	0.4208	0.0011	
A14	4	0.8095	107376.0	25.00	0.3514	0.0015	
A14	5	0.8095	117544.0	25.00	0.3518	0.0017	
A14	6	0.8034	121639.0	24.32	0.1846	0.0018	
A14	7	0.8041	128305.0	25.06	0.3188	0.0020	
A14	8	0.8034	137122.0	24.28	0.3199	0.0022	

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
A14	9	0.8020	150684.0	23.32	0.5307	0.0024	
A14	10	0.7986	159339.2	23.19	0.3675	0.0025	
A14	11	0.8000	166699.9	23.09	0.3566	0.0027	
A14	12	0.8048	174280.6	23.44	0.3320	0.0029	
A14	13	0.8014	178056.6	22.77	0.2751	0.0030	
A14	14	0.8048	186301.6	22.74	0.2987	0.0033	
A14	15	0.8068	189493.0	23.19	0.2175	0.0035	
A14	16	0.8075	197875.5	23.42	0.4223	0.0036	
A14	17	0.8082	200696.0	23.77	0.1786	0.0038	
A14	18	0.8095	209155.0	23.64	0.4436	0.0040	
A14	19	0.8102	212984.6	24.04	0.2359	0.0042	
A14	20	0.8122	213889.7	23.40	0.1980	0.0044	
A14	21	0.7864	219908.5	22.86			D
A14	22	0.7925	220673.3	24.19		0.0047	
A14	23	0.7946	223902.9	23.21	0.2722	0.0049	
A14	24	0.7986	224974.5	24.00	0.1453	0.0051	
A14	25	0.7959	233586.6	22.71	0.5481	0.0053	
A14	26	0.7871	235946.5	22.60	0.1385	0.0055	
A14	27	0.7619	11599.6	23.20		0.0055	
A14	28	0.7551	12112.5	23.54	0.7677	0.0055	
A14	32	0.7422	29876.7	25.19	0.2630	0.0058	
A14	33	0.7517	39949.2	24.69	0.2486	0.0060	
A14	34	0.8782	120216.0	25.54	0.2022	0.0087	
A14	35	0.7891	129904.9	25.50		0.0092	
A14	36	0.8088	141075.8	26.42	0.2585	0.0096	
A14	37	0.8184	149418.6	26.44	0.1789	0.0100	
A14	38	0.8252	154304.1	26.47	0.2098	0.0102	
A15	0	0.7675	0.0	25.00		0.0000	
A15	1	0.6642	88582.5	25.00	1.1731	0.0006	
A15	2	0.7968	113883.0	25.00	1.1992	0.0010	
A15	3	0.7377	146526.4	25.00	0.6796	0.0013	
A15	4	0.8435	172189.0	25.00	1.1106	0.0017	
A15	5	0.8367	179546.0	25.00	0.3377	0.0020	
A15	6	0.8327	196638.0	24.29	0.8957	0.0022	
A15	7	0.8367	201774.0	25.01	0.4224	0.0024	
A15	8	0.8415	212063.0	24.39	0.5909	0.0026	
A15	9	0.8340	232835.0	23.28	1.0720	0.0029	
A15	10	0.8259	243053.2	22.89	0.5175	0.0031	
A15	11	0.8265	253620.3	23.04	0.6873	0.0033	
A15	12	0.8299	265303.9	23.35	0.6515	0.0035	

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
A15	13	0.8259	271596.3	22.69	0.5099	0.0037	
A15	14	0.8293	276560.3	22.72	0.3223	0.0040	
A15	15	0.8231	283159.8	23.16	0.3293	0.0042	
A15	16	0.8211	296391.6	23.44	0.7915	0.0044	
A15	17	0.8211	304051.4	23.78	0.4201	0.0047	
A15	18	0.8170	311764.5	23.63	0.4914	0.0049	
A15	19	0.8122	315888.6	24.04	0.2323	0.0051	
A15	20	0.8088	322704.1	23.37	0.4574	0.0053	
A15	21	0.7905	326042.4	22.99			D
A15	22	0.7884	327580.6	23.88		0.0058	
A15	23	0.7830	334390.7	23.31	0.3870	0.0060	
A15	24	0.7844	339151.2	24.00	0.2847	0.0063	
A15	25	0.7748	344536.8	22.75	0.3744	0.0065	
A15	28	0.7748	349861.4	23.52	0.3483	0.0067	
A15	32	0.7721	374444.1	25.15	0.5659	0.0071	
A15	33	0.7707	377146.9	24.72	0.2213	0.0074	
A15	34	0.8170	409791.0	25.54	0.1793	0.0106	
A15	35	0.7741	409638.9	25.45		0.0113	
A15	36	0.7755	419738.8	26.46	0.3040	0.0118	
A15	37	0.7728	421410.5	26.53	0.0898	0.0123	
A15	38	0.7660	444196.3	26.79	0.7333	0.0126	
A16	0	0.7665	0.0	25.00		0.0000	
A16	1	0.6820	31077.3	25.00	0.4137	0.0006	
A16	33	0.6374	183237.4	24.73	0.2175	0.0062	
H01	0		0.0				
H01	2		5029.0	25.00			
H01	3		5145.0				
H01	4		5075.0	25.00			
H01	5		4968.0	57.00			
H01	6	0.9810	4791.0	57.00			
H01	7	1.0483	4715.0	57.00			
H01	8	1.0395	4591.0	57.00			
H01	9	1.0864	4635.0	57.00			
H01	10	1.0932	4686.6	57.47			
H01	11	0.9415	4921.6	57.44			
H01	12	0.9347	4779.2	57.54			
H01	13	0.9333	4797.6	57.54			
H01	14	0.9327	4805.1	57.48			
H01	15	0.9354	4842.8	57.55			
H01	16	0.9361	4842.7	57.54			

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
H01	17	0.9408	4821.3	57.53			
H01	18	0.9354	4899.6	57.52			
H01	19	0.9517	4914.0	57.30			
H01	20	0.9361	4813.9	54.87			
H01	21	0.9769	4819.5	54.92			
H01	22	0.9701	4915.1	54.90			
H01	23	0.9694	4790.3	54.75			
H01	24	0.9748	4666.7	54.68			
H01	25	0.9673	4943.6	54.57			
H01	28	0.9585	4927.3	54.56			
H01	29	0.9735	4925.4	54.65			
H01	32	0.9728	4928.5	54.28			
H01	33	0.9980	5005.7	54.90			
H01	34	0.9707	4807.0	25.59			
H01	35	0.9599	4988.5	25.74			
H01	36	0.9755	4943.7	25.84			
H01	37	0.9701	4960.6	26.80			
H01	38	0.9762	4791.8	26.76			
H02	0	0.7654	0.0	25.00		0.0000	
H02	1	0.6445	34143.0	25.00	0.5024	0.0005	
H02	2	0.7381	42119.4	25.00	0.5927	0.0007	
H02	3	0.7285	56361.3	25.00	0.4726	0.0010	
H02	4	0.7483	69255.4	25.00	0.4006	0.0014	
H02	5	0.8707	74308.0	57.00	0.4636	0.0016	
H02	6	0.8517	78468.0	57.00	0.1910	0.0017	
H02	7	0.8327	84527.0	57.00	0.3103	0.0019	
H02	8	0.8259	89875.0	57.00	0.2577	0.0021	
H02	9	0.8150	97155.0	57.00	0.4088	0.0023	
H02	10	0.8054	99543.5	57.48	0.1230	0.0025	
H02	11	0.7966	109209.3	57.44	0.5300	0.0026	
H02	12	0.7891	113053.5	57.52	0.1952	0.0028	
H02	13	0.7803	117894.3	57.59	0.3157	0.0030	
H02	14	0.7728	120688.6	57.52	0.1192	0.0032	
H02	15	0.7612	132106.5	57.57	0.5138	0.0034	
H02	16	0.7578	132920.1	57.56	0.1054	0.0035	
H02	17	0.7524	140643.2	57.51	0.3449	0.0038	
H02	18	0.7456	143698.2	57.54	0.1819	0.0039	
H02	19	0.7401	148562.8	57.34	0.2612	0.0041	
H02	20	0.7367	141243.0	54.90	-0.2408	0.0043	
H02	21	0.7333	152210.8	54.76	0.5216	0.0045	

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
H02	22	0.7306	147702.6	55.11	-0.1584	0.0046	
H02	23	0.7265	154091.9	54.69	0.3511	0.0048	
H02	24	0.7245	158618.8	54.69	0.2185	0.0051	
H02	25	0.7197	160355.1	54.50	0.1725	0.0052	
H02	28	0.7177	160556.4	54.67	0.0747	0.0054	
H02	32	0.7122	164496.9	54.27	0.1172	0.0057	
H02	33	0.7190	164041.6	54.90	0.0970	0.0060	
H02	34	0.7565	172299.1	57.58	0.0559	0.0086	
H02	35	0.7122	168128.1	57.26		0.0091	
H02	36	0.7122	167803.4	57.20	0.0419	0.0095	
H02	37	0.7109	166562.6	57.15	0.0121	0.0099	
H02	38	0.7095	166685.4	57.24	0.0617	0.0101	
H03	0	0.7633	0.0	25.00		0.0000	
H03	1	1.1524	16068.0	25.00	0.3240	0.0006	
H03	2	1.3462	20151.0	25.00	0.5356	0.0007	
H03	3	1.3583	29230.0	25.00	0.3695	0.0011	
H03	4	1.3605	40989.0	25.00	0.3686	0.0015	
H03	5	1.7687	40312.0	57.00	0.3793	0.0018	
H03	6	1.9551	40136.0	57.00	0.3350	0.0020	
H03	7	1.9850	43198.0	57.00	0.3756	0.0022	
H03	8	1.9959	46527.0	57.00	0.2883	0.0024	
H03	9	1.9701	47904.0	57.00	0.1314	0.0026	
H03	10	1.9204	50801.0	57.46	0.1854	0.0029	
H03	11	1.7231	52800.8	57.44	-0.2070	0.0031	
H03	12	1.7048	56527.1	57.51	0.2514	0.0033	
H03	13	1.7129	60272.3	57.56	0.4251	0.0035	
H03	14	1.6463	63140.2	57.50	0.0728	0.0038	
H03	15	1.7163	68214.1	57.57	0.5594	0.0040	
H03	16	1.7068	70368.7	57.56	0.2212	0.0042	
H03	17	1.6878	75346.3	57.53	0.3041	0.0045	
H03	18	1.6769	78355.1	57.52	0.2677	0.0047	
H03	19	1.6476	81417.4	57.29	0.1915	0.0049	
H03	20	1.6313	84196.5	54.85	0.2608	0.0051	
H03	21	1.4340	87802.3	54.75			D
H03	22	1.4279	90244.8	54.91		0.0056	
H03	23	1.4075	91848.9	54.78	0.0983	0.0058	
H03	24	1.2327	96146.2	54.60	-0.2728	0.0061	
H03	25	1.4197	99881.5	54.76	1.3239	0.0063	
H04	0	0.7641	0.0	25.00		0.0000	
H04	1	0.6826	48119.3	25.00	0.4264	0.0005	

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
H04	2	0.7892	59593.0	25.00	0.5252	0.0007	
H04	3	0.7889	77738.0	25.00	0.3877	0.0010	
H04	4	0.7619	98413.2	25.00	0.2944	0.0014	
H04	5	0.8571	104628.0	57.00	0.2745	0.0016	
H04	6	0.8592	114623.0	57.00	0.3897	0.0017	
H04	7	0.8585	119653.0	57.00	0.2549	0.0019	
H04	8	0.8537	127648.0	57.00	0.2604	0.0021	
H04	9	0.8469	137763.0	57.00	0.3929	0.0023	
H04	10	0.8361	146891.7	57.49	0.3105	0.0024	
H04	11	0.8286	153529.7	57.45	0.2724	0.0026	
H04	12	0.8898	158901.5	57.53	0.5523	0.0028	
H04	13	0.9088	163547.2	57.56	0.4789	0.0029	
H04	14	0.9170	168813.6	57.52	0.2566	0.0032	
H04	15	0.9177	173821.4	57.58	0.2790	0.0034	
H04	16	0.9184	177275.8	57.56	0.2786	0.0035	
H04	17	0.9204	183524.2	57.50	0.2972	0.0037	
H04	18	0.9218	188726.0	57.54	0.3375	0.0039	
H04	19	0.9190	190463.5	57.29	0.1790	0.0041	
H04	20	0.9231	194594.7	54.78	0.3619	0.0043	
H04	21	0.8850	199929.3	54.76			D
H04	22	0.8830	201871.9	54.80		0.0046	
H04	23	0.8776	206574.0	54.66	0.2443	0.0048	
H04	24	0.8823	205562.6	54.69	0.1213	0.0050	
H04	25	0.8748	212939.6	54.72	0.4271	0.0052	
H04	28	0.8728	213216.1	54.62	0.1365	0.0054	
H04	29	0.8735	219034.3	54.61	0.3398	0.0055	
H04	30	0.8599	217804.0	54.23		0.0056	
H04	32	0.7224	59662.4	54.23		0.0057	
H04	33	0.6592	74406.3	54.99	0.1304	0.0060	
H04	34	0.8673	138847.0	57.56	0.1791	0.0086	
H04	35	0.7558	154758.6	57.24		0.0091	
H04	36	0.7701	154991.9	57.21	0.0896	0.0095	
H04	37	0.7259	169502.9	57.18	0.1001	0.0099	
H04	38	0.7762	166105.8	57.20	0.2229	0.0101	
H05	0	0.7674	0.0	25.00		0.0000	
H05	1	0.6821	75112.3	25.00	0.9944	0.0006	
H05	2	0.7871	93921.0	25.00	0.8321	0.0010	
H05	3	0.7995	124793.0	25.00	0.9634	0.0013	
H05	4	0.7959	150110.0	25.00	0.5828	0.0018	
H05	5	0.9048	167685.0	57.00	0.9664	0.0020	

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
H05	6	0.9068	176627.0	57.00	0.5295	0.0023	
H05	7	0.9116	182254.0	57.00	0.4458	0.0025	
H05	8	0.9095	189596.0	57.00	0.3616	0.0027	
H05	9	0.9027	203508.0	57.00	0.7359	0.0029	
H05	10	0.8952	215382.0	57.50	0.5688	0.0032	
H05	11	0.8912	225912.1	57.45	0.5868	0.0034	
H05	12	0.8891	224955.2	57.50	0.0582	0.0036	
H05	13	0.8816	238826.1	57.57	0.8451	0.0038	
H05	14	0.8796	247595.0	57.49	0.3776	0.0041	
H05	15	0.8728	255709.6	57.57	0.3901	0.0043	
H05	16	0.8667	258067.7	57.57	0.1900	0.0045	
H05	17	0.8612	257527.5	57.52	0.0452	0.0048	
H05	18	0.8558	271372.9	57.56	0.7105	0.0050	
H05	19	0.8476	276400.3	57.35	0.2510	0.0053	
H05	20	0.8014	268451.7	54.75	-0.7150	0.0055	
H05	21	0.8367	285098.9	54.75	1.2419	0.0057	
H05	22	0.8116	286843.0	54.89	-0.1435	0.0059	
H05	23	0.8102	292517.3	54.84	0.3533	0.0062	
H05	24	0.8068	291073.9	54.73	0.0387	0.0065	
H05	25	0.7986	300298.9	54.57	0.5417	0.0066	
H05	28	0.7925	303016.6	54.52	0.1594	0.0069	
H05	29	0.7878	308722.7	54.61	0.3069	0.0071	
H05	32	0.7803	313306.1	54.22	0.2475	0.0073	
H05	33	0.7701	317129.6	54.85	0.0649	0.0077	
H05	34	0.8150	359383.0	57.58	0.1757	0.0110	
H05	35	0.7599	361896.1	57.27		0.0116	
H05	36	0.7585	381270.5	57.20	0.4438	0.0121	
H05	37	0.7517	382867.2	57.16	0.0515	0.0126	
H05	38	0.7429	384661.6	57.19	0.0577	0.0129	
H06	0	0.7652	0.0	25.00		0.0000	
H06	1	0.6894	35181.8	25.00	0.5484	0.0005	
H06	2	0.7990	45979.0	25.00	0.7044	0.0008	
H06	3	0.7968	61993.0	25.00	0.6351	0.0010	
H06	4	0.7959	80421.0	25.00	0.5107	0.0014	
H06	5	1.0068	90881.0	57.00	1.2557	0.0016	
H06	6	1.0027	98153.0	57.00	0.5076	0.0017	
H06	7	1.0082	100822.0	57.00	0.3067	0.0019	
H06	8	0.8905	105344.0	57.00	-0.3427	0.0021	
H06	9	0.9102	114761.0	57.00	0.7773	0.0023	
H06	10	0.9585	124642.5	57.50	1.0207	0.0024	

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
H06	11	0.9299	130240.4	57.44	0.2135	0.0026	
H06	12	0.9551	134908.0	57.52	0.5233	0.0028	
H06	13	0.9429	145323.3	57.58	0.7797	0.0029	
H06	14	0.9435	153765.5	57.50	0.4580	0.0032	
H06	15	0.9469	160692.2	57.60	0.5239	0.0034	
H06	16	0.9299	165440.0	57.54	0.2559	0.0035	
H06	17	0.9367	175602.1	57.50	0.6611	0.0037	
H06	18	0.9327	180895.5	57.53	0.4168	0.0039	
H06	19	0.9020	185173.7	57.33	0.0367	0.0041	
H06	20	0.9170	185004.4	54.85	0.3693	0.0043	
H06	21	0.9435	196811.3	54.76	1.0665	0.0045	
H06	22	0.9286	194247.7	54.82	-0.1868	0.0046	
H06	23	0.9224	203379.3	54.73	0.5766	0.0048	
H06	24	0.9252	200476.1	54.60	0.0178	0.0050	
H06	25	0.9156	207000.0	54.55	0.5319	0.0052	
H06	28	0.9116	212417.0	54.54	0.3736	0.0054	
H06	29	0.8891	220836.0	54.76	0.3143	0.0056	
H06	32	0.8714	225229.1	54.27	0.1794	0.0057	
H06	33	0.8673	232669.4	54.80	0.2580	0.0061	
H06	34	0.9381	286373.0	57.60	0.2937	0.0086	
H06	35	0.7721	289401.9	57.24		0.0091	
H06	36	0.7701	298125.9	57.21	0.2769	0.0095	
H06	37	0.7619	319779.8	57.12	0.4643	0.0099	
H06	38	0.7592	323314.6	57.17	0.2188	0.0101	
H07	0	0.7676	0.0	25.00		0.0000	
H07	1	0.6839	64589.5	25.00	0.8452	0.0007	
H07	2	0.7871	90322.0	25.00	0.8918	0.0010	
H07	3	0.7916	109724.0	25.00	0.6229	0.0014	
H07	4	0.7483	136018.0	25.00	0.4402	0.0018	
H07	5	0.8844	141556.0	57.00	0.6234	0.0021	
H07	6	0.8837	148826.0	57.00	0.4220	0.0023	
H07	7	0.8878	156854.0	57.00	0.5156	0.0025	
H07	8	0.8803	162038.0	57.00	0.2081	0.0028	
H07	9	0.8769	175202.0	57.00	0.7186	0.0030	
H07	10	0.8687	187185.0	57.46	0.5432	0.0032	
H07	11	0.8626	190767.4	57.48	0.2140	0.0034	
H07	12	0.8571	196517.5	57.53	0.2709	0.0037	
H07	13	0.8483	202687.7	57.57	0.3599	0.0039	
H07	14	0.8442	202277.0	57.53	0.0395	0.0042	
H07	15	0.8367	214488.9	57.57	0.5127	0.0044	

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
H07	16	0.8306	221124.4	57.54	0.3631	0.0046	
H07	17	0.7673	232199.1	57.54	-0.1305	0.0049	
H07	18	0.8129	230889.3	57.51	0.6273	0.0051	
H07	19	0.8048	233655.7	57.31	0.1363	0.0053	
H07	20	0.7925	237736.5	54.79	0.2065	0.0056	
H07	21	0.8095	242462.6	54.77	0.4818	0.0058	
H07	22	0.7932	243600.5	54.91	-0.0323	0.0060	
H07	23	0.7925	246320.6	54.77	0.2184	0.0063	
H07	24	0.7871	250250.5	54.59	0.1729	0.0066	
H07	25	0.7782	254590.6	54.48	0.2463	0.0067	
H07	28	0.7728	256975.9	54.61	0.1330	0.0070	
H07	32	0.7558	274183.9	54.28	0.2903	0.0074	
H07	33	0.7422	280266.6	54.91	0.0805	0.0079	
H07	34	0.7769	298868.0	57.61	0.0875	0.0111	
H07	35	0.7585	317108.9	57.27		0.0118	
H07	36	0.7422	312607.7	57.18	-0.1314	0.0123	
H07	37	0.7422	317212.2	57.08	0.1419	0.0128	
H07	38	0.7381	325244.0	57.20	0.2699	0.0131	
H08	0	0.7627	0.0	25.00		0.0000	
H08	1	0.6912	21943.5	25.00	0.3786	0.0004	
H08	2	0.7628	30122.0	25.00	0.5666	0.0006	
H08	3	0.7442	44594.7	25.00	0.4376	0.0008	
H08	4	0.6939	60512.9	25.00	0.2796	0.0012	
H08	5	0.9048	75104.0	57.00	1.1189	0.0014	
H08	6	0.8633	87846.0	57.00	0.5244	0.0016	
H08	7	0.8633	94781.0	57.00	0.4313	0.0017	
H08	8	0.8891	99913.0	57.00	0.3666	0.0019	
H08	9	0.9027	104912.0	57.00	0.4462	0.0021	
H08	10	0.9095	111234.2	57.50	0.4334	0.0023	
H08	11	0.9218	113188.2	57.46	0.2761	0.0024	
H08	12	0.9442	117207.9	57.50	0.3953	0.0026	
H08	13	0.9497	120423.4	57.57	0.3757	0.0028	
H08	14	0.9776	120682.7	57.52	0.2198	0.0030	
H08	15	0.9803	128236.4	57.57	0.4948	0.0032	
H08	16	0.9918	128728.7	57.54	0.2379	0.0034	
H08	17	1.0020	130825.4	57.52	0.2459	0.0036	
H08	18	1.0122	136081.0	57.52	0.5058	0.0037	
H08	19	1.0068	139995.3	57.35	0.2809	0.0039	
H08	20	1.0034	140587.7	54.93	0.1759	0.0041	
H08	21	0.9449	143697.4	54.73			D

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
H08	22	0.9313	139708.2	54.89		0.0045	
H08	23	0.9374	147489.7	54.70	0.5414	0.0046	
H08	24	0.9544	148978.2	54.62	0.2648	0.0049	
H08	25	0.9333	151230.8	54.56	0.0771	0.0050	
H08	28	0.9231	151662.4	54.54	0.0495	0.0052	
H08	32	0.9211	157370.3	54.30	0.2013	0.0055	
H08	33	0.8755	159407.3	54.90	-0.1047	0.0059	
H08	34	1.1605	187271.0	57.60	0.3035	0.0084	
H08	35	0.8422	174282.2	57.27		0.0089	
H08	36	0.8714	177002.5	57.18	0.2604	0.0093	
H08	37	0.8973	184050.1	57.15	0.3226	0.0097	
H08	38	0.9095	185622.8	57.19	0.2420	0.0100	
H09	0	0.7651	0.0	25.00		0.0000	
H09	1	0.6999	57333.3	25.00	0.7138	0.0007	
H09	2	0.8109	75354.0	25.00	0.9508	0.0010	
H09	3	0.8152	96851.0	25.00	0.6994	0.0013	
H09	4	0.8095	118386.0	25.00	0.4878	0.0017	
H09	5	1.0204	131398.0	57.00	1.3428	0.0020	
H09	6	0.9864	137246.0	57.00	0.1632	0.0022	
H09	7	1.0075	144339.0	57.00	0.6524	0.0024	
H09	8	0.9864	159068.0	57.00	0.5407	0.0026	
H09	21	1.1238	261553.0	54.82	0.5312	0.0056	
H09	22	1.1156	267783.0	54.74	0.4558	0.0058	
H09	36	0.8082	363582.0	57.19	-0.0058	0.0118	
H09	37	0.8122	372355.2	57.07	0.2782	0.0123	
H09	38	0.8415	376665.6	57.21	0.6600	0.0126	
H10	0	0.7631	0.0	25.00		0.0000	
H10	1	0.6958	15667.6	25.00	0.2645	0.0004	
H10	2	0.7756	19151.0	25.00	0.2887	0.0006	
H10	3	0.6574	28904.0	25.00	0.1810	0.0009	
H10	4	0.7211	43000.0	25.00	0.3277	0.0013	
H10	5	0.9660	48348.0	57.00	0.8615	0.0014	
H10	6	0.9245	53716.0	57.00	0.2141	0.0016	
H10	7	0.9211	54774.0	57.00	0.0925	0.0017	
H10	8	0.8810	63180.0	57.00	0.2653	0.0020	
H10	9	0.8354	69892.0	57.00	0.2026	0.0021	
H10	10	0.8401	73189.6	57.48	0.2201	0.0023	
H10	11	0.8279	80718.0	57.43	0.3962	0.0025	
H10	12	0.8211	85133.6	57.53	0.2029	0.0027	
H10	13	0.8122	88402.4	57.56	0.2068	0.0028	

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
H10	14	0.8088	94701.5	57.46	0.2401	0.0030	
H10	15	0.8000	96977.8	57.54	0.1103	0.0032	
H10	16	0.7483	107021.7	57.55	0.2246	0.0034	
H10	17	0.7537	111477.4	57.53	0.2297	0.0036	
H10	18	0.7476	114550.1	57.55	0.1738	0.0037	
H11	0	0.7660	0.0	25.00		0.0000	
H11	1	0.6813	14498.2	25.00	0.1869	0.0006	
H11	2	0.7650	10306.2	25.00	-0.0594	0.0010	
H11	3	0.7547	18749.1	25.00	0.2311	0.0014	
H11	4	0.7075	29788.7	25.00	0.1653	0.0019	
H11	5	0.9456	33137.0	57.00	0.4845	0.0021	
H11	6	0.9184	35384.0	57.00	0.0804	0.0023	
H11	7	0.7803	38540.0	57.00	-0.1069	0.0025	
H11	8	0.8871	46237.0	57.00	0.4412	0.0028	
H11	9	0.8810	52026.0	57.00	0.2670	0.0030	
H11	10	0.8721	55870.9	57.52	0.1628	0.0032	
H11	11	0.9184	62614.3	57.47	0.5400	0.0034	
H11	12	0.8143	65807.1	57.52	-0.1405	0.0037	
H11	13	0.8544	71183.0	57.58	0.4889	0.0038	
H11	14	0.8469	75410.8	57.49	0.1375	0.0041	
H11	15	0.8510	80896.8	57.60	0.2665	0.0044	
H11	16	0.8320	82791.9	57.52	0.0508	0.0046	
H11	17	0.8299	87887.8	57.51	0.1939	0.0049	
H11	18	0.7490	96415.8	57.54	0.0112	0.0051	
H11	19	0.8694	94306.4	57.33	0.4934	0.0053	
H11	20	0.7667	100524.9	54.86	-0.1559	0.0055	
H11	21	0.8490	113103.4	54.75	0.8886	0.0058	
H11	22	0.8429	119106.1	54.73	0.2811	0.0060	
H11	23	0.8388	125948.8	54.77	0.3050	0.0063	
H11	24	0.8381	133082.9	54.62	0.2814	0.0065	
H11	25	0.8102	137980.2	54.66	0.1032	0.0067	
H11	28	0.8327	144749.5	54.60	0.4623	0.0070	
H11	32	0.8150	158051.4	54.34	0.2455	0.0074	
H11	35	0.7585	251991.5	57.22		0.0118	
H12	0	0.7652	0.0	25.00		0.0000	
H12	1	0.6948	37238.2	25.00	0.5832	0.0005	
H12	2	0.8067	49575.0	25.00	0.7904	0.0008	
H12	3	0.7981	67140.0	25.00	0.6557	0.0010	
H12	4	0.6565	89667.4	25.00	0.1763	0.0014	
H12	5	0.9252	98231.0	57.00	1.9848	0.0016	

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
H12	6	0.9020	105780.0	57.00	0.3759	0.0017	
H12	7	0.9259	112751.0	57.00	0.6966	0.0019	
H12	8	0.8551	116438.0	57.00	-0.1743	0.0021	
H12	9	0.9816	133704.0	57.00	2.1118	0.0023	
H12	10	0.9415	143903.3	56.06	0.3826	0.0025	
H12	11	0.9728	153911.3	57.43	1.1485	0.0026	
H13	0	0.7660	0.0	25.00		0.0000	
H13	1	0.7037	76529.9	25.00	0.5364	0.0007	
H13	2	0.8325	96644.0	25.00	0.6536	0.0010	
H13	3	0.8428	116313.0	25.00	0.4103	0.0014	
H13	4	0.8571	144344.0	25.00	0.3794	0.0019	
H13	5	0.9728	153674.0	57.00	0.5266	0.0021	
H13	6	0.9673	163761.0	57.00	0.3639	0.0023	
H13	7	1.0048	173529.0	57.00	0.6043	0.0025	
H13	8	1.0170	178473.0	57.00	0.2453	0.0028	
H13	9	1.0327	188455.0	57.00	0.4993	0.0030	
H13	10	1.0299	195873.4	56.48	0.3190	0.0032	
H13	11	1.0340	203640.9	57.47	0.4240	0.0034	
H13	12	1.0510	208565.4	57.49	0.3379	0.0036	
H13	13	1.0537	215850.0	57.56	0.4625	0.0038	
H13	14	1.0741	222580.4	57.53	0.3441	0.0041	
H13	15	1.0374	225272.2	57.58	-0.0159	0.0044	
H13	16	1.0755	233598.1	57.52	0.7123	0.0046	
H13	17	1.0796	237472.0	57.50	0.2332	0.0048	
H13	18	1.0864	242454.9	57.56	0.3888	0.0050	
H13	19	1.0456	249436.3	54.23	0.1391	0.0053	
H13	20	1.0517	251314.0	54.79	0.2494	0.0055	
H13	21	0.9918	258038.4	54.76			D
H13	22	0.9769	260611.6	54.84		0.0060	
H13	23	0.9735	263554.9	54.61	0.1996	0.0062	
H13	24	0.9850	267304.4	54.69	0.2721	0.0065	
H13	25	0.9680	272947.1	54.58	0.2297	0.0067	
H13	28	0.9476	275916.6	54.68	0.0662	0.0069	
H13	30	0.9286	279162.7	54.33		0.0072	
H13	32	0.7381	27242.4	54.32		0.0074	
H13	33	0.7279	52824.8	54.95	0.2792	0.0078	
H13	34	0.9993	152863.0	57.61	0.2294	0.0110	
H13	35	0.8088	173455.4	57.25		0.0117	
H13	36	0.8306	176936.6	57.20	0.1330	0.0122	
H13	37	0.8592	196805.2	57.09	0.3187	0.0127	

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
H13	38	0.8755	199080.5	57.16	0.1757	0.0130	
H14	0	0.7634	0.0	25.00		0.0000	
H14	1	0.6766	39292.7	25.00	0.3300	0.0005	
H14	2	0.7815	49231.0	25.00	0.3725	0.0008	
H14	3	0.7771	62762.0	25.00	0.2841	0.0010	
H14	4	0.7755	79774.0	25.00	0.2314	0.0014	
H14	5	0.8844	84852.0	57.00	0.3347	0.0016	
H14	6	0.8673	92197.0	57.00	0.2434	0.0017	
H14	7	0.8830	94353.0	57.00	0.1971	0.0019	
H14	8	0.8673	101589.0	57.00	0.1853	0.0021	
H14	9	0.8639	114358.0	57.00	0.4520	0.0023	
H14	10	0.8537	120956.3	56.82	0.2296	0.0025	
H14	11	0.8517	126080.3	57.48	0.2609	0.0026	
H14	12	0.8551	130451.8	57.52	0.2097	0.0028	
H14	13	0.8531	134328.3	57.57	0.2483	0.0029	
H14	14	0.8592	139577.9	57.50	0.2038	0.0032	
H14	15	0.8551	141319.5	57.57	0.1211	0.0034	
H14	16	0.8333	147092.3	57.55	0.1784	0.0035	
H14	17	0.8395	151914.3	57.55	0.2140	0.0037	
H14	18	0.8381	156693.6	57.54	0.2604	0.0039	
H14	19	0.8156	158141.3	54.45	0.0623	0.0041	
H14	20	0.8150	162279.0	54.78	0.2217	0.0043	
H14	21	0.8027	167503.0	54.85	0.1673	0.0045	
H14	22	0.7986	170186.4	54.99	0.1628	0.0046	
H14	23	0.7966	171250.0	54.70	0.1260	0.0048	
H14	24	0.7939	174577.6	54.70	0.1480	0.0050	
H14	25	0.7884	178259.8	54.70	0.2285	0.0052	
H14	28	0.7857	181479.2	54.69	0.1724	0.0054	
H14	29	0.7803	183756.7	54.33	0.1462	0.0056	
H14	30	0.7748	184984.9	54.54		0.0056	
H14	32	0.7510	14052.9	54.39		0.0057	
H14	33	0.7354	26274.7	55.02	0.1592	0.0061	
H14	34	0.8483	84085.0	57.63	0.1239	0.0086	
H14	35	0.7755	94018.9	57.25		0.0091	
H14	36	0.7823	100923.2	57.18	0.1294	0.0095	
H14	37	0.7912	107938.1	57.08	0.1255	0.0099	
H14	38	0.7918	112122.2	57.16	0.1316	0.0101	
H15	0	0.7655	0.0	25.00		0.0000	
H15	1	0.7172	76608.6	25.00	0.5924	0.0007	
H15	2	0.8403	91446.0	25.00	0.6176	0.0010	

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
H15	3	0.7916	113766.0	25.00	0.3368	0.0013	
H15	4	0.8571	142633.0	25.00	0.4973	0.0018	
H15	6	0.9177	162069.0	57.00	0.2807	0.0022	
H15	7	0.9660	164384.0	57.00	0.4465	0.0024	
H15	8	0.9735	173117.0	57.00	0.3223	0.0026	
H15	9	0.9878	188476.0	57.00	0.6746	0.0028	
H15	10	0.9810	196102.6	57.03	0.3063	0.0031	
H15	11	0.9857	202759.6	57.46	0.4188	0.0032	
H15	12	1.0020	210960.1	57.49	0.4428	0.0035	
H15	13	1.0034	216315.9	57.56	0.3999	0.0037	
H15	14	1.0231	223057.3	57.49	0.3590	0.0039	
H15	15	1.0122	232437.8	57.57	0.3446	0.0042	
H15	16	1.0048	236544.4	57.54	0.2604	0.0044	
H15	17	1.0190	240358.5	57.53	0.3031	0.0046	
H15	18	1.0259	248543.6	57.57	0.5215	0.0048	
H15	19	0.9776	250347.6	54.52	-0.0671	0.0051	
H15	20	0.9816	257393.6	54.81	0.4165	0.0053	
H15	21	0.9238	262674.9	54.80			D
H15	22	0.9082	264165.7	54.82		0.0057	
H15	23	0.9054	269532.0	54.78	0.2744	0.0060	
H15	24	0.9027	270333.7	54.75	0.1298	0.0062	
H15	25	0.8959	274570.1	54.68	0.2852	0.0064	
H15	28	0.8769	281428.5	54.66	0.1760	0.0067	
H15	29	0.8728	281697.4	54.46	0.1386	0.0069	
H15	30	0.8639	286327.5	54.37		0.0069	
H15	32	0.7422	6499.1	54.33		0.0071	
H15	33	0.7197	30347.0	54.90	0.2711	0.0075	
H15	34	0.9741	135038.0	57.60	0.2333	0.0106	
H15	35	0.7932	152141.3	57.28		0.0113	
H15	36	0.8184	163641.3	57.20	0.2364	0.0117	
H15	37	0.8422	175091.3	57.13	0.2218	0.0122	
H15	38	0.8510	184115.9	57.19	0.2709	0.0125	
H16	0	0.7661	0.0	25.00		0.0000	
H16	1	0.6491	34407.9	25.00	0.5213	0.0005	
H16	2	0.7263	46682.5	25.00	0.6301	0.0008	
H16	3	0.7022	61628.2	25.00	0.4711	0.0010	
H16	4	0.6755	77691.5	25.00	0.2998	0.0014	
H16	5	0.8163	84614.0	57.00	0.7802	0.0016	
H16	6	0.8020	89375.0	57.00	0.2788	0.0018	
H16	7	0.8204	95377.0	57.00	0.5294	0.0019	

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
H16	8	0.8088	104372.0	57.00	0.3693	0.0021	
H16	9	0.8034	115984.0	57.00	0.6565	0.0023	
H16	10	0.7959	123367.1	57.19	0.3870	0.0025	
H16	11	0.7898	129718.6	57.46	0.4190	0.0026	
H16	12	0.7871	137424.9	57.46	0.4133	0.0028	
H16	13	0.7415	149616.7	57.56	0.3341	0.0030	
H16	14	0.7741	150393.2	57.51	0.3314	0.0032	
H16	15	0.7680	165472.0	57.58	0.7330	0.0034	
H16	16	0.7619	171638.7	57.55	0.3864	0.0035	
H16	17	0.7585	181419.8	57.52	0.4365	0.0038	
H16	18	0.7531	186897.8	57.53	0.3507	0.0039	
H16	19	0.7388	188366.0	54.65	0.0837	0.0041	
H16	20	0.7327	197687.2	55.10	0.4881	0.0043	
H16	21	0.7463	204032.1	54.74	0.5580	0.0045	
H16	22	0.7435	208640.7	54.83	0.3179	0.0047	
H16	23	0.7415	213177.8	54.87	0.3014	0.0048	
H16	24	0.7401	217182.1	54.74	0.2446	0.0051	
H16	25	0.7347	224126.4	54.57	0.4962	0.0052	
H16	28	0.7361	229399.6	54.61	0.3777	0.0054	
H16	32	0.7293	235962.9	54.30	0.1818	0.0057	
H16	33	0.7245	248514.5	54.98	0.3272	0.0061	
H16	34	0.7748	280522.0	57.59	0.1709	0.0086	
H16	35	0.7646	299187.8	57.26		0.0091	
H16	36	0.7599	320790.3	57.21	0.5628	0.0095	
H16	37	0.7592	322193.7	57.16	0.1127	0.0099	
H16	38	0.7565	321901.6	57.16	0.0919	0.0101	
HA01	0		0.0				
HA01	2		5301.0	25.00			
HA01	3		5372.0	25.00			
HA01	4		4896.0				
HA01	5		5063.0				
HA01	6	0.9673	4712.0	41.41			
HA01	7	1.0401	4698.0	57.29			
HA01	8	1.0741	4636.0	56.87			
HA01	9	1.0796	4609.0	56.81			
HA01	10	1.0680	4828.6	56.77			
HA01	11	0.9272	4913.0	56.78			
HA01	12	0.9252	4737.4	56.70			
HA01	13	0.9204	4802.7	56.74			
HA01	14	0.9224	4706.0	56.69			

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
HA01	15	0.9197	4886.1	56.48			
HA01	16	0.8776	4934.5	56.65			
HA01	17	0.9272	4904.6	56.54			
HA01	18	0.9054	4917.5	56.81			
HA01	19	0.9367	4825.5	56.55			
HA01	20	0.9238	4883.7	56.51			
HA01	21	0.9782	4925.7	56.60			
HA01	22	0.9660	4766.7	56.58			
HA01	23	0.9714	4639.9	56.66			
HA01	24	0.9721	4880.6	56.78			
HA01	25	0.9667	4859.2	56.80			
HA01	28	0.9687	4908.2	56.82			
HA01	29	0.9694	4938.1	56.72			
HA01	32	0.9701	4901.9	56.72			
HA01	33	1.0020	4971.7	25.38			
HA01	34	0.9687	4972.0	25.17			
HA01	35	0.9639	4954.7	25.21			
HA02	0	0.7664	0.0	25.00		0.0000	
HA02	1	0.6690	31819.4	25.00	0.4155	0.0006	
HA02	2	0.8358	46174.0	25.00	0.6283	0.0010	
HA02	3	0.6785	63923.6	25.00	0.2173	0.0013	
HA02	4	0.6871	72868.8	25.00	0.2355	0.0017	
HA02	5	0.8095	82356.0	42.00	1.0759	0.0018	
HA02	6	0.8109	87872.0	42.09	0.4444	0.0020	
HA02	7	0.7993	90871.0	57.28	-0.0832	0.0021	
HA02	8	0.7912	98872.0	56.87	0.3327	0.0024	
HA02	9	0.7871	107771.0	56.93	0.5082	0.0025	
HA02	10	0.7837	116711.4	56.71	0.4921	0.0027	
HA02	11	0.7789	122444.0	56.79	0.3774	0.0028	
HA02	12	0.7748	128847.3	56.74	0.3395	0.0030	
HA02	13	0.7687	133706.7	56.64	0.3348	0.0032	
HA02	14	0.7653	140333.4	56.65	0.2665	0.0034	
HA02	15	0.7592	154161.5	56.41	0.6901	0.0036	
HA02	16	0.7544	159965.9	56.77	0.3640	0.0038	
HA02	17	0.7503	166766.8	56.72	0.2988	0.0040	
HA02	18	0.7422	174523.9	56.75	0.4072	0.0041	
HA02	19	0.7401	175078.1	56.82	0.0940	0.0043	
HA02	20	0.7347	181387.0	56.53	0.3496	0.0045	
HA02	21	0.7299	184915.3	56.70	0.1946	0.0047	
HA02	22	0.7497	187301.6	56.53			D

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
HA02	23	0.7469	192140.7	56.76		0.0051	
HA02	24	0.7422	193653.2	56.79	0.1130	0.0053	
HA02	25	0.7361	199392.4	56.83	0.3865	0.0054	
HA02	28	0.7340	206139.1	56.84	0.3714	0.0056	
HA02	32	0.7252	213269.5	56.74	0.1701	0.0060	
HA02	33	0.7279	219747.2	56.72	0.2309	0.0063	
HA02	34	0.7646	257896.0	56.51	0.1757	0.0088	
HA02	35	0.7197	278171.5	56.60		0.0094	
HA02	36	0.7122	283794.6	56.55	0.1340	0.0097	
HA02	37	0.7109	286915.6	56.35	0.1246	0.0101	
HA02	38	0.7088	288901.4	56.39	0.1435	0.0104	
HA03	0	0.7630	0.0	25.00		0.0000	
HA03	1	1.0140	25123.0	25.00	0.4411	0.0006	
HA03	2	1.2101	32092.0	25.00	0.6374	0.0008	
HA03	3	1.1966	46673.0	25.00	0.4532	0.0012	
HA03	4	1.2313	61321.0	25.00	0.4133	0.0017	
HA03	5	1.7007	59272.0	42.00	1.0289	0.0019	
HA03	6	1.8061	59739.0	41.31	0.4586	0.0020	
HA03	7	1.7741	62046.0	57.30	-0.0660	0.0022	
HA03	8	1.8218	66268.0	56.85	0.3938	0.0025	
HA03	9	1.7959	68696.0	56.60	0.1936	0.0027	
HA03	10	1.8469	73073.3	56.71	0.5342	0.0030	
HA03	11	1.7143	75980.6	56.71	-0.1197	0.0032	
HA03	12	1.7041	80698.8	56.76	0.3479	0.0034	
HA03	13	1.7136	82884.9	56.65	0.3347	0.0036	
HA03	14	1.7483	86930.8	56.65	0.3439	0.0039	
HA03	15	1.7837	91010.6	56.53	0.4962	0.0041	
HA03	16	1.7864	92593.2	56.65	0.2561	0.0043	
HA03	17	1.8095	98213.5	56.56	0.4681	0.0046	
HA03	18	1.8068	100186.7	56.77	0.2571	0.0048	
HA03	19	1.8224	102350.4	56.69	0.3134	0.0051	
HA03	20	1.8224	106104.6	56.54	0.3998	0.0053	
HA03	21	1.8238	109031.3	56.52	0.3189	0.0055	
HA03	22	0.8327	100474.9	56.68			D
HA03	24	0.8966	112903.4	56.84	-1.1429	0.0063	
HA03	25	0.9082	115970.0	56.76	0.2886	0.0064	
HA03	28	0.9299	120685.3	56.84	0.3120	0.0067	
HA03	29	0.9354	123578.4	56.72	0.2022	0.0069	
HA03	32	0.9490	128607.2	56.73	0.3486	0.0071	
HA03	33	0.9694	139704.0	56.75	0.3057	0.0076	

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
HA03	34	1.2701	197527.0	56.43	0.3251	0.0108	
HA03	35	0.8374	191477.8	56.80		0.0115	
HA03	36	0.8755	199598.6	56.40	0.3292	0.0119	
HA03	37	0.9211	209234.9	56.32	0.3701	0.0124	
HA03	38	0.9415	212104.5	56.30	0.2715	0.0128	
HA04	0	0.7639	0.0	25.00		0.0000	
HA04	1	0.6775	51280.4	25.00	0.4506	0.0005	
HA04	2	0.7910	66628.0	25.00	0.5566	0.0008	
HA04	3	0.7784	86396.0	25.00	0.3632	0.0011	
HA04	4	0.8027	106935.0	25.00	0.3629	0.0015	
HA04	5	0.9184	119486.0	42.00	0.8782	0.0016	
HA04	6	0.9279	123248.0	41.66	0.3341	0.0017	
HA04	7	0.9088	131254.0	57.27	0.0802	0.0019	
HA04	8	0.9061	142816.0	56.91	0.3674	0.0021	
HA04	9	0.9007	150735.0	56.82	0.3512	0.0023	
HA04	10	0.9054	154416.2	56.74	0.2572	0.0025	
HA04	11	0.9082	162517.0	56.79	0.4634	0.0026	
HA04	12	0.9136	170404.9	56.68	0.3890	0.0028	
HA04	13	0.9150	172230.4	56.68	0.2463	0.0030	
HA04	14	0.9224	180962.1	56.68	0.3297	0.0032	
HA04	15	0.9231	187505.2	56.56	0.3513	0.0034	
HA04	16	0.9238	190110.6	56.66	0.2675	0.0035	
HA04	17	0.9299	197947.9	56.58	0.3533	0.0038	
HA04	18	0.9272	201311.0	56.83	0.2583	0.0039	
HA04	19	0.9293	204119.3	56.65	0.2490	0.0041	
HA04	20	0.9279	209469.2	56.56	0.3324	0.0043	
HA04	21	0.9238	210931.3	56.62	0.1638	0.0045	
HA04	22	0.7905	211115.4	56.67			D
HA04	23	0.7973	218282.7	56.71		0.0049	
HA04	24	0.8027	221814.5	56.77	0.2658	0.0051	
HA04	25	0.8020	224081.7	56.77	0.2632	0.0052	
HA04	28	0.8048	229128.4	56.80	0.2895	0.0054	
HA04	29	0.8041	231251.7	56.59	0.2081	0.0056	
HA04	30	0.7993	231119.8	56.74		0.0056	
HA04	32	0.7510	19438.1	56.70		0.0057	
HA04	33	0.7374	37723.8	56.75	0.2439	0.0061	
HA04	34	0.8891	117628.0	56.44	0.1926	0.0086	
HA04	35	0.7898	126498.0	56.61		0.0091	
HA04	36	0.7932	138581.0	56.42	0.2140	0.0095	
HA04	37	0.8088	146630.0	56.47	0.1793	0.0099	

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
HA04	38	0.8095	151039.7	56.54	0.1551	0.0101	
HA05	0	0.7659	0.0	25.00		0.0000	
HA05	1	0.6865	52802.2	25.00	0.7213	0.0006	
HA05	2	0.8009	78767.0	25.00	0.8660	0.0010	
HA05	3	0.7903	105256.0	25.00	0.6945	0.0014	
HA05	4	0.8231	129526.0	25.00	0.6334	0.0018	
HA05	5	1.0476	142132.0	42.00	2.2454	0.0020	
HA05	6	1.0830	148546.0	41.61	0.9354	0.0022	
HA05	7	1.0435	160603.0	57.26	0.0525	0.0024	
HA05	8	1.0476	168816.0	56.88	0.4698	0.0027	
HA05	9	1.0435	182963.0	56.83	0.8779	0.0029	
HA05	10	1.0320	192355.0	56.82	0.5108	0.0031	
HA05	11	1.0408	198950.1	56.80	0.6746	0.0033	
HA05	12	1.0456	208617.5	56.76	0.6630	0.0035	
HA05	13	0.7762	205104.4	56.65			D
HA05	14	1.0531	231681.5	56.72	0.6637	0.0040	
HA05	15	1.0565	241966.2	56.49	0.7470	0.0042	
HA05	16	0.9898	249289.6	56.67	-0.3337	0.0044	
HA05	17	1.0694	261774.0	56.60	1.4644	0.0047	
HA05	18	1.0646	270841.6	56.75	0.6575	0.0049	
HA05	19	1.0714	275198.6	56.67	0.4952	0.0051	
HA05	20	1.0707	279090.7	56.50	0.3964	0.0053	
HA05	21	1.0741	285072.3	56.61	0.5518	0.0055	
HA05	22	0.7946	281327.3	56.61			D
HA05	29	0.7755	325793.0	56.64	-0.4107	0.0069	
HA05	34	1.0810	414548.0	56.42			
HA06	0	0.7654	0.0	25.00		0.0000	
HA06	1	0.6857	36467.8	25.00	0.5627	0.0005	
HA06	2	0.8063	49165.0	25.00	0.7680	0.0008	
HA06	3	0.7837	69626.0	25.00	0.6253	0.0011	
HA06	4	0.8095	88492.0	25.00	0.5596	0.0015	
HA06	5	1.0272	102611.0	42.00	2.2313	0.0016	
HA06	6	1.0422	106677.0	42.03	0.5774	0.0018	
HA06	7	1.0027	111953.0	57.24	-0.1881	0.0019	
HA06	8	0.9925	122352.0	56.78	0.5324	0.0021	
HA06	9	0.9830	132391.0	56.82	0.6709	0.0023	
HA06	10	0.9782	144647.2	56.68	0.8127	0.0025	
HA06	11	0.9735	149887.8	56.75	0.4600	0.0026	
HA06	12	0.9741	161201.2	56.75	0.7663	0.0028	
HA06	13	0.9687	167597.9	56.72	0.5770	0.0030	

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
HA06	14	0.9673	177175.0	56.65	0.4956	0.0032	
HA06	15	0.9619	187364.8	56.39	0.6821	0.0034	
HA06	16	0.9578	194758.5	56.68	0.6142	0.0035	
HA06	17	0.9592	205661.0	56.68	0.6458	0.0038	
HA06	18	0.9524	211677.3	56.74	0.4541	0.0039	
HA06	19	0.9497	213602.7	56.60	0.2386	0.0041	
HA06	20	0.9435	228137.4	56.68	0.9083	0.0043	
HA06	21	0.9374	232101.5	56.60	0.3145	0.0045	
HA06	22	0.7850	232940.5	56.49			D
HA06	23	0.7830	225880.8	56.58		0.0049	
HA06	24	0.7932	250256.0	56.65	1.4590	0.0051	
HA06	25	0.7912	256962.4	56.76	0.5644	0.0052	
HA06	28	0.7925	266030.7	56.81	0.5724	0.0054	
HA06	29	0.7898	271832.3	56.61	0.4347	0.0056	
HA06	32	0.7905	283182.7	56.65	0.7902	0.0057	
HA06	33	0.8014	293209.1	56.72	0.4313	0.0061	
HA06	34	0.8585	355570.0	56.42	0.3152	0.0086	
HA06	35	0.7735	356434.4	56.60		0.0091	
HA06	36	0.7755	371580.6	56.47	0.4885	0.0095	
HA06	37	0.7755	371765.2	56.43	0.1102	0.0099	
HA06	38	0.7762	377622.2	56.46	0.3635	0.0102	
HA07	0	0.7660	0.0	25.00		0.0000	
HA07	1	0.6883	66178.2	25.00	0.8547	0.0006	
HA07	2	0.8228	95023.0	25.00	0.9897	0.0011	
HA07	3	0.8152	123041.0	25.00	0.7238	0.0014	
HA07	4	0.8503	149143.0	25.00	0.6758	0.0019	
HA07	5	1.0748	162655.0	42.00	2.3875	0.0021	
HA07	6	1.1129	168481.0	41.35	0.9591	0.0023	
HA07	7	1.0755	174476.0	57.32	-0.3604	0.0025	
HA07	8	1.0707	196800.0	56.88	0.9801	0.0028	
HA07	9	1.0667	206022.0	56.81	0.5966	0.0030	
HA07	10	1.0612	217134.4	56.74	0.6500	0.0033	
HA07	11	1.0619	226079.8	56.79	0.7183	0.0035	
HA07	12	1.0680	239934.0	56.74	0.8786	0.0037	
HA07	13	1.0660	244397.1	56.70	0.4614	0.0039	
HA07	14	1.0687	258781.5	56.79	0.6615	0.0042	
HA07	15	1.0660	264768.2	56.57	0.4451	0.0044	
HA07	16	1.0612	274910.7	56.66	0.7291	0.0046	
HA07	17	1.0680	286085.0	56.65	0.6679	0.0049	
HA07	18	1.0639	291994.4	56.81	0.4560	0.0051	

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
HA07	19	1.0626	299580.1	56.58	0.5497	0.0054	
HA07	20	1.0537	304691.4	56.54	0.3251	0.0056	
HA07	21	1.0449	310797.5	56.55	0.3672	0.0059	
HA07	22	0.7918	309815.1	56.59			D
HA07	23	0.7939	288318.8	56.70		0.0064	
HA07	24	0.8088	328971.3	56.81	1.8902	0.0066	
HA07	25	0.8082	339594.3	56.68	0.7086	0.0068	
HA07	28	0.8109	340016.9	56.84	0.2052	0.0070	
HA07	29	0.8095	347666.8	56.64	0.4730	0.0073	
HA07	32	0.8122	357805.6	56.68	0.6547	0.0075	
HA07	33	0.8231	370650.7	56.67	0.4345	0.0079	
HA07	34	0.9136	441234.0	56.39	0.3385	0.0113	
HA07	35	0.7912	440116.0	56.69		0.0119	
HA07	36	0.8075	459145.0	56.51	0.6354	0.0124	
HA07	37	0.8231	454657.9	56.66	0.1755	0.0129	
HA07	38	0.8259	468020.8	56.49	0.5694	0.0132	
HA08	0	0.7638	0.0	25.00		0.0000	
HA08	1	0.6417	15339.2	25.00	0.2223	0.0005	
HA08	2	0.7349	22066.8	25.00	0.3368	0.0008	
HA08	3	0.6995	31972.0	25.00	0.2626	0.0011	
HA08	4	0.7007	44626.6	25.00	0.2947	0.0015	
HA08	5	0.7755	51089.0	42.00	0.4980	0.0016	
HA08	6	0.7694	59012.8	42.23	0.5426	0.0018	
HA08	7	0.7388	67855.5	57.33	0.2139	0.0019	
HA08	8	0.7401	76739.8	56.83	0.3820	0.0021	
HA08	9	0.7361	86712.8	56.88	0.5154	0.0023	
HA08	10	0.7361	95057.4	56.67	0.4423	0.0025	
HA08	11	0.7333	101771.7	56.79	0.4165	0.0026	
HA08	12	0.7327	107937.5	56.64	0.3268	0.0028	
HA08	13	0.7293	113514.2	56.71	0.3747	0.0030	
HA08	15	0.7313	129143.5	56.50	0.3332	0.0034	
HA08	16	0.7320	133465.6	56.58	0.3272	0.0036	
HA08	17	0.7313	140708.4	56.68	0.3224	0.0038	
HA08	18	0.7272	146237.5	56.71	0.3204	0.0039	
HA08	19	0.6551	149507.2	56.67	-0.4239	0.0041	
HA08	20	0.6415	153304.9	56.50	0.1072	0.0043	
HA08	21	0.7204	159911.9	56.61			D
HA08	22	0.7170	159595.4	56.47			D
HA08	23	0.6680	142689.3	56.61		0.0049	
HA08	24	0.6782	171281.8	56.77	1.3703	0.0051	

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
HA08	25	0.6503	174665.2	56.72	-0.0801	0.0052	
HA09	0	0.7662	0.0	25.00		0.0000	
HA09	1	0.6937	66783.9	25.00	0.5499	0.0006	
HA09	2	0.8296	91416.0	25.00	0.5754	0.0010	
HA09	3	0.8231	113597.0	25.00	0.3816	0.0014	
HA09	4	0.8435	140294.0	25.00	0.4064	0.0019	
HA09	5	0.9660	148692.0	42.00	0.7510	0.0020	
HA09	6	0.9918	152654.0	40.88	0.4720	0.0022	
HA09	7	0.9850	165428.0	57.32	0.2303	0.0024	
HA09	8	1.0020	167241.0	56.84	0.2095	0.0027	
HA09	9	0.9980	176985.0	56.85	0.4062	0.0029	
HA09	10	1.0054	188119.7	56.78	0.4984	0.0031	
HA09	11	1.0102	191518.6	56.73	0.3067	0.0033	
HA09	12	1.0224	196176.2	56.72	0.3272	0.0035	
HA09	13	1.0252	201090.5	56.79	0.3791	0.0037	
HA09	14	1.0340	211294.7	56.77	0.3584	0.0040	
HA09	15	1.0347	216133.8	56.49	0.3093	0.0042	
HA09	16	1.0313	220786.4	56.62	0.3130	0.0044	
HA09	17	1.0435	228381.4	56.69	0.3741	0.0047	
HA09	18	1.0401	231247.8	56.71	0.2389	0.0049	
HA09	19	1.0435	236228.4	56.59	0.3308	0.0051	
HA09	20	1.0381	241605.1	56.53	0.2889	0.0054	
HA09	21	1.0299	246000.1	56.57	0.2370	0.0056	
HA09	22	0.7891	243294.0	56.49			D
HA09	23	0.7850	227269.0	56.69		0.0061	
HA09	24	0.8075	253483.5	56.70	0.9469	0.0063	
HA09	25	0.8109	257854.1	56.77	0.3330	0.0065	
HA09	28	0.8150	261848.2	56.83	0.2431	0.0067	
HA09	29	0.8184	268162.8	56.59	0.3431	0.0069	
HA09	30	0.8197	266653.1	56.72		0.0071	
HA09	31	0.7646	24121.6	56.68		0.0071	
HA09	32	0.7510	26919.6	56.61	0.4797	0.0071	
HA09	33	0.7293	51821.8	56.77	0.2716	0.0076	
HA09	34	0.8952	149410.0	56.46	0.2033	0.0107	
HA09	35	0.8034	164495.0	56.54		0.0113	
HA09	36	0.8218	174970.9	56.48	0.2147	0.0118	
HA09	37	0.8422	185066.6	56.45	0.2083	0.0123	
HA09	38	0.8497	189691.7	56.56	0.1801	0.0126	
HA10	0	0.7643	0.0	25.00		0.0000	
HA10	1	0.6442	15063.0	25.00	0.2192	0.0005	

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
HA10	2	0.7351	21790.3	25.00	0.3320	0.0008	
HA10	3	0.7008	31850.0	25.00	0.2685	0.0011	
HA10	5	0.7619	38858.1	42.00	0.1342	0.0016	
HA10	6	0.7578	41191.3	41.73	0.1732	0.0018	
HA10	7	0.7626	42374.0	57.26	-0.0017	0.0019	
HA10	8	0.7483	44675.5	56.80	0.0811	0.0021	
HA10	9	0.7286	44910.6	56.80	-0.0189	0.0023	
HA10	10	0.7524	43561.5	56.75	0.0299	0.0025	
HA10	11	0.7558	45382.8	56.72	0.1456	0.0026	
HA10	12	0.7252	45486.4	56.72	-0.0520	0.0028	
HA10	13	0.7483	45081.6	56.74	0.0938	0.0030	
HA10	14	0.7476	47346.6	56.73	0.0923	0.0032	
HA10	15	0.7497	47638.9	56.57	0.0496	0.0034	
HA10	16	0.7517	46157.3	56.59	-0.0413	0.0036	
HA10	17	0.7476	48700.3	56.71	0.1068	0.0038	
HA10	18	0.7524	48744.4	56.74	0.0485	0.0039	
HA10	19	0.7565	49068.6	56.54	0.0564	0.0041	
HA10	20	0.7442	50238.5	56.62	0.0451	0.0043	
HA10	21	0.7633	49034.2	56.66	0.0312	0.0045	
HA10	22	0.7565	50107.6	56.54	0.0594	0.0047	
HA10	23	0.7333	42490.2	56.77	-0.3158	0.0049	
HA10	24	0.7646	49997.2	56.82	0.4858	0.0051	
HA10	25	0.7476	52861.1	56.73	0.1286	0.0052	
HA10	28	0.7639	50648.0	56.76	-0.0199	0.0054	
HA10	32	0.7558	10277.5	56.58		0.0057	
HA10	33	0.7565	20575.2	56.78	0.2473	0.0061	
HA10	34	0.6673	43394.5	56.49	0.0594	0.0087	
HA10	35	0.7088	32022.2	56.69		0.0091	
HA10	36	0.6884	30051.9	56.42	-0.0524	0.0095	
HA10	38	0.6422	27525.9	56.60	-0.0475	0.0102	
HA11	0	0.7663	0.0	25.00		0.0000	
HA11	1	0.6857	67739.9	25.00	0.5246	0.0006	
HA11	2	0.8299	92823.0	25.00	0.5652	0.0010	
HA11	3	0.8231	115833.0	25.00	0.3762	0.0014	
HA11	4	0.8571	138522.0	25.00	0.3639	0.0019	
HA11	5	0.9728	153767.0	42.00	0.9176	0.0021	
HA11	6	1.0068	153610.0	41.67	0.3351	0.0023	
HA11	7	1.0027	162090.0	57.25	0.1188	0.0025	
HA11	8	1.0231	167901.0	56.82	0.3097	0.0028	
HA11	9	1.0272	177040.0	56.87	0.4220	0.0030	

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
HA11	10	1.0272	182385.3	56.66	0.2795	0.0032	
HA11	11	1.0340	193547.7	56.76	0.5804	0.0034	
HA11	12	1.0463	200428.6	56.71	0.3819	0.0036	
HA11	13	1.0490	204519.5	56.71	0.3517	0.0038	
HA11	14	1.0599	210827.1	56.67	0.2779	0.0041	
HA11	15	1.0612	217838.0	56.65	0.3703	0.0044	
HA11	16	1.0578	219227.6	56.49	0.2020	0.0045	
HA11	17	1.0714	228831.2	56.64	0.4195	0.0048	
HA11	18	1.0694	231834.8	56.68	0.2515	0.0050	
HA11	19	1.0714	236787.2	56.44	0.3194	0.0053	
HA11	20	1.0619	239588.8	56.42	0.1800	0.0055	
HA11	21	1.0551	245225.7	56.64	0.2786	0.0057	
HA11	22	0.8211	243310.4	56.51			D
HA11	23	0.8136	196691.2	56.61		0.0063	
HA11	24	0.8381	251489.7	56.72	1.6184	0.0065	
HA11	25	0.8265	254832.9	56.91	0.1473	0.0067	
HA11	28	0.8313	259972.0	56.82	0.2859	0.0069	
HA11	29	0.8333	264427.8	56.74	0.2737	0.0071	
HA11	30	0.8299	266071.4	56.69		0.0072	
HA11	32	0.7429	16062.8	56.75		0.0073	
HA11	33	0.7279	39700.0	56.71	0.2472	0.0078	
HA11	34	0.9122	138306.0	56.38	0.1956	0.0110	
HA11	35	0.8088	152385.3	56.62		0.0116	
HA11	36	0.8259	162788.7	56.37	0.1970	0.0121	
HA11	37	0.8476	173502.2	56.26	0.1879	0.0127	
HA11	38	0.8592	178777.5	56.57	0.2201	0.0129	
HA12	0	0.7631	0.0	25.00		0.0000	
HA12	1	0.6760	34453.3	25.00	0.5170	0.0005	
HA12	2	0.7941	45822.0	25.00	0.6808	0.0008	
HA12	3	0.7732	63762.0	25.00	0.5421	0.0011	
HA12	4	0.7959	82710.0	25.00	0.5277	0.0015	
HA12	5	0.9932	94898.0	42.00	1.8789	0.0016	
HA12	6	1.0354	98494.0	41.93	0.7585	0.0018	
HA12	7	0.9333	102983.0	55.07	-0.4396	0.0020	
HA12	8	0.9599	112723.0	56.84	0.8683	0.0021	
HA12	9	0.9007	124699.0	56.83	0.3457	0.0023	
HA12	10	0.9422	131990.8	56.68	0.8641	0.0025	
HA12	11	0.9422	134891.2	56.75	0.3142	0.0026	
HA12	12	0.9449	144815.1	56.74	0.6608	0.0028	
HA12	13	0.9381	153376.3	56.74	0.6929	0.0030	

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
HA12	14	0.9367	166467.9	56.79	0.6000	0.0032	
HA12	15	0.9054	174856.5	56.54	0.2786	0.0034	
HA12	16	0.8932	181723.3	56.60	0.4280	0.0036	
HA12	17	0.8197	190502.1	56.66	-0.2031	0.0038	
HA12	19	0.7694	182450.2	56.56	-0.4305	0.0041	
HA12	20	0.8102	184569.7	56.47	0.6585	0.0043	
HA12	21	0.9293	198846.1	56.56	2.2462	0.0045	
HA12	22	0.7844	201914.6	56.48			D
HA12	23	0.7517	180386.1	56.71		0.0049	
HA12	24	0.7816	211739.3	56.75	2.0229	0.0051	
HA12	25	0.7653	229484.8	56.77	0.8621	0.0052	
HA12	28	0.7694	238189.5	56.78	0.5876	0.0054	
HA12	32	0.7599	251230.2	56.74	0.3250	0.0057	
HA12	33	0.7755	264830.8	56.72	0.5196	0.0061	
HA12	35	0.6259	316407.3	56.73		0.0091	
HA12	36	0.7354	325593.8	56.50	1.3289	0.0095	
HA12	37	0.7415	333163.2	56.37	0.2751	0.0099	
HA12	38	0.7456	342798.3	56.63	0.5589	0.0102	
HA13	0	0.7675	0.0	25.00		0.0000	
HA13	1	0.6648	45675.4	25.00	0.6123	0.0006	
HA13	2	0.7756	65268.0	25.00	0.6640	0.0010	
HA13	3	0.7547	86053.1	25.00	0.5129	0.0014	
HA13	4	0.7823	100020.0	25.00	0.3663	0.0019	
HA13	5	0.8912	112778.0	42.00	1.1694	0.0021	
HA13	6	0.8993	116324.0	41.77	0.3901	0.0022	
HA13	7	0.8912	121899.0	56.50	0.0215	0.0025	
HA13	8	0.8796	127216.0	56.85	0.2603	0.0027	
HA13	9	0.8701	138463.0	56.83	0.5332	0.0029	
HA13	10	0.8571	144329.9	56.72	0.2599	0.0031	
HA13	11	0.8476	147437.8	56.81	0.1742	0.0033	
HA13	12	0.8401	156456.3	56.75	0.3978	0.0035	
HA13	13	0.8299	159625.8	56.64	0.1838	0.0037	
HA13	14	0.8211	162684.5	56.73	0.1008	0.0040	
HA13	15	0.8116	171292.0	56.61	0.3785	0.0042	
HA13	16	0.8014	172717.9	56.62	0.0703	0.0044	
HA13	17	0.7762	177484.1	56.74	0.0440	0.0047	
HA13	18	0.7844	180775.9	56.73	0.2995	0.0049	
HA13	19	0.7769	183866.7	56.62	0.1559	0.0051	
HA13	20	0.7667	188407.3	56.49	0.1764	0.0053	
HA13	21	0.7633	201134.4	56.62	0.5557	0.0056	

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
HA13	22	0.7565	201783.6	56.57	0.0559	0.0058	
HA13	23	0.7374	190030.2	56.66	-0.4428	0.0061	
HA13	24	0.7456	209771.1	56.77	0.9741	0.0063	
HA13	25	0.7265	211648.8	56.71	-0.0365	0.0065	
HA13	28	0.7252	214659.8	56.99	0.1879	0.0067	
HA13	32	0.7129	218257.8	56.71	0.0561	0.0071	
HA13	33	0.7136	219901.6	56.64	0.0862	0.0075	
HA13	34	0.7483	237296.1	56.42	0.0815	0.0107	
HA13	35	0.7524	241351.7	56.71		0.0113	
HA13	36	0.7422	241783.7	56.37	0.0080	0.0117	
HA13	37	0.7354	244966.2	56.21	0.0671	0.0122	
HA13	38	0.7259	244375.1	56.59	-0.0297	0.0125	
HA14	0	0.7644	0.0	25.00		0.0000	
HA14	1	0.6809	50501.2	25.00	0.4535	0.0005	
HA14	2	0.7948	63431.0	25.00	0.4992	0.0008	
HA14	3	0.7824	85103.0	25.00	0.4079	0.0011	
HA14	4	0.8027	105266.0	25.00	0.3465	0.0015	
HA14	5	0.9048	113934.0	42.00	0.6727	0.0016	
HA14	6	0.9238	121768.0	41.64	0.5859	0.0018	
HA14	7	0.9027	132602.0	56.88	0.1282	0.0020	
HA14	8	0.8986	135842.0	56.84	0.2014	0.0021	
HA14	9	0.8980	148648.0	56.91	0.5204	0.0023	
HA14	10	0.8952	154323.8	56.68	0.2899	0.0025	
HA14	11	0.8966	159902.8	56.79	0.3561	0.0026	
HA14	12	0.9034	167212.5	56.61	0.3739	0.0028	
HA14	13	0.9020	167231.1	56.73	0.1452	0.0030	
HA14	14	0.9068	177205.8	56.66	0.3361	0.0032	
HA14	15	0.9054	181261.6	56.53	0.2591	0.0034	
HA14	16	0.9014	185451.4	56.59	0.2812	0.0035	
HA14	17	0.9095	187735.3	56.70	0.2091	0.0038	
HA14	18	0.9068	196014.5	56.75	0.3866	0.0039	
HA14	19	0.9061	199830.6	56.59	0.2757	0.0041	
HA14	20	0.9000	207003.7	56.47	0.3286	0.0043	
HA14	21	0.8932	208428.5	56.56	0.1422	0.0045	
HA14	22	0.7782	209166.2	56.59			D
HA14	23	0.7789	206912.9	56.68		0.0049	
HA14	24	0.7878	217752.4	56.74	0.5213	0.0051	
HA14	25	0.7721	222712.8	56.78	0.1764	0.0052	
HA14	28	0.7762	227380.4	56.81	0.2927	0.0054	
HA14	29	0.7748	228194.1	56.51	0.1668	0.0056	

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
HA14	32	0.7776	228456.1	56.64	0.1825	0.0057	
HA14	33	0.7932	238685.9	56.75	0.2803	0.0061	
HA14	34	0.7578	287326.1	56.16	0.0817	0.0087	
HA14	35	0.7755	277012.8	56.74		0.0091	
HA14	36	0.7823	281764.4	56.48	0.1810	0.0095	
HA14	37	0.7925	286522.8	56.38	0.1787	0.0099	
HA14	38	0.7946	287473.3	56.65	0.1769	0.0102	
HA15	0	0.7675	0.0	25.00		0.0000	
HA15	1	0.6659	71906.6	25.00	0.9493	0.0006	
HA15	2	0.7941	111841.0	25.00	1.2508	0.0010	
HA15	3	0.7968	139225.0	25.00	0.7680	0.0014	
HA15	4	0.8163	167776.0	25.00	0.6862	0.0019	
HA15	5	0.9048	179607.0	42.00	1.1693	0.0021	
HA15	6	0.8762	183157.0	49.87	-0.2526	0.0023	
HA15	7	0.9020	198823.0	56.97	0.7413	0.0026	
HA15	8	0.8912	201643.0	56.76	0.1529	0.0028	
HA15	9	0.8857	219938.0	56.83	0.8947	0.0030	
HA15	10	0.8714	222725.6	56.69	0.0973	0.0032	
HA15	11	0.8653	231926.5	56.81	0.5412	0.0034	
HA15	12	0.8633	248090.4	56.70	0.7659	0.0036	
HA15	13	0.8558	244944.1	56.76	-0.1177	0.0038	
HA15	14	0.8095	256678.4	56.72	0.0314	0.0041	
HA15	15	0.8374	265916.6	56.52	0.9014	0.0044	
HA15	16	0.8286	273159.5	56.56	0.3796	0.0046	
HA15	17	0.8259	284018.6	56.69	0.4415	0.0048	
HA15	18	0.8184	287478.9	56.66	0.1866	0.0051	
HA15	19	0.8136	286821.9	56.57	0.0609	0.0053	
HA15	20	0.8027	295221.4	56.58	0.3234	0.0055	
HA15	21	0.8075	303607.0	56.67	0.5506	0.0058	
HA15	22	0.7612	304505.8	56.53			D
HA15	23	0.7537	316662.1	56.66		0.0063	
HA15	24	0.7571	327139.6	56.77	0.6252	0.0065	
HA15	25	0.7476	332088.3	56.78	0.2167	0.0067	
HA15	28	0.7503	335974.0	56.84	0.3388	0.0069	
HA15	32	0.7408	345193.4	56.75	0.1840	0.0073	
HA15	33	0.7463	349849.2	56.77	0.2156	0.0078	
HA15	34	0.7490	396399.9	56.36	0.1365	0.0111	
HA15	35	0.7605	394924.9	56.69		0.0117	
HA15	36	0.7585	396558.8	56.54	0.1049	0.0121	
HA15	37	0.7544	400817.2	56.36	0.1195	0.0127	

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
HA15	38	0.7435	404185.1	56.46	0.0743	0.0130	
HA16	0	0.7666	0.0	25.00		0.0000	
HA16	1	0.6693	33666.5	25.00	0.4414	0.0006	
HA16	2	0.7078	48428.9	25.00	0.4253	0.0010	
HA16	3	0.6785	63624.7	25.00	0.3907	0.0013	
HA16	4	0.7143	76368.5	25.00	0.3784	0.0017	
HA16	5	0.8163	81787.0	42.00	0.7460	0.0018	
HA16	6	0.8265	84791.0	49.48	0.2076	0.0020	
HA16	7	0.8122	94628.0	57.09	0.3255	0.0022	
HA16	8	0.8054	97869.0	56.79	0.2118	0.0024	
HA16	9	0.7993	110128.0	56.98	0.6629	0.0025	
HA16	10	0.7918	110081.3	56.64	0.0231	0.0027	
HA16	11	0.7857	121086.2	56.74	0.6901	0.0029	
HA16	12	0.7810	128628.9	56.71	0.3938	0.0030	
HA16	13	0.7741	129586.7	56.78	0.0921	0.0032	
HA16	14	0.7694	142015.3	56.70	0.4590	0.0034	
HA16	15	0.7639	152479.9	56.50	0.5608	0.0036	
HA16	16	0.7585	156750.3	56.63	0.2858	0.0038	
HA16	17	0.7544	161398.6	56.63	0.2224	0.0040	
HA16	18	0.7497	172742.9	56.67	0.5874	0.0042	
HA16	19	0.7456	172450.0	56.64	0.0483	0.0043	
HA16	20	0.7395	180987.5	56.47	0.4321	0.0045	
HA16	21	0.7361	187724.5	56.60	0.3758	0.0047	
HA16	22	0.7510	186290.9	56.42			D
HA16	23	0.7463	188888.0	56.69		0.0051	
HA16	24	0.7456	193993.8	56.79	0.3593	0.0053	
HA16	25	0.7388	200386.8	56.76	0.3845	0.0054	
HA16	28	0.7381	205213.3	56.66	0.3308	0.0056	
HA16	32	0.7293	213255.1	56.66	0.2015	0.0060	
HA16	33	0.7388	219176.1	56.75	0.2651	0.0063	
HA16	34	0.7517	270469.9	56.40	0.1914	0.0089	
HA16	35	0.7565	276382.3	56.64		0.0094	
HA16	36	0.7476	280257.3	56.47	0.0979	0.0097	
HA16	37	0.7442	285448.9	56.42	0.1519	0.0101	
HA16	38	0.7422	288846.7	56.34	0.2355	0.0104	
N01	0		0.0				
N01	2		5102.0	25.00			
N01	3		5290.0	25.00			
N01	4		4846.0				
N01	5		4896.0				

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
N01	6	1.0014	4723.0	24.15			
N01	7	1.0680	4705.0	24.83			
N01	8	1.1156	4635.0	24.35			
N01	9	1.0993	4631.0	23.66			
N01	10	1.1014	4646.2	23.51			
N01	11	0.9626	4986.4	23.07			
N01	12	0.9544	4826.5	23.61			
N01	13	0.9524	4790.2	22.59			
N01	14	0.9531	4709.2	22.75			
N01	15	0.9592	4849.4	23.32			
N01	16	0.9592	4886.4	23.60			
N01	17	0.9510	4684.2	23.74			
N01	18	0.9619	4924.4	23.64			
N01	19	0.9714	4827.6	24.45			
N01	20	0.9320	4841.1	23.29			
N01	21	0.9816	4967.6	22.82			
N01	22	0.9741	4841.1	23.38			
N01	23	0.9776	4869.8	23.64			
N01	24	0.9830	4850.7	24.83			
N01	25	0.9796	4876.6	22.93			
N01	28	0.9789	4936.4	23.56			
N01	29	0.9803	4881.1	25.09			
N01	32	0.9810	4835.1	25.15			
N01	33	0.9973	4977.8	54.97			
N01	34	0.9435	4869.0	57.63			
N01	35	0.9599	4989.9	57.21			
N01	37	0.9741	5025.4	57.09			
N01	38	0.9755	5048.4	57.17			
N02	0	0.7678	0.0	25.00		0.0000	
N02	1	0.6581	31724.4	25.00	0.4679	0.0006	
N02	2	0.7295	49768.4	25.00	0.5969	0.0009	
N02	3	0.6298	61179.3	25.00	0.1270	0.0011	
N02	4	0.6224	81028.9	25.00	0.3805	0.0016	
N02	5	0.6422	87470.0	25.00	0.4631	0.0017	
N02	6	0.6442	90808.1	24.18	0.2744	0.0019	
N02	7	0.6490	90949.0	24.80	0.0822	0.0020	
N02	8	0.6503	103759.3	24.36	0.5245	0.0022	
N02	9	0.6490	120865.8	23.75	0.8747	0.0024	
N02	10	0.6340	124262.4	23.40	0.0904	0.0026	
N02	11	0.6469	138987.3	23.04	1.0499	0.0027	

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
N02	12	0.6490	145160.4	23.56	0.3355	0.0029	
N02	13	0.6449	149681.1	22.56	0.3314	0.0031	
N02	14	0.6259	161934.9	22.95	0.3031	0.0033	
N02	15	0.6415	165918.9	23.30	0.4167	0.0035	
N02	16	0.6429	174340.4	23.59	0.5408	0.0037	
N02	17	0.6442	180594.4	23.75	0.3099	0.0039	
N02	18	0.6415	189022.2	23.62	0.4973	0.0040	
N02	19	0.6456	193945.8	24.49	0.3214	0.0042	
N02	20	0.6224	197144.0	23.25	-0.0439	0.0044	
N02	21	0.6395	204715.9	22.91	0.6334	0.0046	
N02	22	0.6408	211966.1	23.40	0.4542	0.0048	
N02	23	0.6415	218935.9	23.59	0.4097	0.0050	
N02	24	0.6463	222332.2	24.80	0.2393	0.0052	
N02	25	0.6374	226792.4	22.94	0.3037	0.0053	
N02	28	0.6395	234132.7	23.53	0.4304	0.0055	
N02	32	0.7279	29383.5	25.24		0.0059	
N02	33	0.6857	42230.5	25.39	0.2859	0.0062	
N02	34	0.7415	109513.0	24.99	0.2598	0.0087	
N02	35	0.7265	118802.0	25.29		0.0093	
N02	36	0.7333	123071.0	25.86	0.1637	0.0096	
N02	37	0.7354	138118.2	26.14	0.3829	0.0100	
N02	38	0.7354	140090.2	26.72	0.1174	0.0103	
N03	0	0.7632	0.0	25.00		0.0000	
N03	1	1.0790	15257.0	25.00	0.2937	0.0006	
N03	2	1.2508	19721.0	25.00	0.4301	0.0008	
N03	3	1.2360	27852.0	25.00	0.3091	0.0011	
N03	4	1.1905	40481.0	25.00	0.2785	0.0016	
N03	5	1.1633	44963.0	25.00	0.2237	0.0018	
N03	6	1.1374	46730.0	24.22	0.0959	0.0020	
N03	7	1.1245	51576.0	24.74	0.2727	0.0022	
N03	8	1.1048	58632.0	24.33	0.2773	0.0025	
N03	9	1.0844	62918.0	23.69	0.2104	0.0027	
N03	10	1.0605	68913.9	23.52	0.2569	0.0029	
N03	11	1.0435	73843.1	23.04	0.2812	0.0031	
N03	12	1.0354	79131.3	23.58	0.2409	0.0033	
N03	13	1.0156	83190.3	22.53	0.2278	0.0035	
N03	14	1.0034	89263.8	22.98	0.2043	0.0038	
N03	15	0.9946	93972.0	23.35	0.2182	0.0040	
N03	16	0.9857	98391.1	23.58	0.2431	0.0042	
N03	17	0.9823	106244.5	23.75	0.3130	0.0045	

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
N03	18	0.9667	109497.0	23.39	0.1495	0.0047	
N03	19	0.9667	113352.5	24.47	0.2045	0.0049	
N03	20	0.9422	117329.5	23.17	0.1394	0.0052	
N03	21	0.9320	121922.3	22.90	0.1957	0.0054	
N03	22	0.9245	128645.2	23.33	0.3145	0.0056	
N03	23	0.9190	133019.9	23.57	0.2103	0.0058	
N03	24	0.9231	137316.7	24.79	0.2054	0.0061	
N03	25	0.9020	141333.5	23.00	0.1863	0.0063	
N03	26	0.8932	143741.8	23.80	0.1455	0.0065	
N03	27	0.7551	4609.6	24.00		0.0065	
N03	28	0.7531	8508.6	23.49	0.4213	0.0065	
N03	32	0.7837	24143.9	25.19	0.2873	0.0070	
N03	33	0.8027	38896.8	25.07	0.2864	0.0074	
N03	34	0.9592	120203.0	24.99	0.2654	0.0106	
N03	35	0.7925	129156.5	25.27		0.0112	
N03	36	0.8088	142046.8	25.94	0.3014	0.0117	
N03	37	0.8265	149595.7	26.17	0.2036	0.0122	
N03	38	0.8422	150873.2	26.66	0.1548	0.0125	
N04	0	0.7649	0.0	25.00		0.0000	
N04	1	0.6955	49156.9	25.00	0.4363	0.0006	
N04	2	0.8013	71812.0	25.00	0.5142	0.0009	
N04	3	0.8008	89080.0	25.00	0.4032	0.0011	
N04	4	0.8027	112249.0	25.00	0.3479	0.0015	
N04	5	0.8027	117122.0	25.00	0.2344	0.0017	
N04	6	0.8014	123105.0	24.27	0.3320	0.0019	
N04	7	0.8020	122349.0	24.69	0.0557	0.0020	
N04	8	0.8027	137134.0	24.28	0.4476	0.0022	
N04	9	0.8000	150858.0	23.60	0.5382	0.0024	
N04	10	0.8000	160077.4	23.53	0.3787	0.0026	
N04	11	0.7966	164783.6	23.05	0.2874	0.0027	
N04	12	0.7986	167403.4	23.54	0.1756	0.0029	
N04	13	0.7946	177526.0	22.56	0.5246	0.0031	
N04	14	0.7966	182967.4	22.96	0.2143	0.0033	
N04	15	0.7986	190791.1	23.32	0.3563	0.0035	
N04	16	0.8000	193396.6	23.60	0.2339	0.0037	
N04	17	0.8048	201608.3	23.75	0.3342	0.0039	
N04	18	0.7946	203844.6	23.71	0.1231	0.0040	
N04	19	0.8007	205516.3	24.37	0.2062	0.0042	
N04	20	0.7946	209534.4	23.14	0.2413	0.0044	
N04	21	0.7973	210666.7	22.90	0.1780	0.0046	

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
N04	22	0.7993	215892.0	23.32	0.3164	0.0048	
N04	23	0.8027	222894.7	23.53	0.3658	0.0049	
N04	24	0.8116	224930.9	24.72	0.2038	0.0052	
N04	25	0.8041	228091.6	23.08	0.2746	0.0053	
N04	26	0.8048	230158.0	24.00	0.2581	0.0054	
N04	27	0.7605	17298.8	23.00		0.0054	
N04	28	0.7510	20685.9	23.32	0.3369	0.0055	
N04	32	0.7429	37526.0	25.23	0.2553	0.0058	
N04	33	0.7442	53951.8	25.06	0.2582	0.0062	
N04	34	0.8714	128337.0	24.92	0.2011	0.0087	
N04	35	0.7891	137045.0	25.29		0.0092	
N04	36	0.8041	142568.3	25.99	0.1619	0.0096	
N04	37	0.8102	152636.3	26.14	0.1965	0.0100	
N04	38	0.8238	158479.8	26.74	0.2510	0.0103	
N05	0	0.7658	0.0	25.00		0.0000	
N05	1	0.6652	92002.9	25.00	1.0946	0.0007	
N05	2	0.8046	117014.0	25.00	1.4657	0.0010	
N05	3	0.8126	145609.0	25.00	0.9528	0.0013	
N05	4	0.7823	178722.0	25.00	0.5382	0.0019	
N05	5	0.8299	188691.0	25.00	1.1118	0.0021	
N05	6	0.8340	197083.0	24.30	0.6836	0.0022	
N05	7	0.7871	194053.0	24.24	-0.5810	0.0025	
N05	8	0.8449	218379.0	24.27	1.5308	0.0027	
N05	9	0.8435	235333.0	23.58	0.9522	0.0029	
N05	10	0.8442	248889.7	23.46	0.7527	0.0032	
N05	11	0.8422	258066.0	23.03	0.6686	0.0034	
N05	12	0.8463	264736.8	23.39	0.4535	0.0036	
N05	13	0.8408	275987.0	22.54	0.7840	0.0038	
N05	14	0.7980	282382.3	22.93	-0.1836	0.0041	
N05	15	0.7952	293189.4	23.20	0.5285	0.0043	
N05	16	0.8367	297656.1	23.57	1.1803	0.0045	
N05	17	0.8367	305986.8	23.75	0.4269	0.0048	
N05	18	0.7891	311102.6	23.69	-0.4511	0.0050	
N05	19	0.8177	314592.1	24.31	0.7433	0.0053	
N05	20	0.7571	334864.2	23.11	0.0101	0.0055	
N05	21	0.8150	320755.6	22.91	0.5540	0.0057	
N05	22	0.8088	329506.7	23.34	0.4408	0.0059	
N05	23	0.8048	335296.4	23.50	0.3253	0.0062	
N05	24	0.8054	337879.0	24.69	0.1873	0.0065	
N05	25	0.7939	339203.8	23.12	0.1116	0.0066	

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
N05	28	0.7891	345034.2	23.37	0.2950	0.0069	
N05	29	0.7884	351881.4	24.96	0.3738	0.0071	
N05	32	0.7850	352056.9	25.28	0.1001	0.0073	
N05	33	0.7837	356086.1	25.08	0.1660	0.0078	
N05	34	0.7973	398824.0	24.93	0.1632	0.0110	
N05	35	0.7633	400716.3	25.29		0.0117	
N05	36	0.7599	418322.8	26.02	0.3967	0.0121	
N05	37	0.7592	417601.0	26.14	0.0620	0.0126	
N05	38	0.7592	398542.3	26.69	-0.4481	0.0130	
N06	0	0.7623	0.0	25.00		0.0000	
N06	1	0.7003	36092.1	25.00	0.5884	0.0005	
N06	2	0.8071	56034.0	25.00	0.7490	0.0008	
N06	3	0.8021	73611.0	25.00	0.6701	0.0011	
N06	4	0.8027	98788.0	25.00	0.6102	0.0015	
N06	5	0.8027	104783.0	25.00	0.4293	0.0017	
N06	6	0.8034	108548.0	24.32	0.3639	0.0018	
N06	7	0.8034	112151.0	24.37	0.2844	0.0020	
N06	8	0.8054	125907.0	24.21	0.7012	0.0022	
N06	9	0.8020	138374.0	23.50	0.7845	0.0024	
N06	10	0.8034	151972.8	23.49	0.8299	0.0026	
N06	11	0.7993	157995.9	23.00	0.4866	0.0027	
N06	12	0.8034	166761.1	23.28	0.5722	0.0029	
N06	13	0.7980	175969.6	22.57	0.7211	0.0030	
N06	14	0.7973	182994.9	22.89	0.3532	0.0033	
N06	15	0.8034	184290.7	23.33	0.2336	0.0035	
N06	16	0.8034	200617.6	23.53	1.1793	0.0036	
N06	17	0.8075	207119.8	23.69	0.4317	0.0038	
N06	18	0.8034	215800.2	23.71	0.5850	0.0040	
N06	19	0.8082	219048.2	24.29	0.3492	0.0042	
N06	20	0.7952	225766.9	23.08	0.3763	0.0044	
N06	21	0.7986	232695.5	22.90	0.5344	0.0046	
N06	22	0.7986	236420.3	23.31	0.3460	0.0047	
N06	23	0.7993	242883.2	23.38	0.4156	0.0049	
N06	24	0.8068	253336.5	24.72	0.7465	0.0051	
N06	25	0.7966	254806.8	23.15	0.1741	0.0053	
N06	28	0.7966	251154.7	23.46	-0.0508	0.0055	
N06	29	0.8027	269486.6	24.89	1.2076	0.0056	
N06	32	0.8041	273520.7	25.30	0.4176	0.0058	
N06	33	0.8088	282877.2	25.09	0.4006	0.0062	
N06	34	0.9109	340119.0	24.93	0.4013	0.0087	

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
N06	35	0.7762	346551.4	25.23		0.0092	
N06	36	0.7925	351704.5	25.94	0.4079	0.0096	
N06	37	0.7946	352217.8	26.12	0.1249	0.0100	
N06	38	0.8075	358099.9	26.66	0.5741	0.0102	
N07	0	0.7658	0.0	25.00		0.0000	
N07	1	0.6710	90381.1	25.00	1.0772	0.0007	
N07	2	0.8082	106775.0	25.00	1.1389	0.0010	
N07	3	0.8231	134617.0	25.00	0.9545	0.0013	
N07	4	0.8435	167167.0	25.00	0.7310	0.0019	
N07	5	0.8367	173907.0	25.00	0.3718	0.0021	
N07	6	0.8374	183834.0	24.32	0.7149	0.0023	
N07	7	0.8395	188755.0	24.44	0.3619	0.0025	
N07	8	0.8415	196677.0	24.20	0.4060	0.0027	
N07	9	0.8395	215746.0	23.54	1.0222	0.0030	
N07	10	0.8367	230031.5	23.49	0.7217	0.0032	
N07	11	0.8327	235837.0	23.02	0.4267	0.0034	
N07	12	0.8313	245163.5	23.35	0.4789	0.0036	
N07	13	0.8259	251957.9	22.57	0.4934	0.0038	
N07	14	0.8218	258732.4	22.89	0.2707	0.0041	
N07	15	0.8231	266843.5	23.24	0.4738	0.0044	
N07	16	0.8190	275302.2	23.55	0.5182	0.0046	
N07	17	0.8190	279092.8	23.70	0.2431	0.0048	
N07	18	0.8122	287997.1	23.68	0.4611	0.0051	
N07	19	0.8122	288485.9	24.19	0.1369	0.0053	
N07	20	0.7980	294401.3	23.07	0.2343	0.0055	
N07	21	0.7952	295457.9	22.88			D
N07	23	0.7884	309024.8	23.43	0.1857	0.0063	
N07	24	0.7898	313213.0	24.71	0.2781	0.0065	
N07	25	0.7796	315429.0	23.18	0.1777	0.0067	
N07	28	0.7755	320248.9	23.49	0.2509	0.0069	
N07	29	0.7762	326474.2	24.87	0.3671	0.0072	
N07	32	0.7735	342909.5	25.32	0.8255	0.0074	
N07	33	0.7728	350816.0	25.13	0.2502	0.0078	
N07	34	0.8088	375477.0	24.88	0.1378	0.0111	
N07	35	0.7714	376378.1	25.25		0.0118	
N07	36	0.7653	385146.8	26.01	0.1851	0.0122	
N07	37	0.7592	402222.8	26.24	0.3300	0.0127	
N07	38	0.7585	404370.3	26.70	0.1644	0.0131	
N08	0	0.7674	0.0	25.00		0.0000	
N08	1	0.6783	18895.7	25.00	0.2614	0.0006	

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
N08	2	0.7663	28914.1	25.00	0.2866	0.0010	
N08	3	0.7561	35673.9	25.00	0.1929	0.0013	
N08	4	0.7483	43701.2	25.00	0.1424	0.0019	
N08	5	0.7415	46344.7	25.00	0.1265	0.0021	
N08	6	0.7374	47046.8	24.31	0.0557	0.0022	
N08	7	0.7320	46933.8	24.45	0.0022	0.0024	
N08	8	0.7245	53285.2	24.18	0.2156	0.0027	
N08	9	0.7156	57901.4	23.55	0.1953	0.0029	
N08	10	0.7122	63058.3	23.43	0.2166	0.0031	
N08	11	0.7041	65025.3	22.98	0.0989	0.0033	
N08	12	0.6993	68300.1	23.64	0.1240	0.0036	
N08	13	0.6898	70710.4	22.56	0.1222	0.0037	
N08	14	0.6803	73032.0	22.86	0.0585	0.0040	
N08	15	0.6796	76991.5	23.26	0.1652	0.0043	
N08	16	0.6762	77967.0	23.50	0.0619	0.0045	
N08	17	0.6707	82195.9	23.69	0.1339	0.0047	
N08	18	0.6626	85109.5	23.73	0.1114	0.0049	
N08	19	0.6612	86717.3	24.15	0.0808	0.0052	
N08	20	0.6456	87406.9	23.09	-0.0036	0.0054	
N08	21	0.6490	90455.8	22.88	0.1565	0.0056	
N08	22	0.6490	88141.1	22.89	-0.0472	0.0058	
N08	23	0.6456	95504.4	23.36	0.2363	0.0061	
N08	24	0.6463	98055.0	24.65	0.1124	0.0063	
N08	25	0.6388	98358.9	23.23	0.0339	0.0065	
N08	28	0.6429	101567.0	23.52	0.1612	0.0068	
N08	32	0.6401	105009.5	25.41	0.0646	0.0072	
N08	33	0.6483	107469.4	25.14	0.0926	0.0076	
N08	34	0.6667	131526.0	24.90	0.0737	0.0108	
N08	35	0.7585	122640.2	25.19		0.0114	
N08	36	0.7476	126214.0	25.94	0.0588	0.0119	
N08	37	0.7422	125378.1	26.21	-0.0083	0.0124	
N08	38	0.7422	129908.8	26.68	0.1677	0.0127	
N09	0	0.7652	0.0	25.00		0.0000	
N09	1	0.7006	58100.9	25.00	0.7692	0.0007	
N09	2	0.8206	72219.0	25.00	0.8073	0.0009	
N09	3	0.6706	98346.0	25.00	0.2486	0.0013	
N09	4	0.7007	124433.4	25.00	0.5842	0.0018	
N09	5	0.7075	126859.9	25.00	0.2171	0.0020	
N09	6	0.7116	138345.1	24.29	0.7378	0.0021	
N09	7	0.7197	138183.3	24.49	0.1247	0.0024	

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
N09	8	0.7259	154212.0	24.17	0.6463	0.0026	
N09	9	0.7224	178485.4	23.18	1.0818	0.0028	
N09	10	0.7327	189757.8	23.41	0.6547	0.0030	
N09	11	0.7320	190401.5	22.95	0.1470	0.0032	
N09	12	0.7388	202377.1	23.68	0.6005	0.0035	
N09	13	0.7354	211679.3	22.53	0.6082	0.0036	
N09	14	0.7401	219845.6	22.87	0.3653	0.0039	
N09	15	0.7469	228135.9	23.21	0.5014	0.0042	
N09	16	0.7490	233661.1	23.49	0.4239	0.0043	
N09	17	0.7537	245042.8	23.66	0.5309	0.0046	
N09	18	0.7531	250251.6	23.71	0.3505	0.0048	
N09	19	0.7571	255239.4	24.15	0.3634	0.0050	
N09	20	0.7524	255589.8	23.08	0.1087	0.0053	
N09	21	0.7531	265681.1	22.89	0.5439	0.0055	
N09	22	0.7517	265143.1	22.82	0.0854	0.0057	
N09	23	0.7565	276761.4	23.32	0.5756	0.0060	
N09	24	0.7639	284426.1	24.64	0.5001	0.0062	
N09	25	0.7558	286119.1	23.27	0.1721	0.0064	
N09	28	0.7585	291615.8	23.55	0.3785	0.0066	
N09	32	0.7646	301367.7	25.51	0.3003	0.0070	
N09	33	0.7701	312556.8	25.18	0.3780	0.0075	
N09	34	0.8374	347417.0	24.98	0.2120	0.0106	
N09	35	0.7755	348026.2	25.20		0.0112	
N09	36	0.7803	352830.9	26.11	0.2117	0.0116	
N09	37	0.7891	354334.0	26.21	0.1822	0.0121	
N09	38	0.7918	353024.9	26.65	0.1045	0.0124	
N10	0	0.7674	0.0	25.00		0.0000	
N10	1	0.6807	22739.2	25.00	0.3036	0.0006	
N10	2	0.7632	33431.7	25.00	0.3334	0.0010	
N10	3	0.7324	41718.3	25.00	0.1777	0.0014	
N10	4	0.7279	50138.5	25.00	0.1644	0.0018	
N10	5	0.7211	54538.4	25.00	0.1964	0.0020	
N10	6	0.7204	55030.9	24.26	0.0627	0.0022	
N10	7	0.7170	55743.1	24.51	0.0442	0.0024	
N10	8	0.7109	62574.6	24.13	0.2329	0.0027	
N10	9	0.7020	69818.0	23.28	0.2948	0.0029	
N10	10	0.7020	74516.3	23.41	0.2163	0.0031	
N10	11	0.6946	75808.5	22.95	0.0693	0.0033	
N10	12	0.6905	78782.8	23.58	0.1159	0.0035	
N10	13	0.6823	82251.7	22.57	0.1797	0.0037	

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
N10	14	0.6660	86753.3	22.87	0.0931	0.0040	
N10	15	0.6755	90911.9	23.22	0.2236	0.0042	
N10	16	0.6735	91323.0	23.49	0.0476	0.0044	
N10	17	0.6531	96465.3	23.42	0.0978	0.0047	
N10	18	0.6551	99431.2	23.71	0.1707	0.0049	
N10	19	0.6605	99798.7	24.16	0.0765	0.0051	
N10	20	0.6537	101588.3	23.03	0.0842	0.0054	
N10	21	0.6565	105765.0	22.89	0.2026	0.0056	
N10	22	0.6612	99648.7	22.82	-0.1549	0.0058	
N10	23	0.6592	106953.5	23.29	0.2491	0.0061	
N10	24	0.6626	111104.0	24.63	0.1896	0.0063	
N10	25	0.6565	111822.2	23.27	0.0681	0.0065	
N10	28	0.6667	112920.0	23.59	0.1364	0.0067	
N10	32	0.6660	117414.0	25.50	0.0946	0.0071	
N10	33	0.6789	119585.2	25.22	0.1122	0.0076	
N10	34	0.7061	139930.0	24.95	0.0732	0.0107	
N10	35	0.7592	134558.0	25.17		0.0113	
N10	36	0.7476	141515.0	25.91	0.1220	0.0118	
N10	37	0.7422	146908.6	26.16	0.1093	0.0123	
N10	38	0.7422	146138.2	26.67	0.0180	0.0126	
N11	0	0.7653	0.0	25.00		0.0000	
N11	1	0.7026	58125.5	25.00	0.7177	0.0007	
N11	2	0.8176	75060.0	25.00	0.8069	0.0010	
N11	3	0.8271	105118.0	25.00	0.8514	0.0014	
N11	4	0.8367	127172.0	25.00	0.5061	0.0019	
N11	5	0.8299	138188.0	25.00	0.5431	0.0021	
N11	6	0.8272	143421.0	24.25	0.3844	0.0023	
N11	7	0.8299	140904.0	24.56	-0.0279	0.0025	
N11	8	0.8306	155635.0	24.15	0.6075	0.0027	
N11	9	0.8279	172687.0	23.34	0.8380	0.0030	
N11	10	0.8265	184398.3	23.39	0.5901	0.0032	
N11	11	0.8231	182336.1	22.93	-0.0249	0.0034	
N11	12	0.8286	197961.1	23.56	0.7559	0.0036	
N11	13	0.8218	201763.6	22.54	0.2825	0.0038	
N11	14	0.8218	207631.3	22.86	0.2576	0.0041	
N11	15	0.8245	217207.7	23.23	0.5105	0.0044	
N11	16	0.8218	225905.8	23.49	0.5247	0.0046	
N11	17	0.8245	231145.5	23.47	0.2962	0.0049	
N11	18	0.8204	236299.4	23.73	0.3053	0.0051	
N11	19	0.8224	240643.2	24.15	0.3051	0.0053	

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
N11	20	0.8136	243617.3	23.02	0.1758	0.0055	
N11	21	0.8095	249122.5	22.89	0.2919	0.0058	
N11	22	0.8007	246140.0	22.80	-0.1211	0.0060	
N11	23	0.8034	263538.2	23.35	0.7416	0.0063	
N11	24	0.8082	265299.7	24.62	0.2080	0.0065	
N11	25	0.7952	269863.6	23.33	0.2400	0.0067	
N11	28	0.7925	271719.1	23.66	0.1436	0.0069	
N11	29	0.7966	277425.6	24.74	0.3897	0.0072	
N11	32	0.7980	284403.3	25.42	0.4441	0.0074	
N11	33	0.7966	287612.3	25.23	0.1308	0.0078	
N11	34	0.8721	342691.0	24.96	0.2701	0.0111	
N11	35	0.7762	351244.0	25.18		0.0118	
N11	36	0.7898	351814.5	25.76	0.1976	0.0122	
N11	37	0.7925	357712.0	26.16	0.2003	0.0127	
N11	38	0.7932	355902.5	26.68	0.0555	0.0131	
N12	0	0.7629	0.0	25.00		0.0000	
N12	1	0.7037	37734.6	25.00	0.6175	0.0005	
N12	2	0.8058	54590.0	25.00	0.6417	0.0009	
N12	3	0.8060	75289.0	25.00	0.7182	0.0012	
N12	4	0.8027	96059.0	25.00	0.5456	0.0015	
N12	5	0.8027	104818.0	25.00	0.5840	0.0017	
N12	6	0.7952	109095.0	24.37	0.3211	0.0018	
N12	7	0.8007	108498.0	24.60	0.0786	0.0020	
N12	8	0.8007	126721.0	24.13	0.8912	0.0022	
N12	9	0.7980	137932.0	23.30	0.6997	0.0024	
N12	10	0.7980	152272.3	23.39	0.8724	0.0026	
N12	11	0.7946	155119.6	22.94	0.2777	0.0027	
N12	12	0.8000	167170.5	23.53	0.7417	0.0029	
N12	13	0.7939	174460.9	22.59	0.5830	0.0030	
N12	14	0.7905	182507.4	22.73	0.3649	0.0033	
N12	15	0.7980	192638.6	23.23	0.7170	0.0035	
N12	16	0.7973	199508.7	23.47	0.5597	0.0036	
N12	17	0.8000	206679.8	23.46	0.4390	0.0039	
N12	18	0.7959	213804.8	23.71	0.4911	0.0040	
N12	19	0.8007	211095.5	24.12	0.0356	0.0042	
N12	20	0.7946	223957.9	23.01	0.7970	0.0044	
N12	21	0.7932	233925.0	22.88	0.6316	0.0046	
N12	22	0.7864	231902.0	22.78	-0.0707	0.0047	
N12	23	0.7918	240001.0	23.33	0.5445	0.0050	
N12	24	0.7973	246417.3	24.55	0.5028	0.0051	

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
N12	25	0.7891	251903.4	23.38	0.4651	0.0053	
N12	28	0.7884	259968.5	23.71	0.5227	0.0055	
N12	29	0.7918	261471.2	24.69	0.2562	0.0057	
N12	32	0.7946	268846.8	25.34	0.6114	0.0058	
N12	33	0.7959	277754.0	25.23	0.3458	0.0062	
N12	34	0.8878	333361.0	24.93	0.3725	0.0087	
N12	35	0.7762	340828.9	25.14		0.0092	
N12	36	0.7912	333982.4	25.58	0.0748	0.0096	
N12	37	0.7946	351360.8	26.12	0.5387	0.0100	
N12	38	0.8054	349852.5	26.68	0.2524	0.0102	
N13	0	0.7655	0.0	25.00		0.0000	
N13	1	0.7214	77682.4	25.00	0.5851	0.0007	
N13	2	0.8514	96644.0	25.00	0.6256	0.0010	
N13	3	0.8705	123373.0	25.00	0.5139	0.0014	
N13	4	0.8707	147493.0	25.00	0.3398	0.0019	
N13	5	0.8776	156438.0	25.00	0.3856	0.0021	
N13	6	0.8728	159684.0	24.36	0.1972	0.0023	
N13	7	0.8789	163715.0	24.61	0.2490	0.0025	
N13	8	0.8891	175713.0	24.10	0.4009	0.0027	
N13	9	0.8966	191823.0	23.28	0.6170	0.0030	
N13	10	0.8980	201311.6	23.37	0.3822	0.0032	
N13	11	0.9034	201727.7	22.92	0.2010	0.0034	
N13	12	0.9197	212956.3	23.54	0.4917	0.0036	
N13	13	0.9204	219105.7	22.55	0.4088	0.0038	
N13	14	0.9306	227324.9	22.79	0.3141	0.0041	
N13	15	0.9395	234437.4	23.23	0.3785	0.0043	
N13	16	0.9374	240921.8	23.49	0.3565	0.0045	
N13	17	0.9531	239454.3	23.41	0.1685	0.0048	
N13	18	0.9476	250751.1	23.70	0.4674	0.0050	
N13	19	0.9578	248907.3	24.10	0.1520	0.0053	
N13	20	0.9517	259936.9	23.04	0.4602	0.0055	
N13	21	0.9449	264526.2	22.85	0.2234	0.0057	
N13	22	0.9163	266614.7	22.94	-0.0309	0.0060	
N13	23	0.9272	271710.8	23.34	0.3218	0.0062	
N13	24	0.9313	275838.0	24.51	0.2607	0.0065	
N13	25	0.9218	279080.4	23.41	0.2503	0.0066	
N13	26	0.8912	281200.3	22.90	-0.0561	0.0068	
N13	27	0.7612	28181.8	22.20		0.0068	
N13	28	0.7531	33321.8	23.75	0.4168	0.0069	
N13	32	0.7354	57910.4	25.28	0.2901	0.0073	

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
N13	33	0.7524	78272.4	25.28	0.2748	0.0078	
N13	34	0.9755	173345.0	24.96	0.2470	0.0110	
N13	35	0.7932	187962.4	25.14		0.0117	
N13	36	0.8259	198879.4	25.59	0.2703	0.0122	
N13	37	0.8517	209258.6	26.15	0.2392	0.0127	
N13	38	0.8680	216894.1	26.69	0.2919	0.0130	
N14	0	0.7650	0.0	25.00		0.0000	
N14	1	0.6993	55118.9	25.00	0.5098	0.0006	
N14	2	0.8073	80532.0	25.00	0.5873	0.0009	
N14	3	0.8113	99555.0	25.00	0.4247	0.0012	
N14	4	0.8095	122603.0	25.00	0.3824	0.0016	
N14	5	0.8095	131224.0	25.00	0.3922	0.0017	
N14	6	0.8041	136045.0	24.38	0.2768	0.0019	
N14	7	0.8034	142485.0	24.59	0.3241	0.0020	
N14	8	0.8041	152584.0	24.07	0.3595	0.0022	
N14	9	0.8020	168011.0	23.22	0.6160	0.0024	
N14	10	0.8020	177034.4	23.36	0.4017	0.0026	
N14	11	0.7973	180070.6	22.89	0.2245	0.0027	
N14	12	0.8034	191722.9	23.54	0.4946	0.0029	
N14	13	0.7986	195467.0	22.57	0.2857	0.0031	
N14	14	0.8027	204792.2	22.74	0.3353	0.0033	
N14	15	0.8068	209775.8	23.35	0.3024	0.0035	
N14	16	0.8054	215842.1	23.43	0.3736	0.0037	
N14	17	0.8122	219796.9	23.44	0.2592	0.0039	
N14	18	0.8102	223253.8	23.66	0.2508	0.0040	
N14	19	0.8150	227300.5	24.05	0.2984	0.0042	
N14	20	0.8102	229652.5	23.09	0.2044	0.0044	
N14	21	0.8068	225232.2	22.86	-0.0271	0.0046	
N14	22	0.8007	232606.4	22.96	0.3226	0.0048	
N14	23	0.8061	238540.1	23.34	0.3261	0.0050	
N14	24	0.8102	236023.4	24.46	0.0715	0.0052	
N14	25	0.8034	239703.7	23.38	0.2970	0.0053	
N14	26	0.7891	242887.3	22.20	0.1839	0.0054	
N14	27	0.7605	12885.6	22.60		0.0055	
N14	28	0.7571	15967.9	23.82	0.3649	0.0055	
N14	32	0.7483	35244.1	25.25	0.3051	0.0058	
N14	33	0.7524	52458.5	25.25	0.2835	0.0062	
N14	34	0.8694	129136.0	25.00	0.2118	0.0087	
N14	35	0.7891	136746.7	25.24		0.0092	
N14	36	0.8054	145382.0	25.55	0.2221	0.0096	

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
N14	37	0.8109	153728.9	26.10	0.1767	0.0100	
N14	38	0.8252	150853.3	26.74	0.0549	0.0103	
N15	0	0.7657	0.0	25.00		0.0000	
N15	1	0.7025	58664.4	25.00	0.4394	0.0007	
N15	2	0.8209	71423.0	25.00	0.4557	0.0010	
N15	3	0.8087	91141.0	25.00	0.3253	0.0013	
N15	4	0.8163	107575.0	25.00	0.2381	0.0018	
N15	5	0.8163	118711.0	25.00	0.3834	0.0020	
N15	6	0.8122	120712.0	24.37	0.1322	0.0022	
N15	7	0.8136	129540.0	24.59	0.3372	0.0024	
N15	8	0.8150	134812.0	24.08	0.1821	0.0026	
N15	9	0.8150	148186.0	23.22	0.4479	0.0028	
N15	10	0.8150	156844.2	23.35	0.3092	0.0031	
N15	11	0.8156	161954.8	22.97	0.2773	0.0032	
N15	12	0.8245	165126.3	23.47	0.1966	0.0035	
N15	13	0.8238	173625.5	22.58	0.4147	0.0036	
N15	14	0.8293	177214.7	22.63	0.1605	0.0039	
N15	15	0.8374	186849.0	23.28	0.3824	0.0042	
N15	16	0.8354	193475.1	23.44	0.3125	0.0043	
N15	17	0.8442	199386.4	23.41	0.2570	0.0046	
N15	18	0.8354	202421.3	23.63	0.1396	0.0048	
N15	19	0.8313	206780.7	23.81	0.1856	0.0051	
N15	20	0.8401	209472.6	23.14	0.2644	0.0053	
N15	21	0.8374	216854.7	22.80	0.2881	0.0055	
N15	22	0.8245	220359.9	22.94	0.1142	0.0057	
N15	23	0.8306	222677.5	23.33	0.1832	0.0060	
N15	24	0.8333	226264.1	24.45	0.2002	0.0062	
N15	25	0.8259	232806.8	23.34	0.3388	0.0064	
N15	26	0.8088	235652.7	22.60	0.1031	0.0066	
N15	27	0.7619	29253.1	22.20		0.0066	
N15	28	0.7578	32453.7	23.88	0.3434	0.0066	
N15	32	0.7408	49297.4	25.22	0.2084	0.0070	
N15	33	0.7463	64097.1	25.31	0.2010	0.0075	
N15	34	0.8925	140414.0	25.02	0.1814	0.0106	
N15	35	0.7912	152183.6	25.20		0.0112	
N15	36	0.8088	162180.5	25.56	0.2078	0.0117	
N15	37	0.8245	172044.6	26.14	0.1921	0.0121	
N15	38	0.8320	177663.6	26.78	0.1944	0.0124	
N16	0	0.7669	0.0	25.00		0.0000	
N16	1	0.6718	37989.3	25.00	0.4999	0.0006	

Table A-2. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr	Outlier Flag
N16	2	0.7027	57261.5	25.00	0.5373	0.0010	
N16	3	0.6995	71190.6	25.00	0.4301	0.0013	
N16	4	0.7211	85165.2	25.00	0.3946	0.0017	
N16	5	0.6476	91156.0	25.00	-0.1328	0.0018	
N16	6	0.6476	96067.7	24.36	0.3497	0.0020	
N16	7	0.6558	97094.6	24.63	0.1642	0.0021	
N16	9	0.6517	120040.7	23.20	0.5025	0.0025	
N16	10	0.6585	131879.2	23.34	0.6697	0.0027	
N16	11	0.6571	136898.2	22.92	0.3617	0.0028	
N16	12	0.6605	142250.6	23.47	0.3190	0.0030	
N16	13	0.6565	148845.5	22.63	0.4516	0.0032	
N16	14	0.6592	158028.5	22.47	0.3859	0.0034	
N16	15	0.6673	163901.6	23.26	0.4234	0.0036	
N16	16	0.6639	168961.7	23.42	0.3268	0.0038	
N16	17	0.6653	176653.3	23.42	0.3688	0.0040	
N16	19	0.6660	186894.0	23.79	0.2894	0.0043	
N16	20	0.6619	191765.5	23.13	0.2988	0.0045	
N16	21	0.7333	197605.2	22.78			D
N16	22	0.7361	201274.8	22.90		0.0049	
N16	23	0.7361	210055.0	23.34	0.4731	0.0051	
N16	24	0.7401	212900.4	24.38	0.2737	0.0053	
N16	25	0.7333	217602.1	23.34	0.3866	0.0054	
N16	28	0.7395	220634.5	23.89	0.3303	0.0056	
N16	32	0.7306	55349.5	25.19		0.0059	
N16	33	0.7048	68094.1	25.34	0.2857	0.0063	
N16	34	0.7639	125933.0	25.17	0.2411	0.0088	
N16	35	0.7680	137149.4	25.25		0.0094	
N16	36	0.7755	144129.2	25.54	0.2574	0.0097	
N16	37	0.7755	150527.4	26.14	0.1895	0.0101	
N16	38	0.7755	149918.8	26.71	0.0289	0.0104	

Code = Cylinder identifier (Hxx and HAxx are heated for cycles >4)
Cycle = Sampling cycle for each particular barrel
atm = Pressure in atmospheres
ppm = Concentration in parts per million
G-value = Calculated G-value (molecules/100 eV)
Watt · yr= Dose expressed as multiple of dose rate in watts by time in years

Table A-3. Measured parameters and calculated G · values for restart cylinders.

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr
A01	0	0.7721	0.5	26.62		0
A01	1	0.7762	104.0	26.62	0.2875	3.59e-06
A01	2	0.7667	661.8	26.14	0.8132	.0000104
A01	3	0.7599	1198.4	26.77	0.7882	.000017
A01	4	0.7510	1726.8	26.59	0.7670	.0000237
A01	5	0.7422	2287.8	26.51	0.7888	.0000304
A01	6	0.7327	2784.7	26.03	0.7030	.0000371
A01	7	0.7190	6412.6	25.61	0.7061	.0000845
A01	8	0.7088	7368.7	25.40	0.6381	.0000979
A01	9	0.7082	8308.5	25.55	0.7367	.0001104
A01	10	0.6932	9142.5	25.48	0.4978	.0001238
A01	11	0.6912	10244.0	25.46	0.7872	.0001371
A01	12	0.6782	11066.3	25.61	0.4758	.0001506
A01	13	0.6755	12002.9	25.57	0.6359	.0001644
A01	14	0.6585	14514.7	25.16	0.5831	.0001987
A01	15	0.6578	15664.8	25.35	0.6878	.0002145
A01	16	0.6429	20970.5	25.29	0.5372	.0002935
A01	17	0.6361	24453.4	24.94	0.5419	.0003467
A01	18	0.6259	28271.7	25.71	0.5486	.0003998
A01	19	0.6088	35317.1	25.51	0.4898	.0005055
A01	20	0.6027	46216.4	26.16	0.4873	.0006782
A01	21	0.5905	52648.5	25.91	0.4262	.0007856
A01	22	0.5755	58733.3	26.40	0.4147	.0008785
A01	23	0.5748	63584.1	26.40	0.5108	.0009567
A01	24	0.5646	70342.9	25.92	0.4347	.0010638
A01	25	0.5755	77695.6	26.77	0.5053	.0011988
H01	0	0.7721	0.5	26.62		0
H01	1	0.8463	97.0	57.10	0.2585	3.70e-06
H01	2	0.8367	592.0	57.19	0.7206	.0000104
H01	3	0.8272	1096.0	57.25	0.7396	.000017
H01	4	0.8170	1573.0	57.28	0.6901	.0000236
H01	5	0.8068	2079.0	57.29	0.7080	.0000304
H01	6	0.7966	2577.0	57.23	0.7018	.0000369
H01	7	0.7796	5940.0	57.24	0.6468	.000084
H01	8	0.7755	6812.0	57.26	0.6206	.0000974
H01	9	0.7592	7705.0	57.22	0.5896	.0001099
H01	10	0.7476	8989.8	57.24	0.8358	.0001231
H01	11	0.7422	9965.4	57.23	0.6650	.0001364
H01	12	0.7306	10891.0	57.20	0.5760	.0001496
H01	13	0.7252	11886.8	57.22	0.6453	.0001633

Table A-3. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr
H01	14	0.7088	14365.7	57.24	0.5709	.0001975
H01	15	0.7088	15546.2	57.23	0.7226	.0002131
H01	16	0.6918	21097.8	57.27	0.5520	.0002917
H01	17	0.6789	24896.9	57.25	0.5499	.0003444
H01	18	0.6755	28803.4	57.19	0.6114	.0003972
H01	19	0.6585	36059.4	57.20	0.5054	.000502
H01	20	0.6469	47989.9	57.03	0.5190	.0006735
H01	21	0.6422	55355.0	57.26	0.5332	.00078
H01	22	0.6367	61125.4	57.01	0.4864	.0008722
H01	23	0.6265	63280.4	57.11	0.1785	.0009501
H01	24	0.6252	70157.0	57.12	0.5173	.0010563
H01	25	0.6252	79311.1	57.21	0.5030	.0012015
HA01	0	0.7721	0.5	26.62		0
HA01	1	0.8354	101.0	56.73	0.2627	3.74e-06
HA01	2	0.8245	585.0	56.79	0.7098	.0000103
HA01	3	0.8136	1162.0	55.90	0.8550	.0000168
HA01	4	0.8027	1549.0	55.52	0.5649	.0000232
HA01	5	0.7946	2038.0	56.10	0.6791	.0000299
HA01	6	0.7837	2503.0	56.03	0.6577	.0000364
HA01	7	0.7735	5763.0	56.14	0.6434	.0000823
HA01	8	0.7585	6941.8	56.09	0.7753	.0000954
HA01	9	0.7456	7777.4	56.20	0.5696	.0001076
HA01	10	0.7422	8761.1	56.11	0.7052	.0001205
HA01	11	0.7293	9735.5	56.22	0.6067	.0001336
HA01	12	0.7245	10523.5	56.42	0.5430	.0001466
HA01	13	0.7102	11540.3	56.41	0.5783	.00016
HA01	14	0.7088	13734.0	56.75	0.5735	.0001933
HA01	15	0.6932	15172.3	56.80	0.6858	.0002087
HA01	16	0.6830	20566.4	56.68	0.5584	.0002854
HA01	17	0.6755	24154.5	56.98	0.5494	.0003371
HA01	18	0.6667	28096.3	56.77	0.5937	.0003887
HA01	19	0.6551	35128.6	56.57	0.5163	.0004913
HA01	20	0.6415	47193.8	56.65	0.5261	.000659
HA01	21	0.6252	54579.1	56.41	0.4768	.0007631
HA01	22	0.6238	59943.4	56.54	0.4763	.0008535
HA01	23	0.6156	63477.9	56.43	0.3318	.0009295
HA01	24	0.6102	70000.3	56.48	0.4629	.0010334
HA01	25	0.6102	74024.1	56.49	0.2199	.0011917
N01	0	0.7721	0.5	26.62		0
N01	1	0.7762	124.0	26.62	0.3236	3.81e-06

Table A-3. (continued).

Code	Cycle	Pressure (atm)	Hydrogen (ppm)	Temperature (Celsius)	G-value (molecules/ 100 eV)	Watt · yr
N01	2	0.7660	681.7	26.05	0.8214	.0000105
N01	3	0.7599	1223.5	26.76	0.8053	.0000171
N01	4	0.7510	1741.4	26.72	0.7584	.0000237
N01	5	0.7422	2282.4	26.31	0.7570	.0000305
N01	6	0.7327	2805.5	26.03	0.7454	.0000371
N01	7	0.7197	6358.1	25.49	0.7025	.0000839
N01	8	0.7088	7334.3	25.40	0.6520	.0000972
N01	9	0.7088	8264.0	25.60	0.7328	.0001097
N01	10	0.6946	9224.2	25.46	0.6011	.0001228
N01	11	0.6918	10154.0	25.52	0.6642	.0001361
N01	12	0.6776	11073.7	25.55	0.5328	.0001494
N01	13	0.6755	11981.9	25.72	0.6246	.0001631
N01	14	0.6633	14516.3	25.15	0.6225	.000197
N01	15	0.6585	15395.8	25.35	0.4975	.0002126
N01	16	0.6449	20817.0	25.22	0.5613	.0002909
N01	17	0.6415	24578.3	24.95	0.6122	.0003435
N01	18	0.6299	28379.4	25.75	0.5462	.0003961
N01	19	0.6163	35499.4	25.69	0.5174	.0005006
N01	20	0.6082	46238.0	26.04	0.4863	.0006715
N01	21	0.5918	53167.8	26.05	0.4411	.0007777
N01	22	0.5864	59664.5	26.41	0.5326	.0008698
N01	23	0.5755	64601.0	26.38	0.4249	.0009472
N01	24	0.5755	70539.4	25.97	0.4692	.0010531
N01	25	0.5755	73682.5	26.44	0.1786	.0012091

Code = Cylinder identifier (Hxx and HAxx are heated for cycles >4)
Cycle = Sampling cycle for each particular barrel
atm = Pressure in atmospheres
ppm = Concentration in parts per million
G-value = Calculated G-value (molecules/100eV)
Watt · yr = Dose expressed as multiple of dose rate in watts by time in years

A.3 G-value Effects Analysis

For G-value data analysis, data from original test cylinders were selected that exhibited a zero slope over time for different experimental conditions. Regression analyses and testing of the slope coefficient at the 0.05 significance level were performed iteratively for different initial cycle numbers used for the data selection. The iterations and analyses were performed for each experimental condition (e.g., unheated cylinders with polyethylene and ^{239}Pu). Table A-4 presents the selected initial cycle numbers and corresponding Watt · yr Table A-5 summarizes regression analysis results.

The data exhibiting a zero slope over time have different initial original cylinder cycle numbers, depending on experimental condition. The lowest initial cycle numbers associated with the zero slopes are for cement and PVC matrices; these range from 3 to 6 and correspond to Watt · yr from 0.0009 to 0.002. The highest cycle numbers associated with zero slopes are typically PE and include some wet and dry cellulose data sets; the highest associated Watt · yr observed is 0.006.

The effects analysis of MDP experimental results was performed with an ANOVA for cylinders with matrices other than PVC. At the five percent significance level, the analysis showed that matrix has a significant effect on G-value. In addition, two-way interactions involving matrix are also significant. Heating and isotope did not have significant effects. Table A-6 provides analysis results.

For cylinders containing PVC, the effects of isotope and heating are confounded because of restrictions on original design. Therefore, data for these cylinders were tested in two sets against all other matrices with the corresponding characteristics. G-values for PVC were found to be significantly lower than those for other matrices at the five percent level using a Student's **t** test.

Because matrix is the only significant main effect, data were combined over isotope and heating conditions to generate statistics by matrix. Ninety-five percent upper confidence limits (UCL_{95}) and associated statistics for the mean G-value for each matrix tested are given in A-7. The UCL_{95}s range from 0.48 molecule per 100 eV for wet cellulose, to 0.17 molecule per 100 eV for PVC.

Table A-4. Initial cycle numbers and corresponding Watt · yr for experimental conditions.

Experimental condition	Initial cycle number	Watt · yr
Heated cylinders with cement and ^{238}Pu	6	.002
Heated cylinders with cement and ^{239}Pu	6	.002
Heated cylinders with dry cellulose and ^{238}Pu	12	.004
Heated cylinders with dry cellulose and ^{239}Pu	30	.006
Heated cylinders with PE and ^{238}Pu	19	.005
Heated cylinders with PE and ^{239}Pu	18	.004
Heated cylinders with PVC and ^{239}Pu	6	.002
Heated cylinders with wet cellulose and ^{238}Pu	6	.002
Heated cylinders with wet cellulose and ^{239}Pu	6	.002
Unheated cylinders with cement and ^{238}Pu	4	.002
Unheated cylinders with cement and ^{239}Pu	3	.001
Unheated cylinders with dry cellulose and ^{238}Pu	10	.003
Unheated cylinders with dry cellulose and ^{239}Pu	4	.002
Unheated cylinders with PE and ^{238}Pu	17	.005
Unheated cylinders with PE and ^{239}Pu	32	.006
Unheated cylinders with PVC and ^{238}Pu	4	.002
Unheated cylinders with wet cellulose and ^{238}Pu	19	.005
Unheated cylinders with wet cellulose and ^{239}Pu	12	.003

Table A-5. Regression analysis results for selected data.

Experimental condition	Number of observation	Independent variable	Coefficient	Standard error	t	P>|t|	95% Confidence interval	
Heated cylinders with cement and ^{238}Pu	44	time	.0000631	.000307	0.205	0.838	-.0005566	.0006827
		cons	.2389554	.1048567	2.279	0.028	.027346	.4505648
Heated cylinders with cement and ^{239}Pu	38	time	-.0001555	.0001337	-1.163	0.253	-.0004267	.0001157
		cons	.3178316	.0451775	7.035	0.000	.2262074	.4094559
Heated cylinders with dry cellulose and Pu-238	76	time	-.0002544	.0001292	-1.969	0.053	-.0005118	3.00e-06
		cons	.4073895	.0582511	6.994	0.000	.2913218	.5234573
Heated cylinders with dry cellulose and Pu-239	21	time	-.0001322	.000088	-1.502	0.149	-.0003164	.000052
		cons	.2526285	.0595368	4.243	0.000	.1280164	.3772405
Heated cylinders with PE and Pu-238	67	time	-.0003055	.0001909	-1.600	0.114	-.0006867	.0000757
		cons	.3404505	.099344	3.427	0.001	.1420469	.5388542
Heated cylinders with PE and Pu-239	43	time	-.0003238	.0001634	-1.981	0.054	-.0006538	6.27e-06
		cons	.3898543	.0829314	4.701	0.000	.2223709	.5573377
Heated cylinders with PVC and Pu-239	41	time	-.0003711	.0003025	-1.227	0.227	-.0009829	.0002408
		cons	.2800059	.1016631	2.754	0.009	.074373	.4856389
Heated cylinders with wet cellulose and Pu-238	72	time	-.0001276	.0002699	-0.473	0.638	-.0006658	.0004106
		cons	.4874099	.0970356	5.023	0.000	.2938786	.6809412
Heated cylinders with wet cellulose and Pu-239	83	time	-.0001271	.0002821	-0.450	0.654	-.0006884	.0004342
		cons	.5689011	.108461	5.245	0.000	.3530978	.7847044
Unheated cylinders with cement and ^{238}Pu	61	time	-.0000236	.0000564	-0.418	0.677	-.0001364	.0000892
		cons	.2096381	.020818	10.070	0.000	.1679814	.2512948
Unheated cylinders with cement and ^{239}Pu	59	time	-.0001173	.0000749	-1.567	0.123	-.0002673	.0000326
		cons	.3094579	.0242508	12.761	0.000	.2608965	.3580192
Unheated cylinders with dry cellulose and ^{238}Pu	88	time	-.0001938	.0001034	-1.874	0.064	-.0003995	.0000118
		cons	.3908673	.0441134	8.861	0.000	.3031727	.4785619
Unheated cylinders with dry cellulose and ^{239}Pu	117	time	-.0001341	.0000827	-1.621	0.108	-.000298	.0000297
		cons	.2753201	.0304485	9.042	0.000	.2150074	.3356328

Table A-5. (continued).

Experimental condition	Number of observation	Independent variable	Coefficient	Standard error	t	P>|t|	95% Confidence interval	
Unheated cylinders with PE and ^{238}Pu	60	time	-.0003278	.0001707	-1.921	0.060	-.0006694	.0000138
		cons	.4186594	.0848914	4.932	0.000	.2487309	.588588
Unheated cylinders with PE and ^{239}Pu	16	time	-.0002572	.000159	-1.618	0.128	-.0005982	.0000838
		cons	.4049732	.1089378	3.717	0.002	.1713249	.6386216
Unheated cylinders with PVC and ^{238}Pu	58	time	-.0001083	.0000557	-1.945	0.057	-.00022	3.27e-06
		cons	.1507466	.0216038	6.978	0.000	.1074689	.1940243
Unheated cylinders with wet cellulose and ^{238}Pu	41	time	-.0002893	.0001594	-1.815	0.077	-.0006117	.0000331
		cons	.4064097	.0817387	4.972	0.000	.2410776	.5717419
Unheated cylinders with wet cellulose and ^{239}Pu	80	time	-.0003532	.0001849	-1.911	0.060	-.0007212	.0000148
		cons	.5879962	.0785679	7.484	0.000	.4315796	.7444129

Table A-6. ANOVA results.

Source	Partial SS	Degrees of freedom	MS	F (variance ratio)	Prob>F
Model	10.1723188	12	.847693237	13.82	0.0000
iso2	.10818072	1	.10818072	1.76	0.1844
condit2	.025149739	1	.025149739	0.41	0.5221
matrix2	5.50409022	3	1.83469674	29.92	0.0000
iso2 · condit2	.115618597	1	.115618597	1.89	0.1701
iso2 · matrix2	1.75542469	3	.585141565	9.54	0.0000
condit2 · matrix2	1.13817422	3	.379391405	6.19	0.0004
Residual	58.4449896	953	.061327376		
Total	68.6173084	965	.071106019		

Number of observations = 966
R = Multiple correlation coefficient
R-squared = 0.1482
Root MSE = .247644
Adjusted R-squared = 0.1375

A.4 G-value Plots

Figures A-1 through A-9 show plots of G-values calculated from data from unheated original test cylinders versus Watt · yr since loading. Figures A-10 through A-18 show plots of data from heated original test cylinders ver time since loading. Figure A-19 shows plots of the four restart test cylinders. All plots exclude outliers and cylinders with no recent acceptable data.

A.5 Quality Control Data

A.5.1 Gas Chromatograph Quality Control

To ensure the accuracy of the analytical data for hydrogen gas throughout the matrix depletion experiment, four samples of reference standard hydrogen gas were analyzed before each sampling run. There were four cylinders of reference gas, each one being assigned an identification number based on the experimental group to which it belonged. The four reference gas cylinders were identified as follows:

A01: Agitated
H01: Heated
HA01:Heated and agitated
N01: Neither

The quality assurance objective (QAO) for these quality control (QC) samples is based on the percent recovery (%R) as compared to the known concentration of 5050 ppm. For the analytical data for the QC samples and experimental samples within a sampling run to be acceptable, the %R must be within " 10%. The experiment was set up such that a sampling run would be performed only if the QC samples met the established QAO. This inherent QC check prevented sampling runs of questionable quality from occurring.

All data points for the reference gases are within the QAO of 90-110 %R. The %R ranges from a low of 90.91% to a high of 106.38%, with a mean of 96%. The QC hydrogen data have a mean of 4861 ppm and a standard deviation of 160 ppm, indicating a measurement error of only 3.3%. These numbers demonstrate that the experimental samples were analyzed under quality conditions. Therefore, the resulting analytical data can be applied with high confidence for accuracy.

Blank samples were run after each experimental or QC sample to ensure there was no residue of sample remaining in the GC column. Continuation of the sampling run after the blank analysis indicated that the blank sample met the QAO of < 3 x MDLs for the target gases. This demonstrates that the analytical results for the experimental samples were not artificially high; thus providing high confidence for accuracy.

Each experimental or QC sample was analyzed in triplicate on the GC. The autosampler drew a specified volume from each cylinder, injecting it in three aliquots into the GC, resulting in three separate analytical runs for each sample. This provides replicate analytical data for each sample, allowing precision to be measured. Precision for replicate analyses is measured using %RSD. The MDP QAO for %RSD is ± 10%. Each set of analytical data met this QAO; therefore, the results from the third aliquot for each sample were recorded. Based on this, the precision of the analytical data can be accepted with high confidence.

A.5.2 Mass Spectrometer Comparability Results

As an additional QC check for comparability, samples were randomly collected and analyzed using a mass spectrometer (MS). The samples were analyzed in batches and the calibration of the MS was checked before each batch. A batch was analyzed only after the calibration results met all applicable criteria. This ensures that the analytical data for the comparative samples are accurate.

The QAO for comparability (i.e., precision) for analytical data from two different instruments is based on the relative percent difference (RPD) and is ± 25%. Of the 98 samples taken for comparative analysis by the MS, 85 samples (87%) met the RPD QAO. Of the 13 samples that did not meet the QAO, 11 were contaminated by oxygen in the sample bottle, probably due to a leak in the seal. This is evidenced by the indication of oxygen in the mass spectra for these samples. One of the samples was misidentified as sample A03, cycle 4. Based on the log book for the MS samples, the correct identification is H03, cycle 4. With this correction, the resulting RPD meets the QAO. The final sample did not meet the QAO due to water vapor in the sample bottle, as evidenced by the mass spectrum. Correction for the water vapor resulted in the RPD meeting the QAO. Therefore, the precision of the analytical data for the MDP can be trusted with confidence.

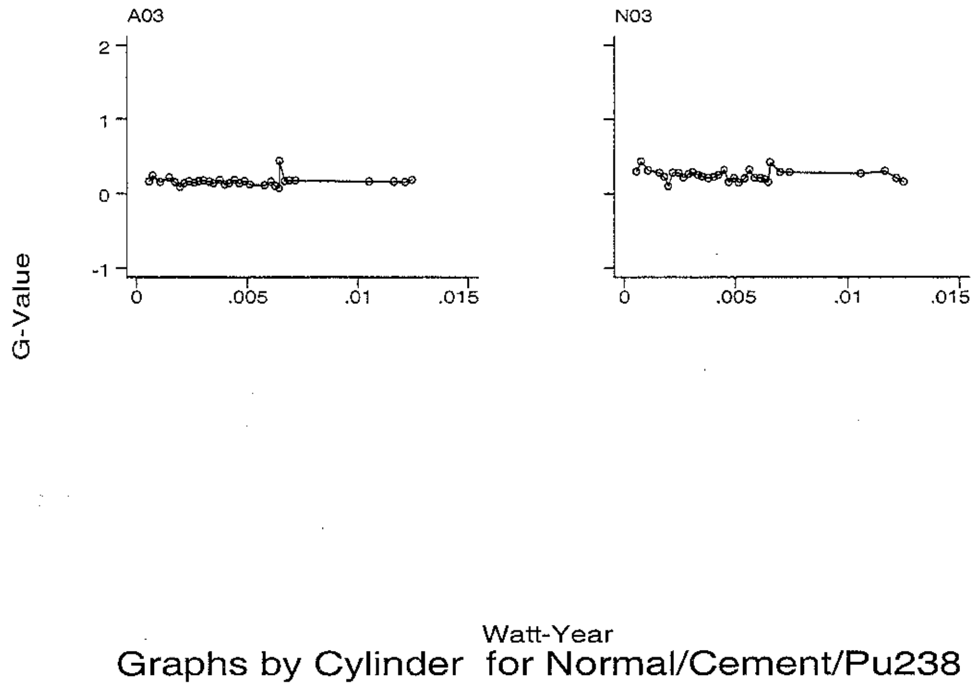


Figure A-1. G-value (molecules/100 eV) behavior over Watt · yr since cylinder loading for unheated cylinders containing cement and ^{238}Pu. Cylinder identifiers are given in the upper left of plots.

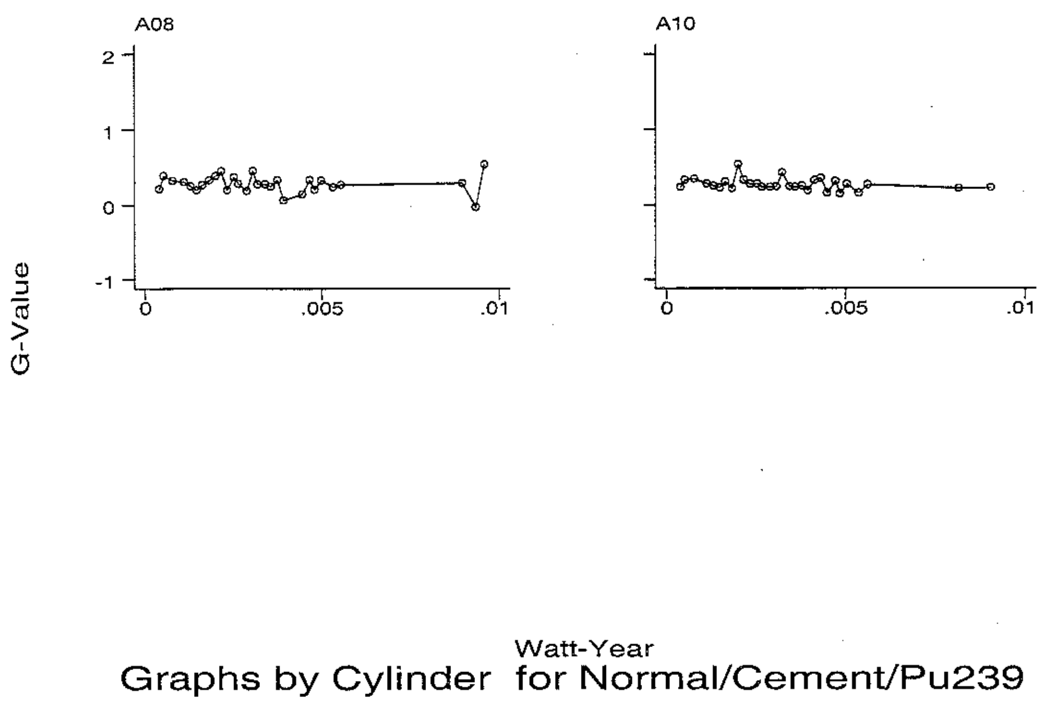


Figure A-2. G-value (molecules/100 eV) behavior over Watt · yr since cylinder loading for unheated cylinders containing cement and ^{239}Pu. Cylinder identifiers are given in the upper left of plots.

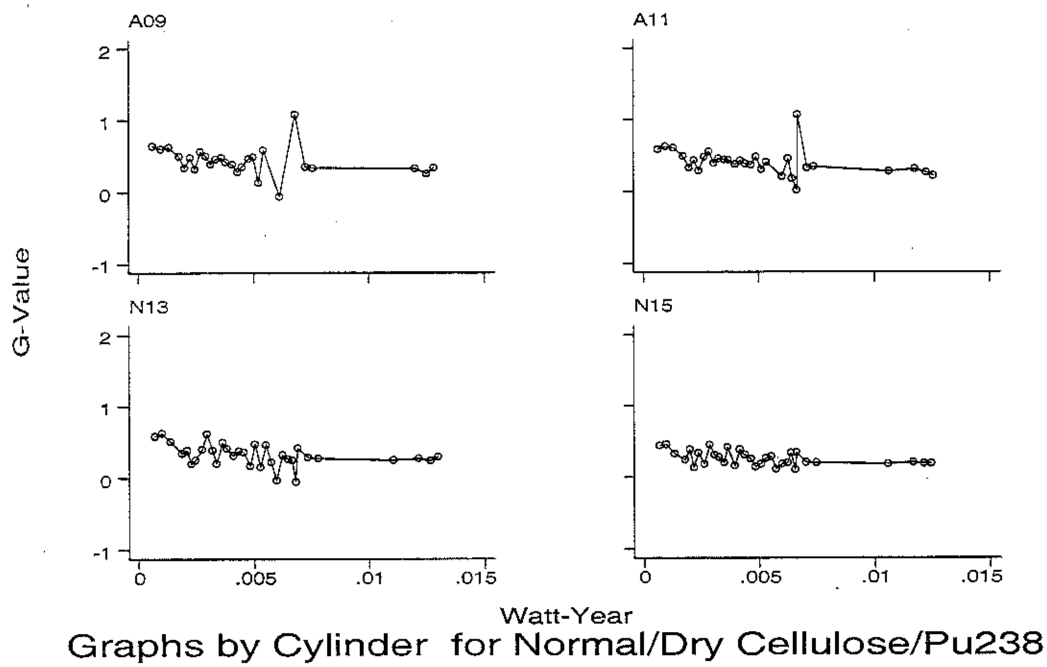


Figure A-3. G-value (molecules/100 eV) behavior over Watt · yr since cylinder loading for unheated cylinders containing dry cellulose and ^{238}Pu. Cylinder identifiers are given in the upper left of plots.

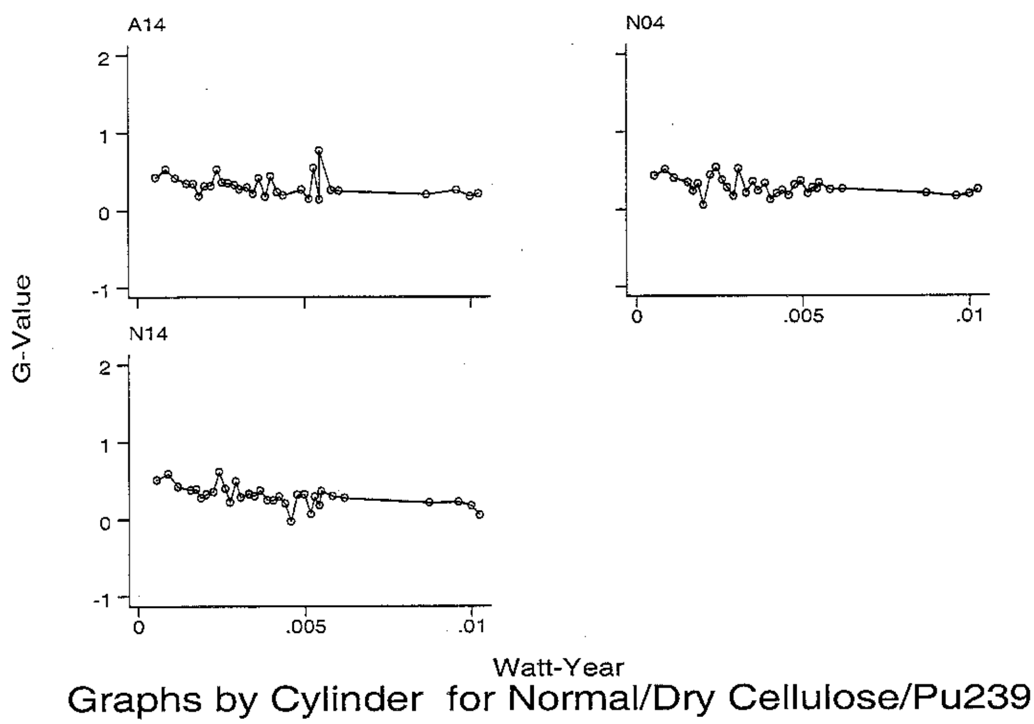


Figure A-4. G-value (molecules/100 eV) behavior over Watt · yr since cylinder loading for unheated cylinders containing dry cellulose and ^{239}Pu. Cylinder identifiers are given in the upper left of plots.

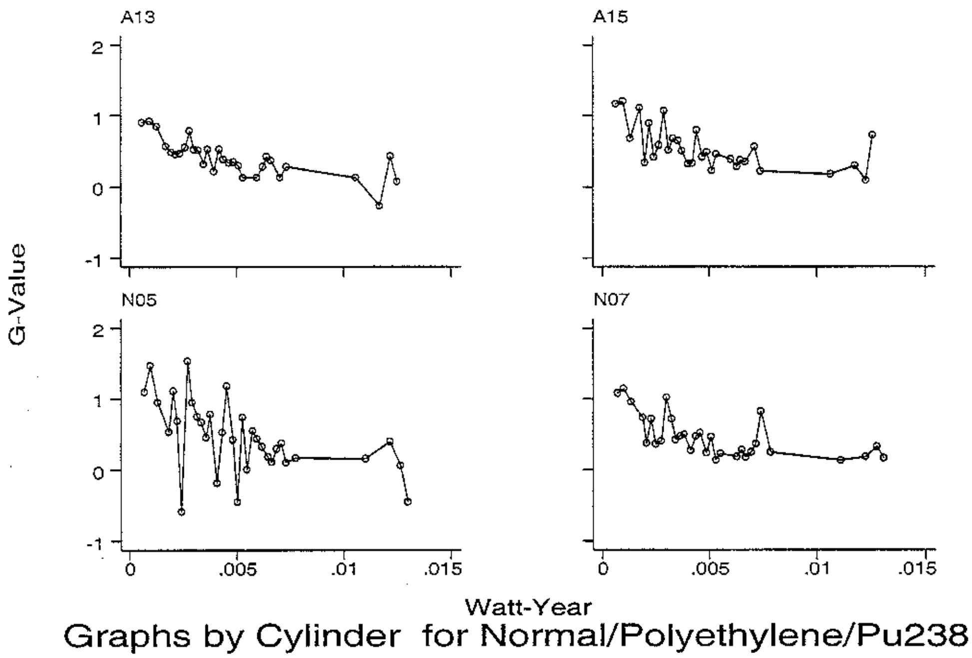


Figure A-5. G-value (molecules/100 eV) behavior over Watt · yr since cylinder loading for unheated cylinders containing polyethylene and ^{238}Pu. Cylinder identifiers are given in the upper left of plots.

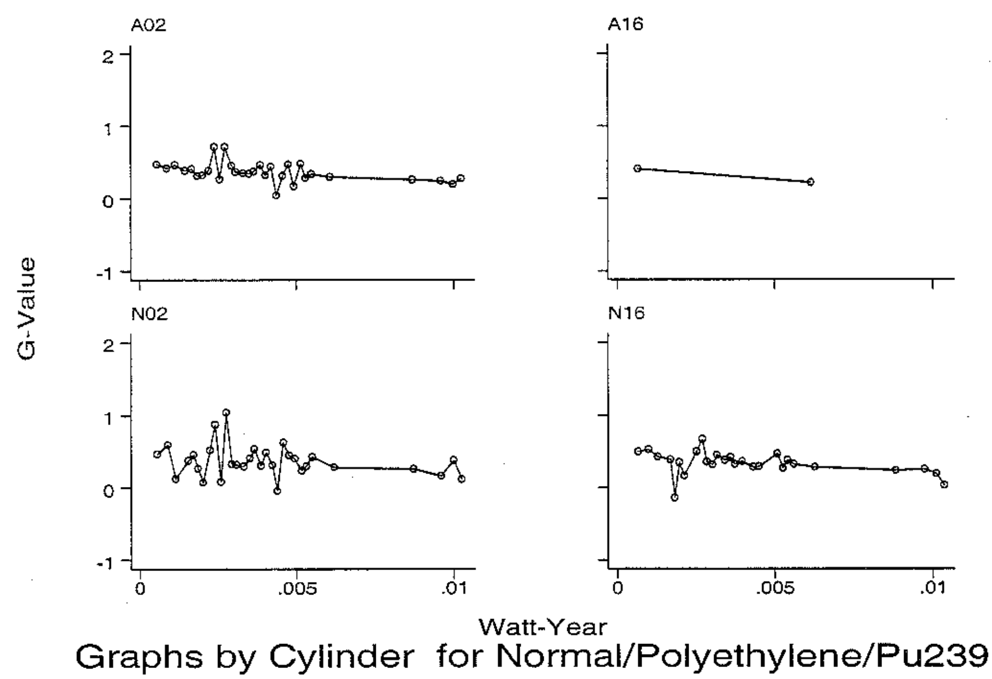


Figure A-6. G-value (molecules/100 eV) behavior over Watt · yr since cylinder loading for unheated cylinders containing polyethylene and ^{239}Pu. Cylinder identifiers are given in the upper left of plots.

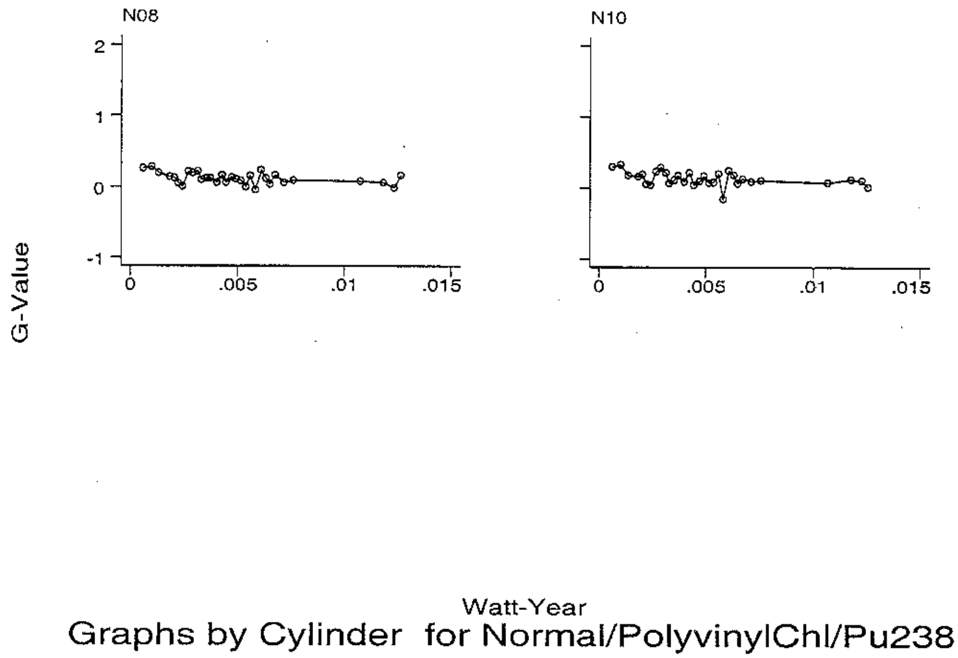


Figure A-7. G-value (molecules/100 eV) behavior over Watt · yr since cylinder loading for unheated cylinders containing PVC and ^{238}Pu. Cylinder identifiers are given in the upper left of plots.

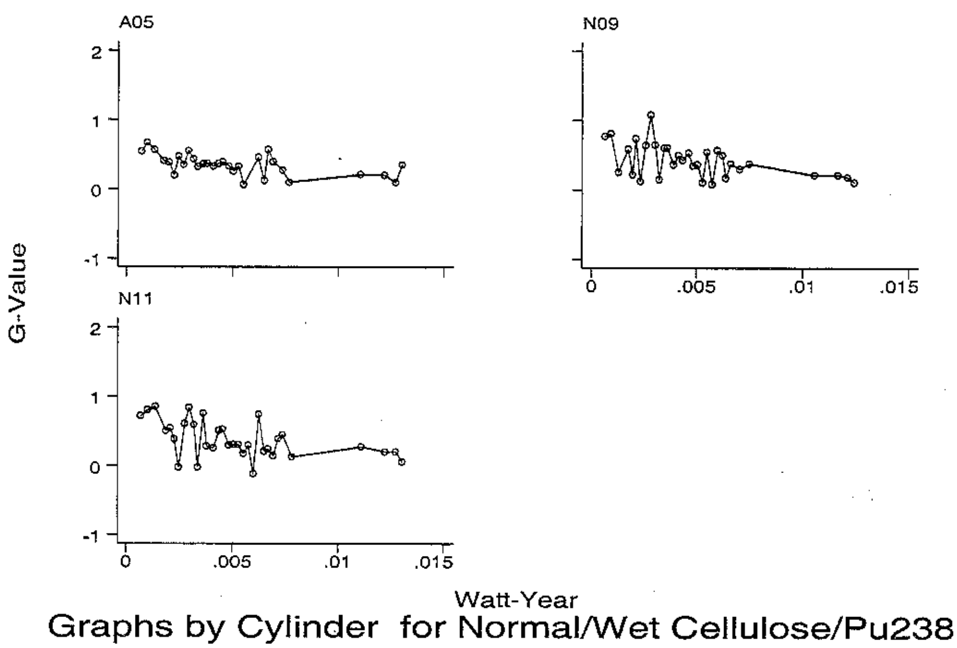


Figure A-8. G-value (molecules/100 eV) behavior over Watt · yr since cylinder loading for unheated cylinders containing wet cellulose and ^{238}Pu. Cylinder identifiers are given in the upper left of plots.

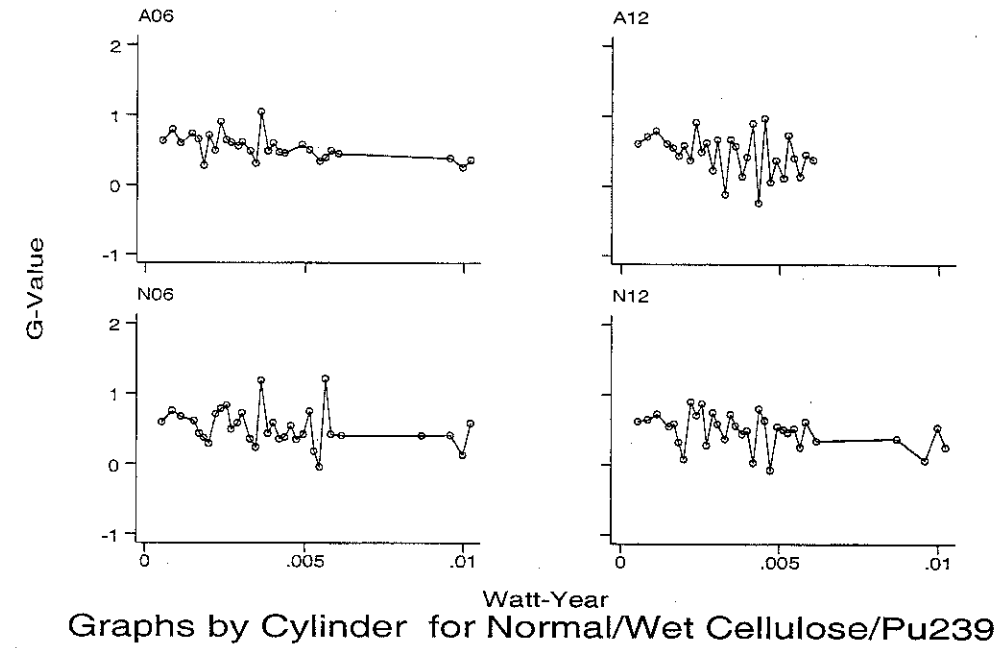
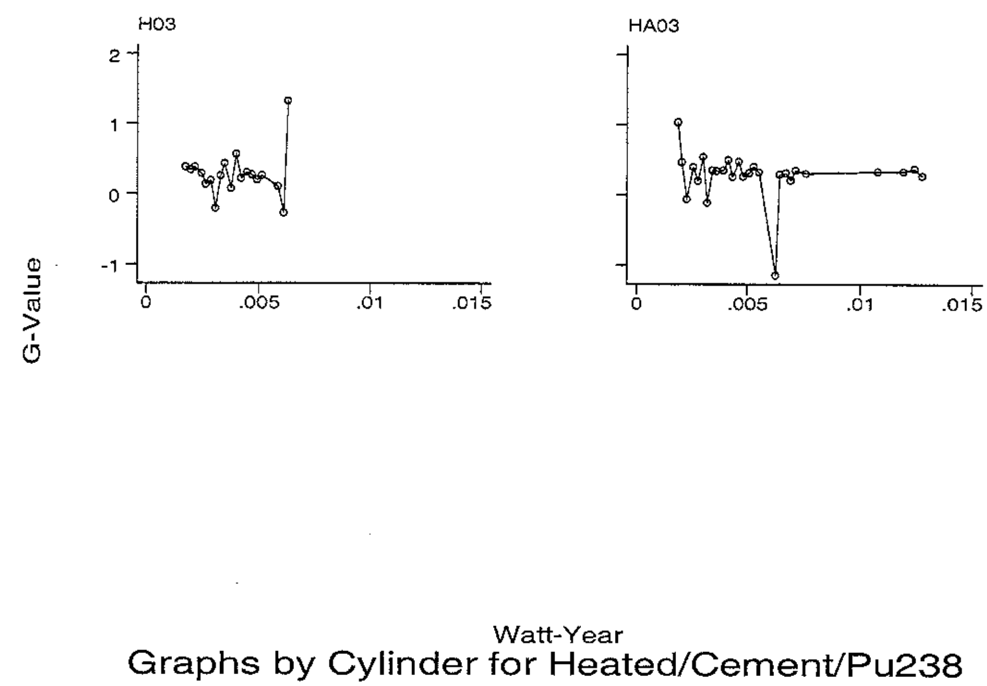


Figure A-9. G-value (molecules/100 eV) behavior over Watt · yr since cylinder loading for unheated cylinders containing wet cellulose and ^{239}Pu. Cylinder identifiers are given in the upper left of plots.

Figure A-10. G-value (molecules/100 eV) behavior over Watt · yr since cylinder loading for heated



cylinders containing cement and ^{238}Pu. Cylinder identifiers are given in the upper left of plots.

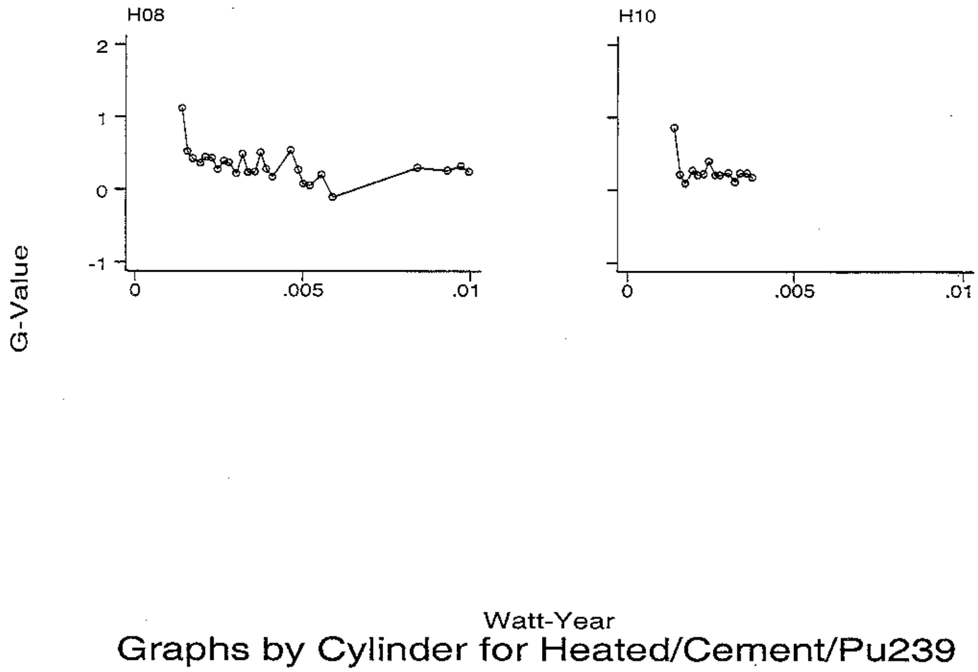


Figure A-11. G-value (molecules/100 eV) behavior over Watt · yr since cylinder loading for heated cylinders containing cement and ^{239}Pu. Cylinder identifiers are given in the upper left of plots.

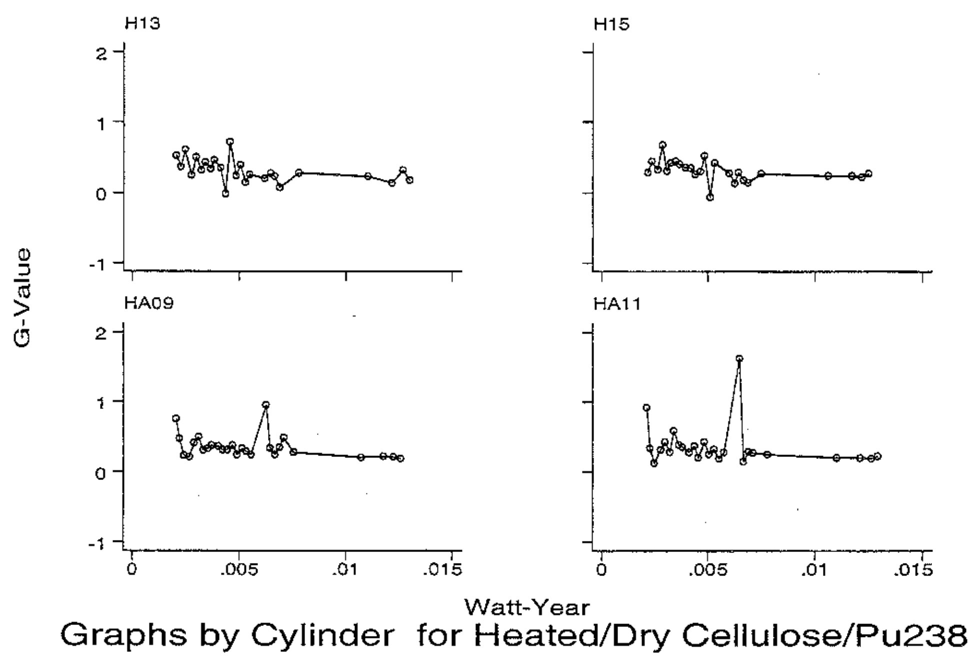


Figure A-12. G-value (molecules/100 eV) behavior over Watt · yr since cylinder loading for heated cylinders containing dry cellulose and ^{238}Pu. Cylinder identifiers are given in the upper left of plots.

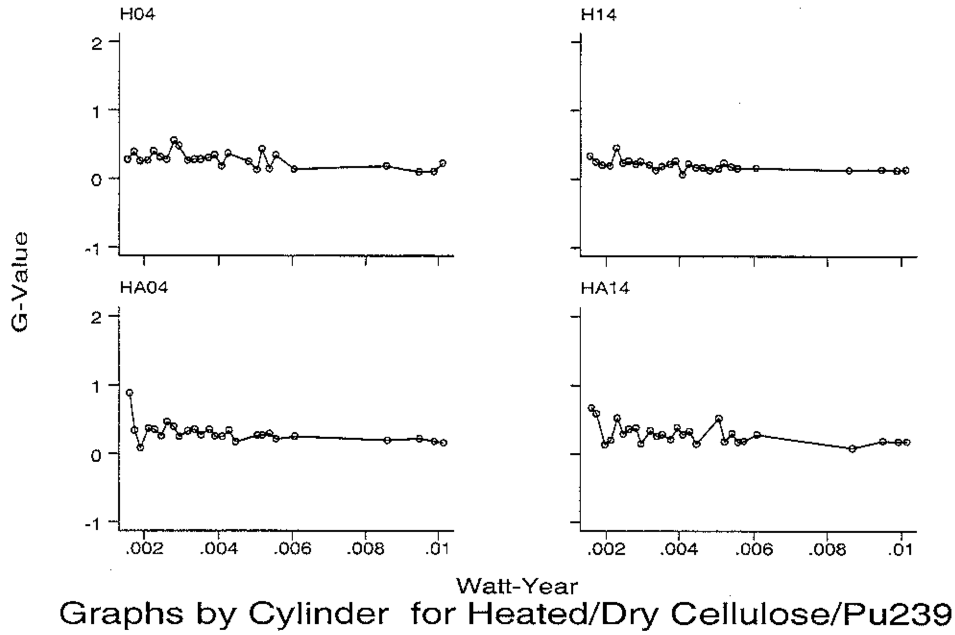


Figure A-13. G-value (molecules/100 eV) behavior over Watt · yr since cylinder loading for heated cylinders containing dry cellulose and ^{239}Pu. Cylinder identifiers are given in the upper left of plots.

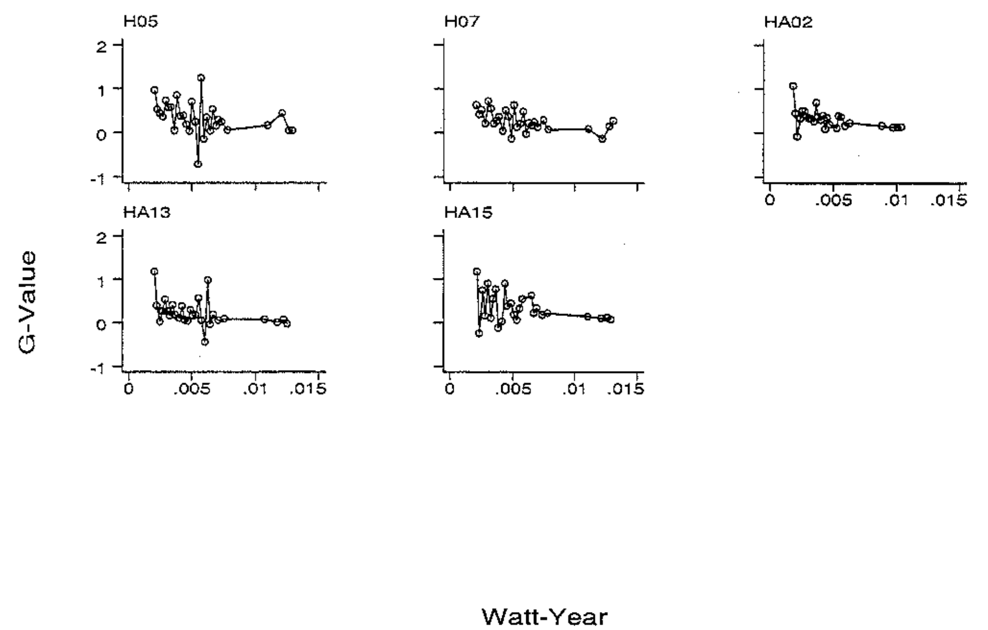


Figure A-14. G-value (molecules/100 eV) behavior over Watt · yr since cylinder loading for heated cylinders containing polyethylene and ^{238}Pu. Cylinder identifiers are given in the upper left of plots.

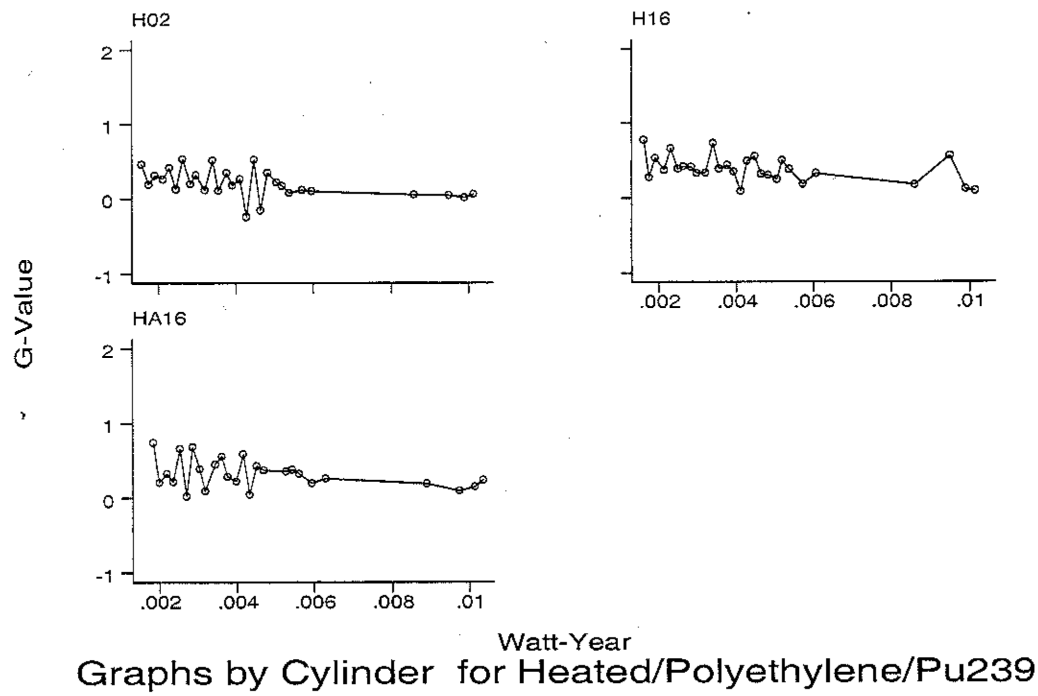


Figure A-15. G-value (molecules/100 eV) behavior over Watt · yr since cylinder loading for heated cylinders containing polyethylene and ^{239}Pu. Cylinder identifiers are given in the upper left of plots.

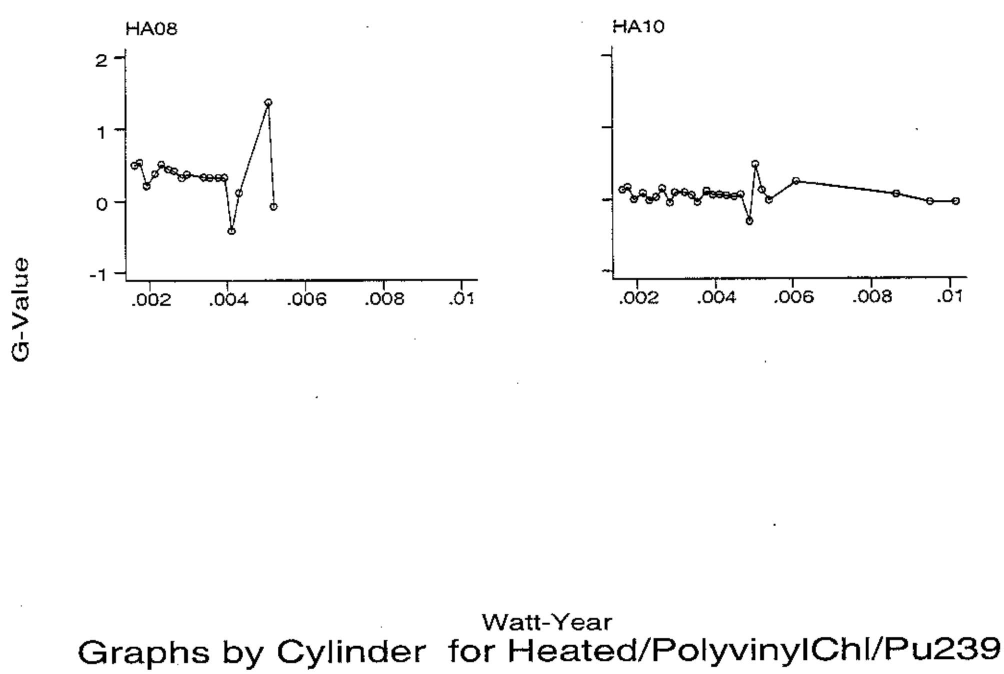


Figure A-16. G-value (molecules/100 eV) behavior over Watt · yr since cylinder loading for heated cylinders containing PVC and ^{239}Pu. Cylinder identifiers are given in the upper left of plots.

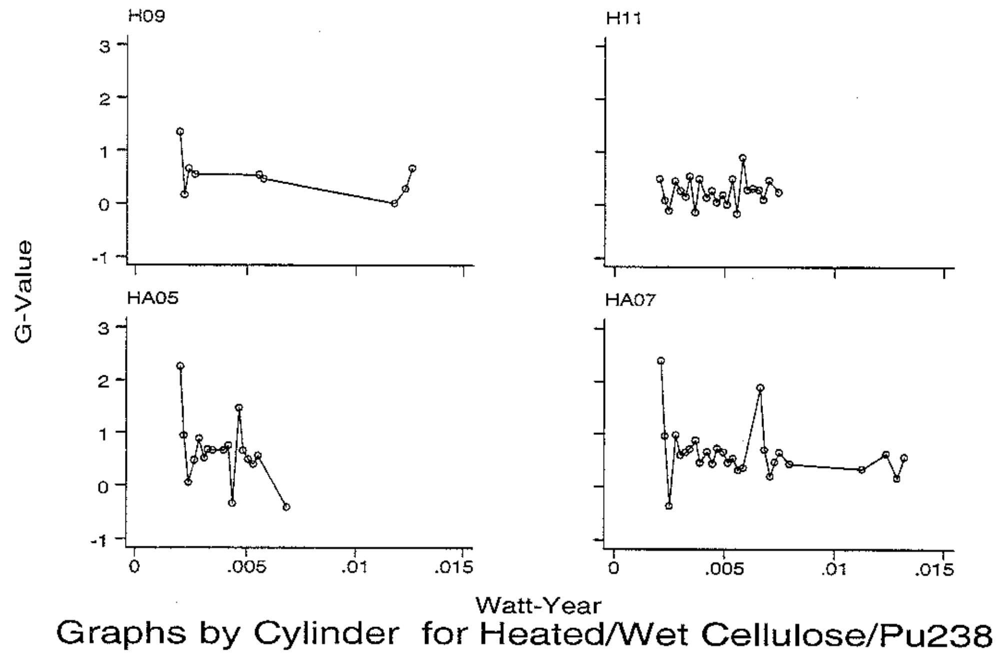


Figure A-17. G-value (molecules/100 eV) behavior over Watt · yr since cylinder loading for heated cylinders containing wet cellulose and ^{238}Pu. Cylinder identifiers are given in the upper left of plots.

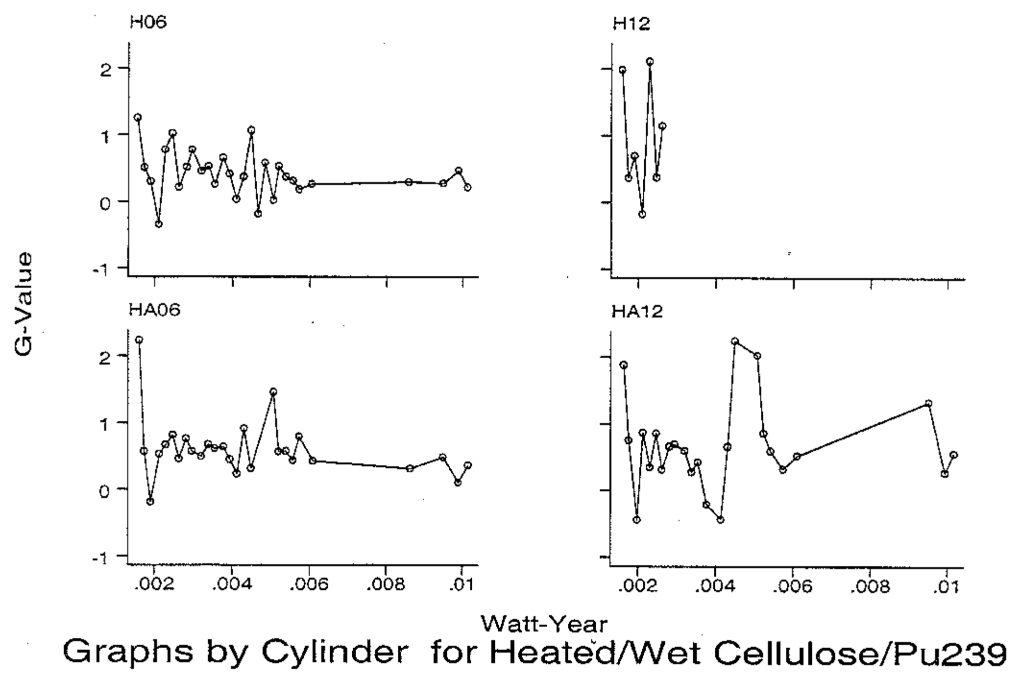


Figure A-18. G-value (molecules/100 eV) behavior over Watt · yr since cylinder loading for heated cylinders containing wet cellulose and ^{239}Pu. Cylinder identifiers are given in the upper left of plots.

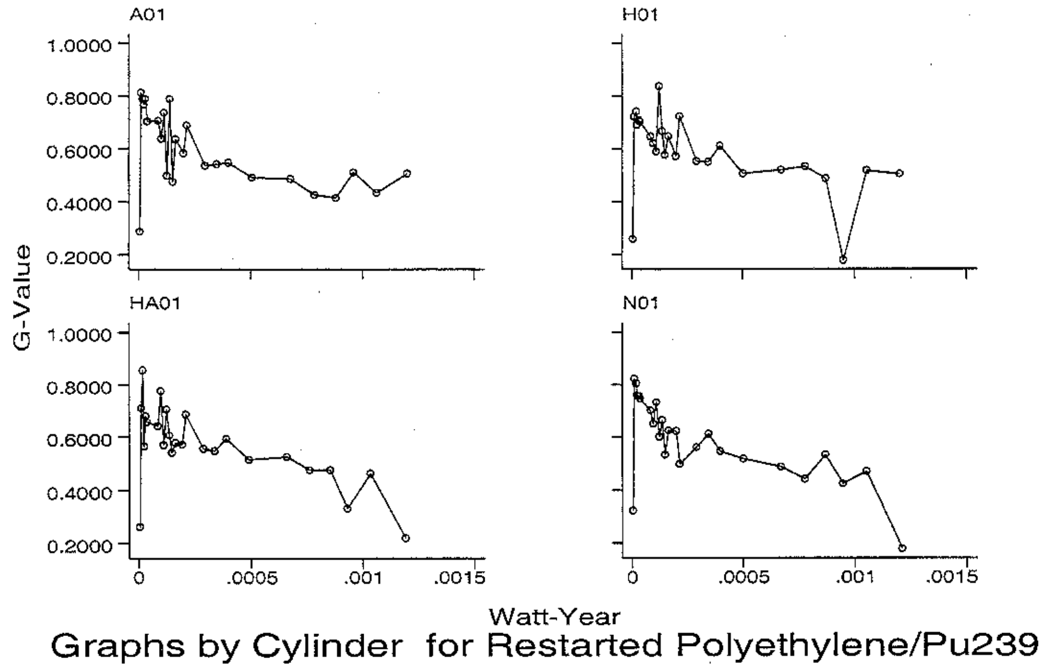


Figure A-19. G-value (molecules/100 eV) behavior over Watt · yr since cylinder loading for restarted cylinders containing polyethylene and ^{239}Pu. Cylinder identifiers are given in the upper left of plots.

Appendix B

TARMATDEP Model Description And Validation Results

B.1 TARMATDEP Code Information

Software Name: TARMATDEP

Category: FORTRAN Code Numerical Simulator - Alpha Radiation Transport through Source and Target Media

Revision Number: 1

Date Last Revised: July 1, 1998

Descriptive Summary: The need for a theoretical program to simulate the real-life phenomenon of matrix depletion arose early on in the course of the MDP efforts. To that end, the TARMATDEP program was developed, using the theory of radiation transport and first-principles of particle collisions. TARMATDEP is a one-dimensional (r-geometry) time-dependent particle transport code that tracks alpha radiation propagation through a source and target material, and determines the effects of alpha collisions with target molecules. Based on user-input dimensions and initial energies, TARMATDEP determines the alpha energy loss profile in two PuO_2 source materials: (1) "Pu-238" and (2) "Pu-239", as well as in five candidate target materials, simulating the contents of TRU waste: (1) polyethylene (PE), (2) poly vinyl chloride (PVC), (3) dry cellulose, (4) wet cellulose, and (5) cement.

Using the alpha energy loss profile, the program calculates the following time-varying parameters in the target materials: (1) instantaneous number of hydrogen bonds broken, (2) running sum of hydrogen bonds broken, and (3) effective G-value. The main parameter of interest, the effective G-value, is provided by TARMATDEP as a function of both time (in sec) as well as dose (in either eV or Watt · yr, depending on user preference). The calculated G-value as a function of time or dose can then be compared to experimental G-values to validate the code, or to other calculated G-values to illustrate the dependence of matrix depletion on various material or geometry parameters.

Related Programs: The program is comprised of the main routine TARMATDEP, the free-format ASCII input file TARMATDEP.INP, and the following ten output files: (1) RADII.DAT, (2) ENERGIES.DAT, (3) ATOMICS.DAT, (4) EDEPOSIT.DAT, (5) H_BONDS.DAT, (6) SUMH_BONDS.DAT, (7) GVALUES.DAT, (8) PROBABLE.DAT, (9) GVALSONLY.DAT, and (10) TARMATDEP.OUT.

Operational Demands: The program currently executes on the Benchmark DEC Alpha workstation. However, since the program is written in standard FORTRAN 77 programming language, the source code can be ported to any platform supporting a FORTRAN 77 compiler, and the executable file re-compiled for the given platform.

Classification: Limited Distribution, developed as part of a government contract, unclassified.

Status: Operational, with ongoing upgrades and/or code maintenance.

Origin/source: Developed by Benchmark Environmental Corporation, 4501 Indian School Road NE, Suite 105, Albuquerque, NM 87110 for the Lockheed Idaho Technologies Company under Subcontract No. C90-132787.

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Documentation/References:

Software Users Manual - TARMATDEP (Rev. 1) - User's Manual, Benchmark Environmental Corporation, Albuquerque, NM (under development).

Software Configuration Log - Software Configuration Log for TARMATDEP (under development).

B.2 Description of the TARMATDEP Model

The TARMATDEP program was developed to theoretically analyze hydrogen gas generation in TRU waste. It tracks alpha radiation propagation through a source and target material and determines the effects on target molecules. The basic radiation transport equation used in TARMATDEP is the linear energy attenuation correlation for alpha particles, which states the amount of energy that an alpha particle of representative initial energy (in MeV) loses by traversing a fixed length of material (in cm). The linear energy attenuation correlation is calculated separately for each material through which the alpha particle travels, and is dependent on the physical properties of the material in question. For example, the attenuation correlation for typical alpha source materials such as $^{238}PuO_2$ and $^{239}PuO_2$ is 3,010.3 MeV/cm and 2,865.0 MeV/cm, respectively, while for typical target materials such as polyethylene or cellulose, the attenuation correlation is approximately 886.65 MeV/cm and 36.35 MeV/cm, respectively.

Using the attenuation data for both the source and target materials, as well as material and geometry properties, TARMATDEP tracks the alpha particles from "birth" in the middle of the source PuO_2 particle to their "death" somewhere inside the target matrix. For those cases where the alpha particles traverse the entire thickness of the target matrix, but yet still carry some energy (such as in cellulose, for example, where the linear energy attenuation is very small), TARMATDEP determines the total energy deposition within the matrix and then "kills off" the particles once they emerge out the other side of the target matrix.

B.2.1 Radiation Chemistry Theory

TARMATDEP assumes a homogeneous PuO_2 source particle and a homogeneous target matrix of specified composition. Basic radiochemistry data on five representative target matrices—PE, PVC, dry and wet cellulose, and cement—such as linear energy attenuation, atomic composition, density, nature and number of various chemical bonds, and average bond breakage energy, is provided as part of the free-format input file, and is processed by the program. Using the provided radiochemistry data, TARMATDEP determines the number of target molecules in the path of each alpha emitted from the PuO_2 source particle. Once an alpha is "born" in the PuO_2 particle and enters the target matrix, an "interaction probability" function is applied to the alpha to determine how many collisions with target molecules the alpha in question will have within each geometry node. The interaction probability function decreases with time and with the total number of collisions—i.e., it is proportional to the running sum of collisions over the total number of target molecules present in the path of the alpha.

For every alpha interaction with a target molecule, a "bond breakage probability" function is applied to the alpha to determine how many hydrogen bonds will be broken as a result of the interaction. The program allows the user to specify a desired hydrogen bond breakage probability. For the purposes of the MDP analyses discussed in this report, the majority of executions of TARMATDEP were conducted to model matrix depletion effects on PE, for which a hydrogen bond breakage probability of 0.2 was used (based on results of radiochemistry work as part of the nuclear rocket program in the 1950's.). For all other target matrix materials, naturally, different hydrogen bond breakage probabilities will need to be used. The actual bond breakage probability is a complex function of the atomic composition of the molecule, the nature and number of various chemical bonds comprising the molecule, and the associated bond breakage energies. For a molecule characterized by predominantly hydrogen bonds, the probability will be greater than that for molecules wherein hydrogen bonds comprise only a small portion of the total number of atomic bonds.

For each geometry node within the target matrix, TARMATDEP tracks the total number of hydrogen bonds broken, and writes it into the "SumH_bonds.dat" file for easy user access. For simplicity, TARMATDEP assumes that one hydrogen gas molecule (H_2) is created for every two hydrogen atoms that are created (i.e., for every two hydrogen bonds that are broken). For additional simplicity, TARMATDEP also assumes that the newly-created H_2 molecule instantaneously diffuses through the target matrix and relocates itself into the ambient space around the matrix—thus contributing to the flammability level of hydrogen in the ambient space.

Based on the number of hydrogen bonds broken, the number of hydrogen atoms created, as well as the number of H_2 molecules created, TARMATDEP determines the corresponding G-value for each geometry node. Since TARMATDEP relies on a straight definition of G-value (number of H_2 molecules created per 100 eV of energy), it is possible within the program to calculate both "absolute" G-values—as a function of total alpha energy emitted—as well as "effective" G-values—as a function of alpha energy deposited in the target matrix. Since all matrix depletion-related studies to date have relied on the effective definition of G-value, all TARMATDEP-related work has, in the interests of consistency, been done using that particular definition.

Once a given alpha has been tracked through the target matrix to the point where it "dies" (i.e., loses all its energy), the program sums up all the discrete nodal G-values to arrive at a total G-value for a particular moment in time. The total G-values are then written into the "Gvalues.dat" and "Gvalsonly.dat" files for easy user access.

B.2.2 Input/Output Description

In its current form, TARMATDEP is fully parametrized, i.e. allows user modification of all pertinent input data. The parametrization is facilitated by the use of a free-format, ASCII input file called "tarmatdep.inp." The input file contains the entire set of source and target material physical properties, as well as geometry specifications.

The program allows for user specification of both the total duration of modeling, as well as the time interval between recording of the calculated data. Thus, for example, the user can specify two years as the total duration of modeling, and then request that calculated data at the end of every month be written to file. Or, alternatively, the duration of the modeling can be set, for example, at 2.5 days, with a recording interval of 29 minutes; TARMATDEP recognizes any combination of real number and the alphanumerics "secs", "mins", "hours", "days", "weeks", "mos", and "years."

As part of recording the calculated data, the program creates up to 10 (ten) files per execution. The files are: (1) "radii.dat", a listing of the outer and node radii, and node volumes, of the model, (2) "energies.dat", a listing of the alpha energy decrease through the source and target material, (3) "atomics.dat", a listing of the total number of source and target material molecules within a given node, (4) "edeposit.dat", a listing of the incremental alpha energy deposition in each node, (5) "H_bonds.dat", a listing of the instantaneous number of hydrogen bonds broken within a given node, (6) "SumH_bonds.dat", a listing of the running sum of hydrogen bonds broken within a given node, (7) "Gvalues.dat", a listing of the absolute G-values within a given node, as well as a cumulative G-value for each time print interval, (8) "Probable.dat", a listing of the time-decreasing probability of availability of intact hydrogen bonds for breaking by radiolysis, within a given node, (9) "Gvalsonly.dat", a summary of only cumulative G-values, for each time print interval, and (10) "Tarmatdep.out", a TARMATDEP-generated output file that is essentially a reprint of the input data and is useful in debugging (i.e., determining exactly how TARMATDEP interpreted the input data given it). Files "radii.dat", "energies.dat", "atomics.dat", "edeposit.dat", "Probable.dat", and "Tarmatdep.out" are primarily useful for debugging and verification purposes. The key files are "H_bonds.dat", "SumH_bonds.dat", "Gvalues.dat", and "Gvalsonly.dat", as they provide answers to the question of time-dependent hydrogen generation by radiolysis in TRU waste.

Each and every one of the eight output files can be activated or suppressed for a given execution of TARMATDEP. Generally, to save time, it is advisable to limit output to the most important files, namely "Gvalues.dat" and "Gvalsonly.dat".

B.2.3 Execution Length

The duration of executions of TARMATDEP is greatly dependent on the complexity of the geometry (i.e., the number of nodes in the source and the target), the total duration of simulation (which can range from minutes to thousands of years), and the size of the calculation step (depending on the desired accuracy, anywhere from 0.001 sec to 1.0 day). Certain high-accuracy runs of TARMATDEP took almost 24 hours on the DEC Alpha; generally, though, most runs performed as part of the MDP work took less than one minute.

B.2.4 Model Geometry

The program performs particle transport tracking in one dimension--the r-geometry of spherical coordinates. Thus, the center of the coordinate system (r=0, time=t) is in the center point of the PuO_2 source particle. The radial dimension increases away from the center point of the particle and into the target material. The one-dimensional model collapses the entire target molecule population into one spatial "ray," into which every alpha particle is "launched." Since there is only this one angle of traversal, each and every alpha particle encounters the same number of target molecules in its radial path; each subsequent alpha, however, is weighted with a decreasing probability of breaking a hydrogen bond, in order to account for the depletion of "fresh" hydrogen bonds in target molecules encountered along the traversal path of the alphas.

A cross-sectional view of the TARMATDEP model geometry is shown in Figure B-1. In a simple geometry case, the effects of alpha radiation emanating from only one PuO_2 particle is analyzed. Since in most cases a number of PuO_2 particles can be assumed to be "clumped" or agglomerated close together, the combined effects of alpha radiation emanating from each of those particles needs to be taken into account, as shown in Figure B-2. For agglomerated scenarios, thus, a separate methodology needs to be employed, so as to take into account the varying paths and varying energies of the alpha radiation. For agglomeration factors greater than 1.0 (i.e., more than one PuO_2 particle radiating into the target matrix), TARMATDEP uses an equivalent "MEGA" particle analogy, wherein a single, large PuO_2 particle is assumed, with a radius derived from an equivalent volume equal to the sum of the volumes of the agglomerated particles. All alpha radiation is then either "born" in the middle of the "MEGA" particle or, if the radius of the "MEGA" particle exceeds the alpha range in PuO_2 (i.e., about 18 um), the outer shell equal to the particular alpha range. The equivalent "MEGA" PuO_2 particle analogy is depicted in Figure B-3.

B.2.5 Calculational Algorithm

The top-level calculation algorithm consists of three loops: (1) time loop, (2) radial dimension loop, and (3) target material loop. Thus, for each second of time, a full sweep through the radial dimension and its associated nodes is done; for each radial node, in turn, a sweep of the five candidate target materials is done. Thus, the output of TARMATDEP is a series of two-dimensional arrays, with each array comprising the radial dimension (rows) and target material (columns) calculated data, and a different 2-D array for each second in time. To conserve output file size, TARMATDEP only writes to file the output data according to the user-specified reporting interval (i.e., every second, minute, hour, day, week, month, or year, or any multiple of the same).

Depending on the user specifications, the algorithm is executed for either the ^{238}Pu or ^{239}Pu source material. The results of the analysis are written to whichever of the eight possible output files the user activates, for the desired total duration of modeling and the time interval between recording of the calculated data.

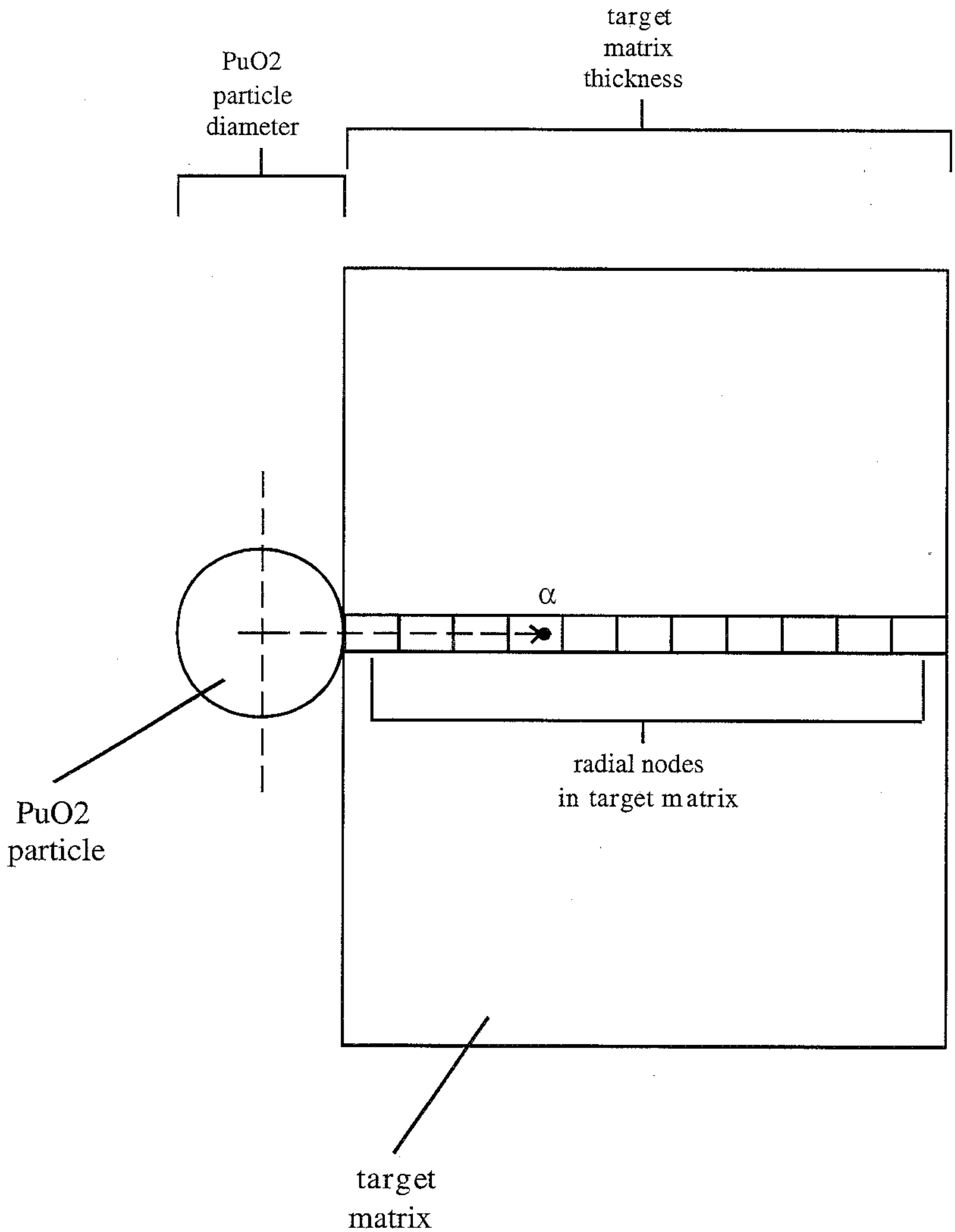


Figure B-1. A cross-sectional view of the TARMATDEP model geometry.

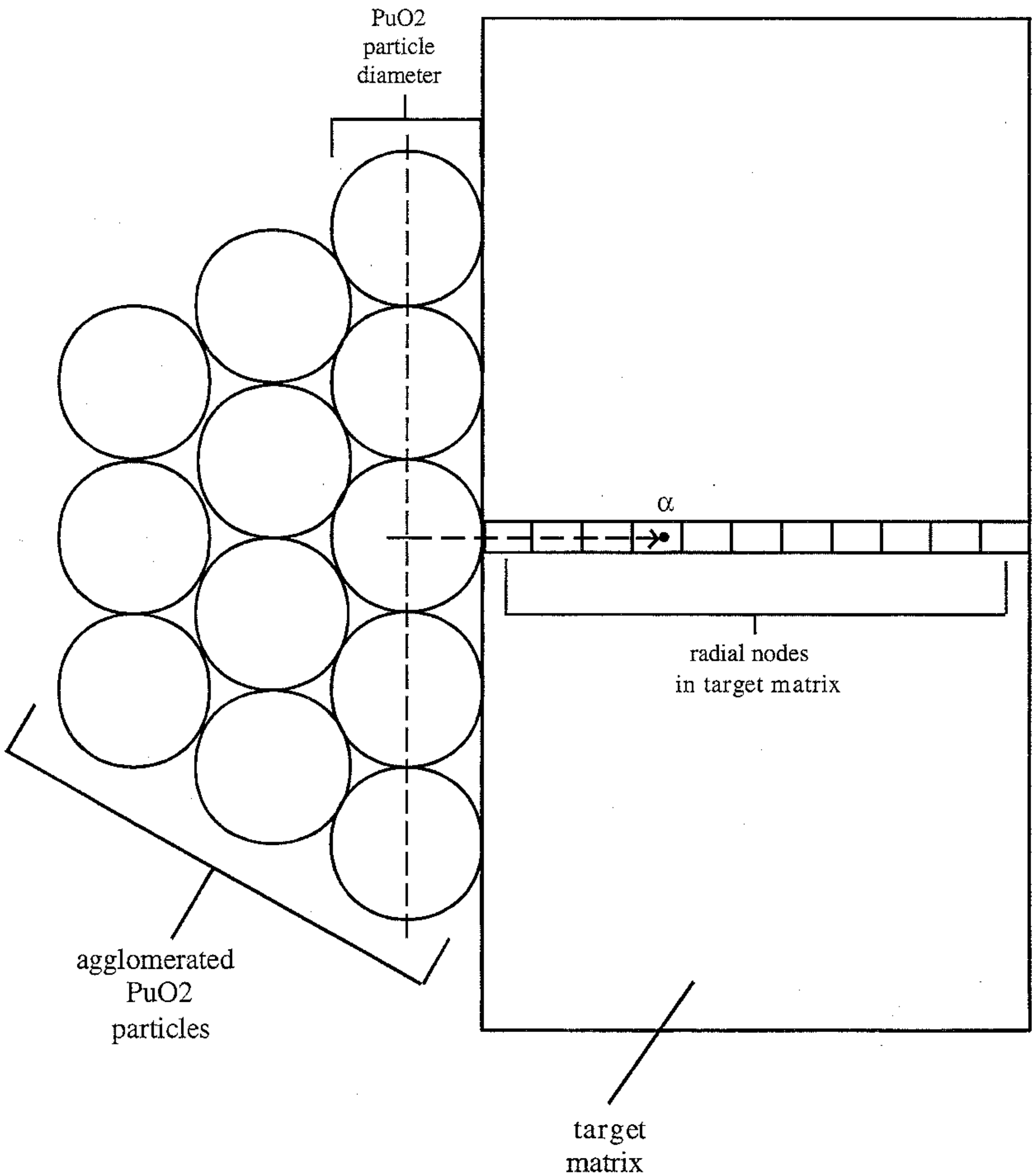


Figure B-2. Combined effects of alpha radiation from agglomerated particles.

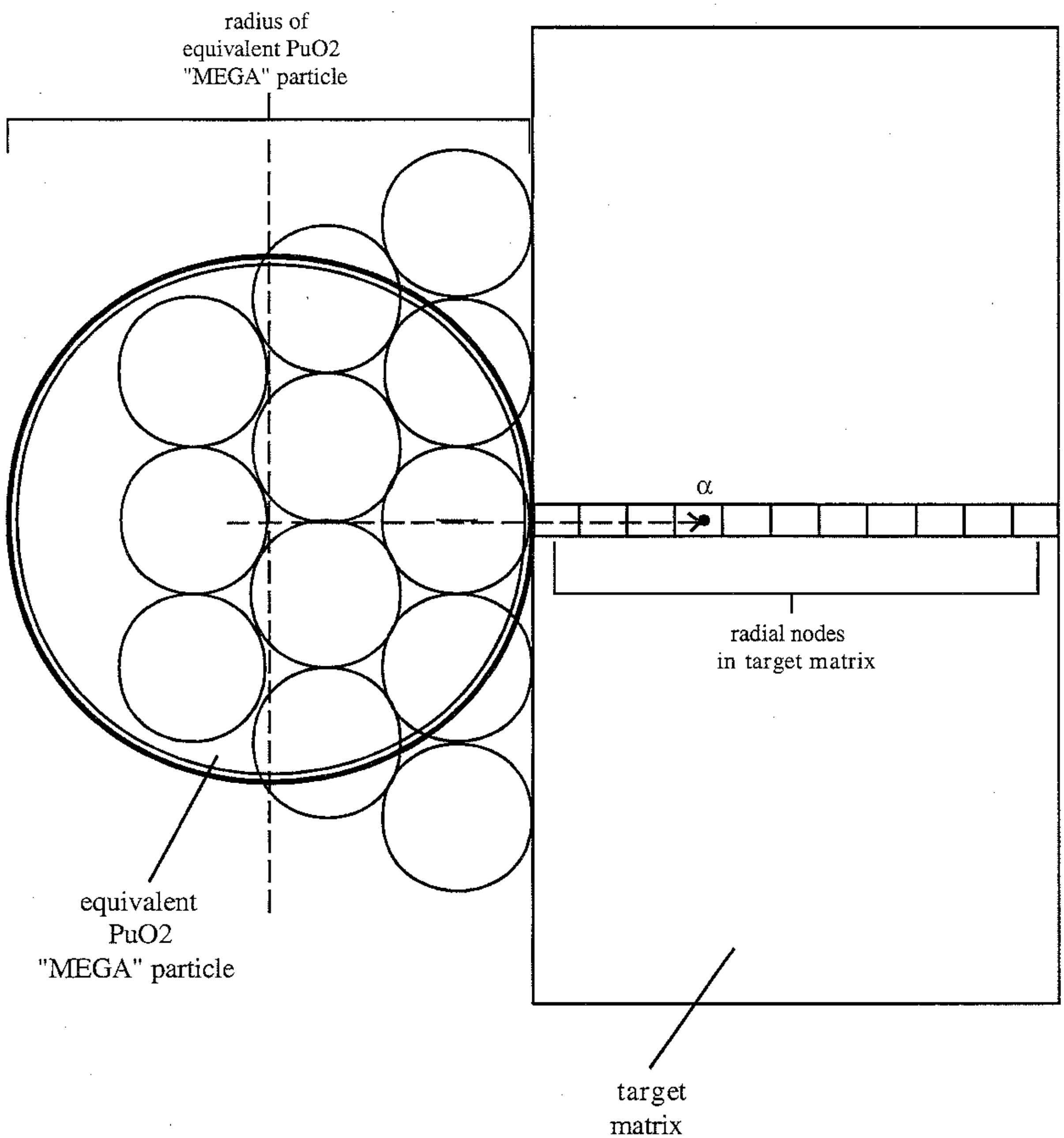


Figure B-3. The equivalent "MEGA" PuO_2 particle analogy.

B.3 TARMATDEP Validation Results

As part of the MDP activities in general, and the TARMATDEP development effort in particular, the program was extensively verified (i.e., analyzed to confirm that it is performing as intended) and validated against existing experimental MDP data. Within the general verification efforts, two major applications of the TARMATDEP program were conducted: (1) to compare its theoretical predictive results to experimental data, and (2) to determine the critical properties or parameters that influence the G-value of a particular target matrix.

B.3.1 Validation Against the Marshall/Cappis Experiments

The first set of TARMATDEP executions was carried out using input parameters that simulated the Marshall/Cappis experiments. Two representative TARMATDEP cases were analyzed, one for PE and one for cellulose. The model results were then plotted against the three combined sets of Marshall/Cappis experimental results, as shown in Figures B-4 and B-5. Overall, excellent agreement between the Marshall/Cappis experimental data and the theoretical predictive results of TARMATDEP was observed, for the entire range from t=1 day to in excess of t=600 days.

B.3.2 Validation Against the LANL MDP Experiments

The second set of TARMATDEP executions was carried out using input parameters that simulated the LANL MDP experiments. Several representative test cases were analyzed, involving both ^{238}Pu and ^{239}Pu, as well as short-term and long-term G-value behavior. As discussed in Section 4.3 of this report, the TARMATDEP simulations of actual LANL MDP experiments indicated excellent agreement with the experimental data over a range of t=1 day to in excess of t=800 days.

B.4 Parametric Analysis Using TARMATDEP

As of the end of FY98, the TARMATDEP theoretical model has been extensively validated against available experimental matrix depletion data. In all cases analyzed, TARMATDEP accurately and correctly predicted the behavior of the G-value curve for any given contaminant, target matrix, and geometry. These successful results give credence to the use of TARMATDEP as a tool to analyze the effects of different properties or parameters on the G-value.

Using TARMATDEP predictive results, it was determined that the behavior of the G-value vs. dose (or time) curve for any given target matrix was primarily influenced by two parameters: (1) PuO_2 particle diameter, and (2) PuO_2 particle agglomeration. A series of analyses were performed with varying particle diameters (3.61 um, 15 um, and 36 um) and particle agglomerations (corresponding to 0.01 W, 0.1 W, and 1.0 W). The results of the analyses are shown on Figures B-6 through B-12. As can be seen from the enclosed plots, increasing PuO_2 particle diameter has a direct influence on the decrease of the overall G-value curve (i.e., the magnitude of the curve), while increasing agglomeration or wattage has a direct influence on the steepness of the overall G-value curve (i.e., the shape of the curve). Thus, it can be concluded that while the magnitude of both the initial, as well as final, G-value is to a large extent dependent on the PuO_2 particle diameter, the shape of the G-value curve, on the other hand, is mostly dependent on the PuO_2 particle agglomeration along the target matrix. In other words, the highest initial G-values are expected to be associated with a very small PuO_2 particle diameter and high agglomeration factors, while the lowest long-term G-values are expected to be found in waste contaminated with highly agglomerated PuO_2 particles of large diameter.

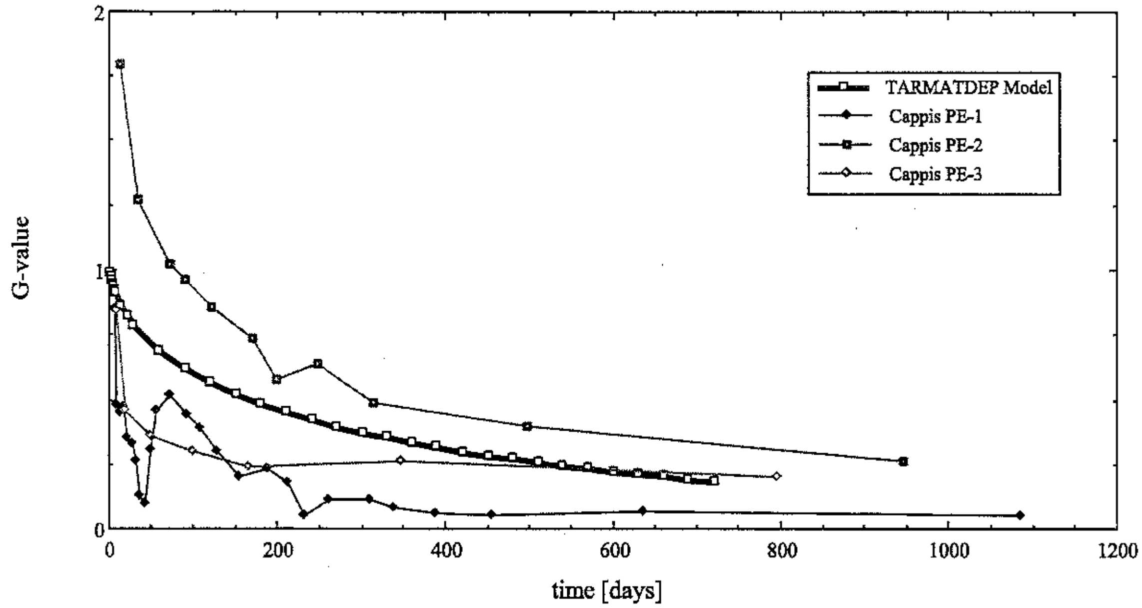


Figure B-4. Comparison of LANL Cappis/Cassini PuO_2 experimental data with TARMATDEP model.

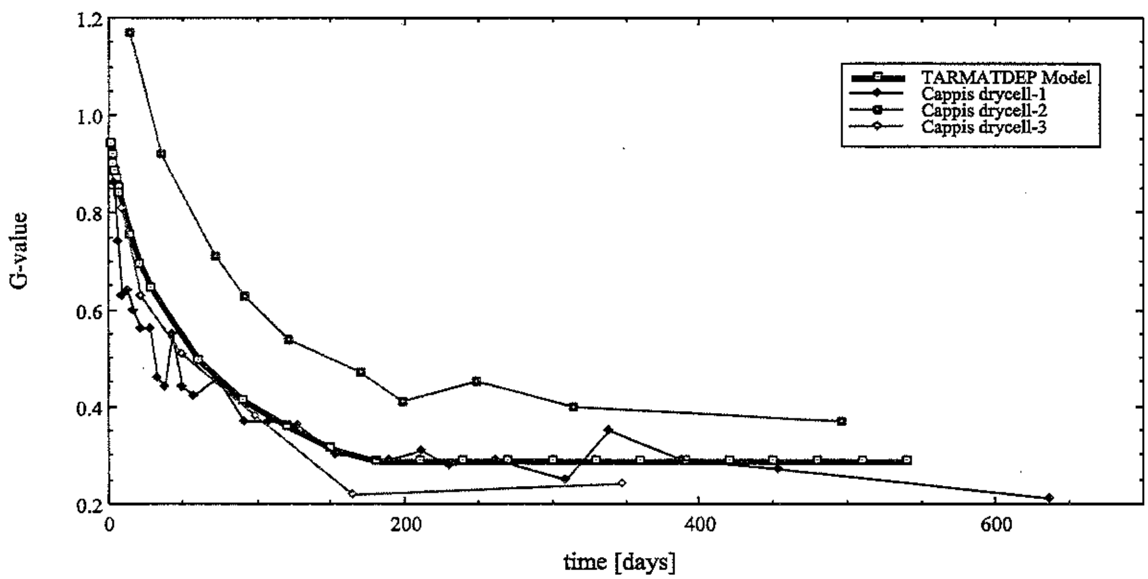


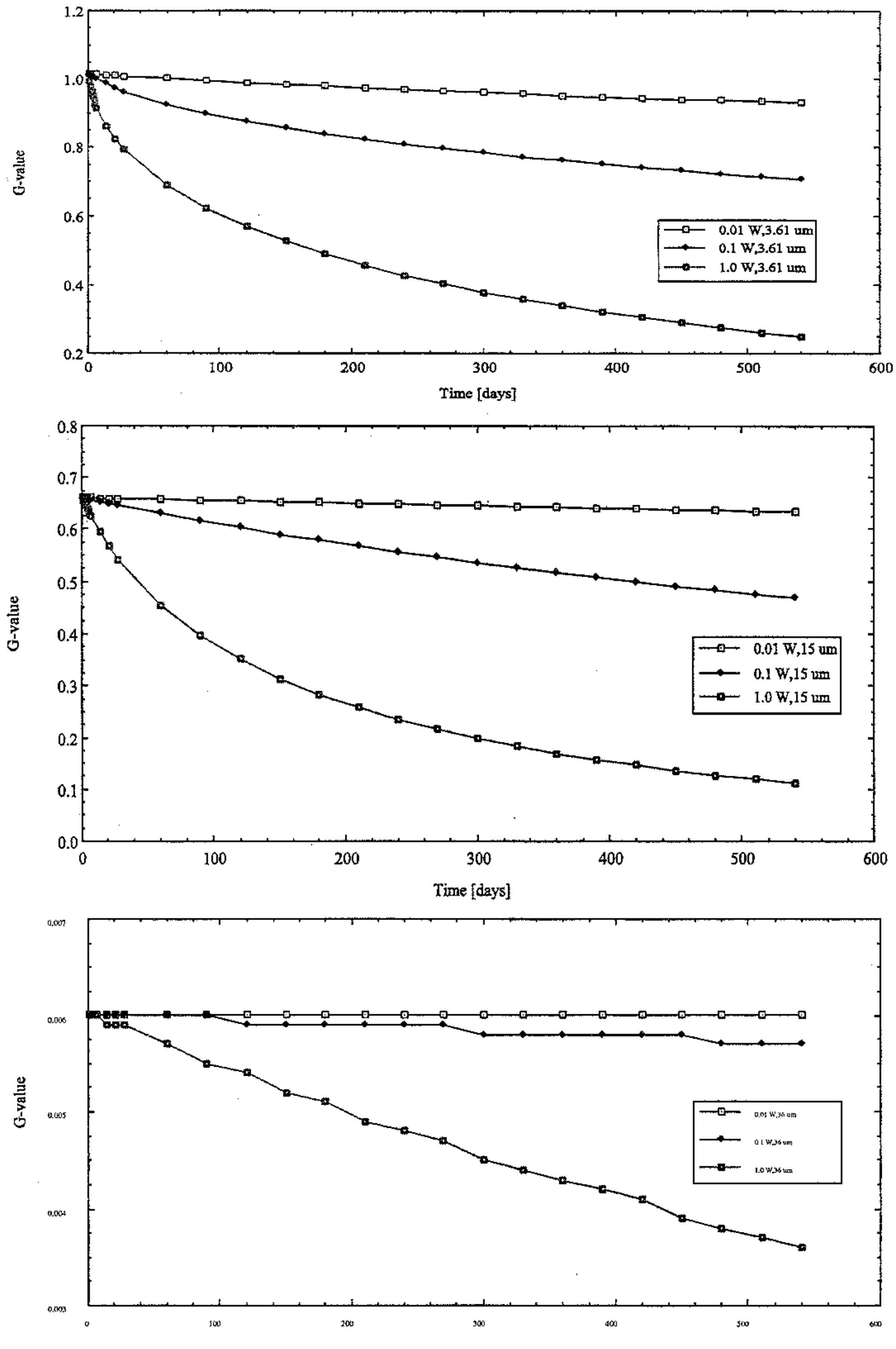
Figure B-5. Comparison of LANL Cappis/Cassini PuO_2 experimental data with TARMATDEP model.

Analysis of the dependence of initial G-value on PuO_2 particle diameter also indicated that, for any given case of particle agglomeration, the initial G-value is bounded and does not increase without limit as the PuO_2 particle diameter is decreased. As shown in Figure B-13, for the sample case of 1.0 W agglomeration and varying PuO_2 particle diameters from 10.0 um down to 0.01 um, the initial G-value asymptotes to an upper bound of approximately 1.1 molecules/100 eV. For different target matrices, agglomeration factors, Pu types, and PuO_2 particle diameters, naturally, the G-value asymptote would vary.

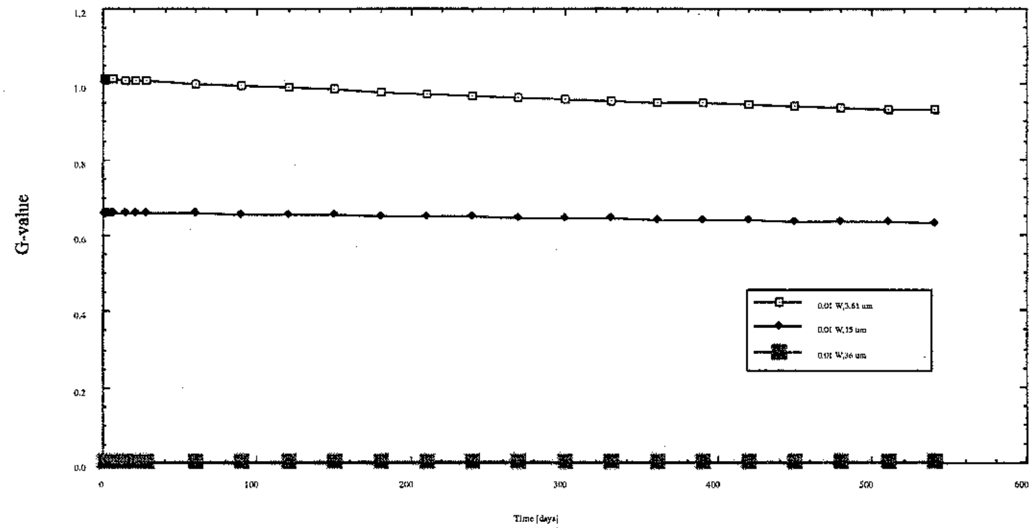
A separate series of TARMATDEP executions were devoted to better understanding of the behavior of the G-value curve versus both time and dose. Of special interest was the relationship between the G-value versus time and the G-value versus dose curves, namely the expectation that a TARMATDEP theoretical simulation of two separate hypothetical cases, at different dose rates, would yield the same results when superimposed on a G-value versus total dose (in Watt · yr) plot. Thus, two separate runs of TARMATDEP were carried out, for the same contaminant (^{238}Pu), the same target matrix (PE), and identical particle and target dimensions and properties, except for a 100x difference in the dose rate—one at 0.01 W, the other at 1.0 W. Both cases were simulated for a total of 400 years, to provide the necessary equivalency.

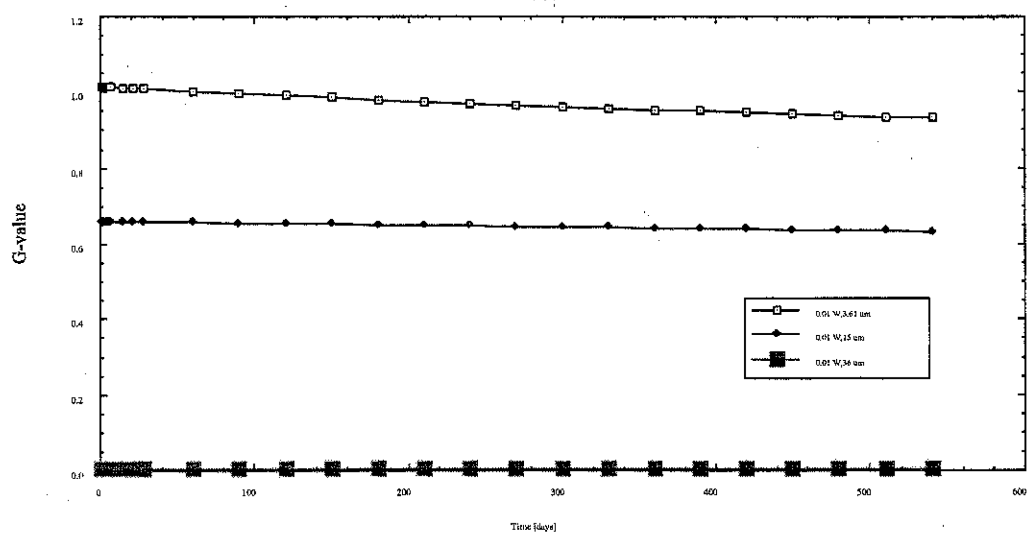
Figure B-14 shows plots of the resultant G-values versus time, for both the 0.01 W and the 1.0 W cases. The G-value in the 0.01 W case takes a long time (approximately 200 years) to decrease significantly, while the G-value in the 1.0 W case, the result of a 100x greater dose, decreases to zero much faster. Overall, the shape and magnitude of the two curves are completely different.

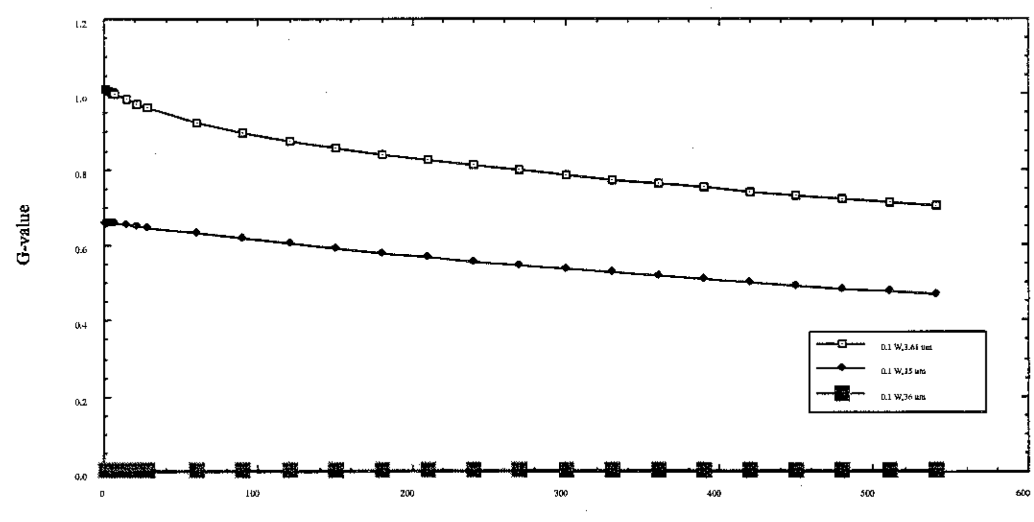
As is shown in Figure B-15, however, once the G-values are plotted versus total dose (i.e., taking into account the 100x difference in the dose rate), the two G-value curves align perfectly over a wide range of doses, from D=0.0 to D=4.0 Watt · yr. Even the slight deviation in G-values starting around 4.0 Watt · yr is due to calculation step inaccuracies, because the 0.01 W case, at 400 years, required the use of a significantly larger calculation step in order to result in a reasonable execution time. Thus, these simulations conclusively support the concept of a dose criteria (0.006 Watt · yr) beyond which G-values have leveled off, approaching the asymptotic value.



Figures B-6, B-7, B-8. Analyses of the effects of increasing PuO_2 particle diameter.







Figures B-9, B-10, and B-11. Analyses of the effects of increasing PuO_2 wattage.

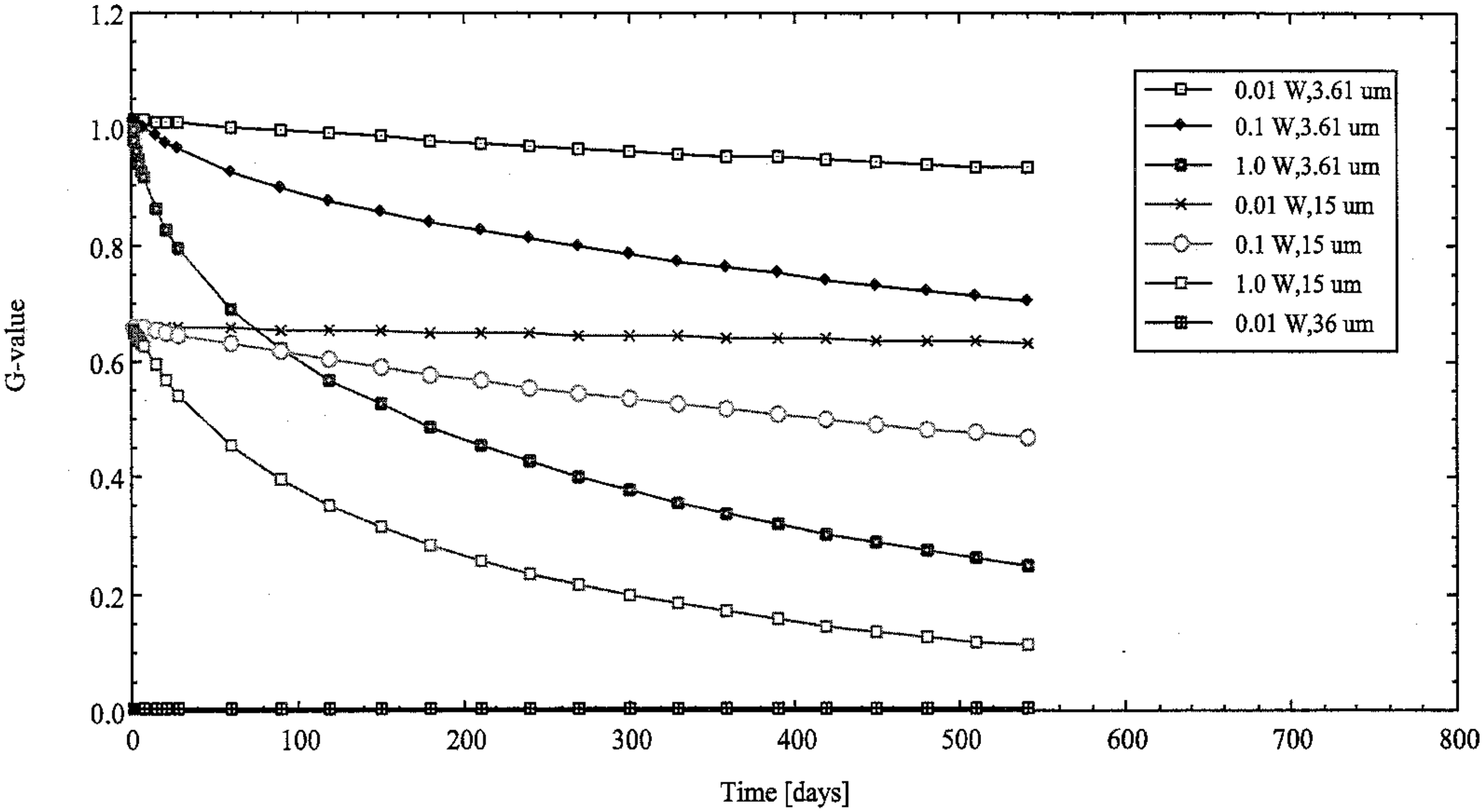


Figure B-12. Analysis of the effects of increasing PuO_2 particle diameter and wattage.

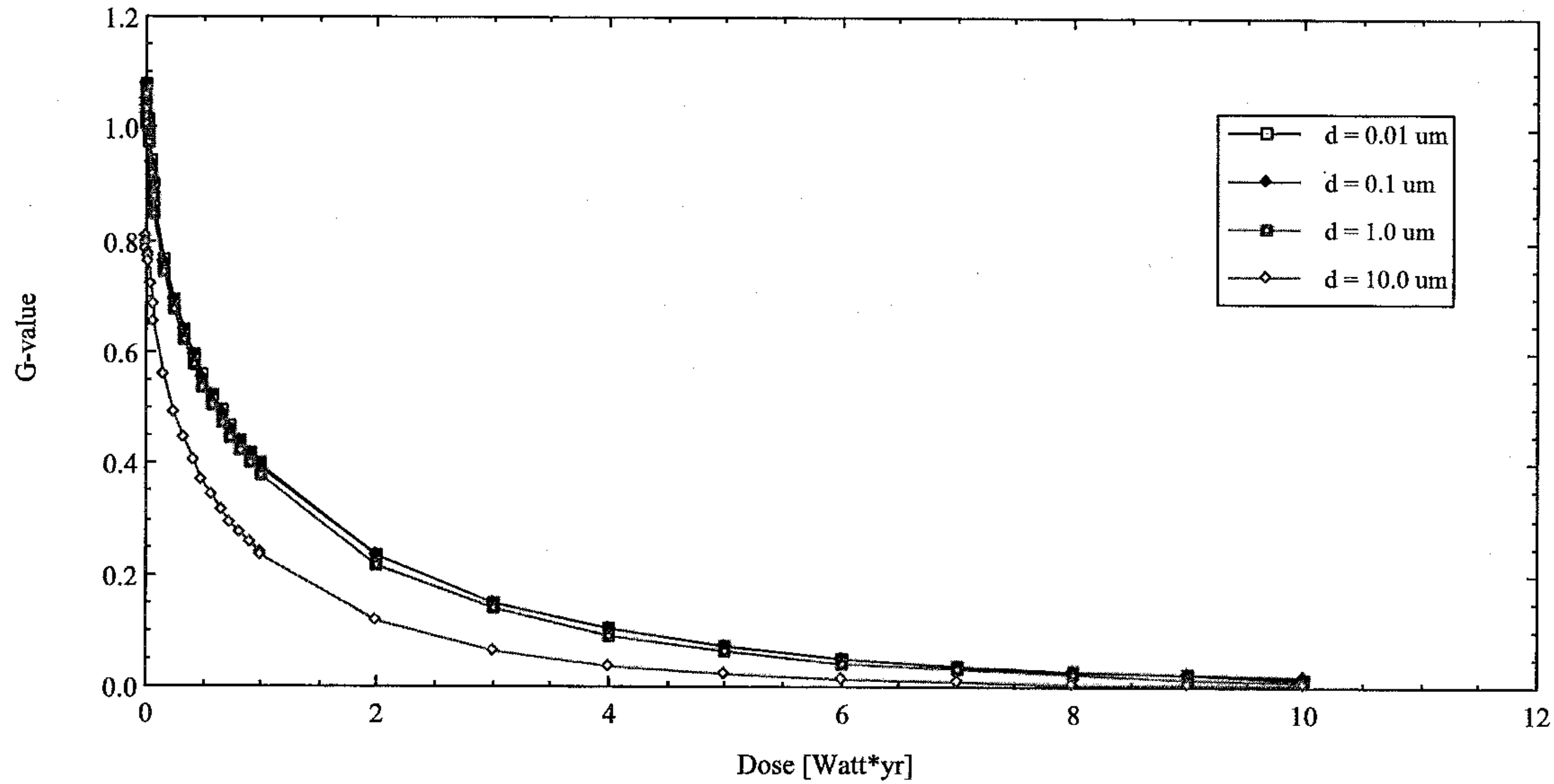


Figure B-13. Sample case of 1.0 W agglomeration and varying PuO_2 particle diameters.

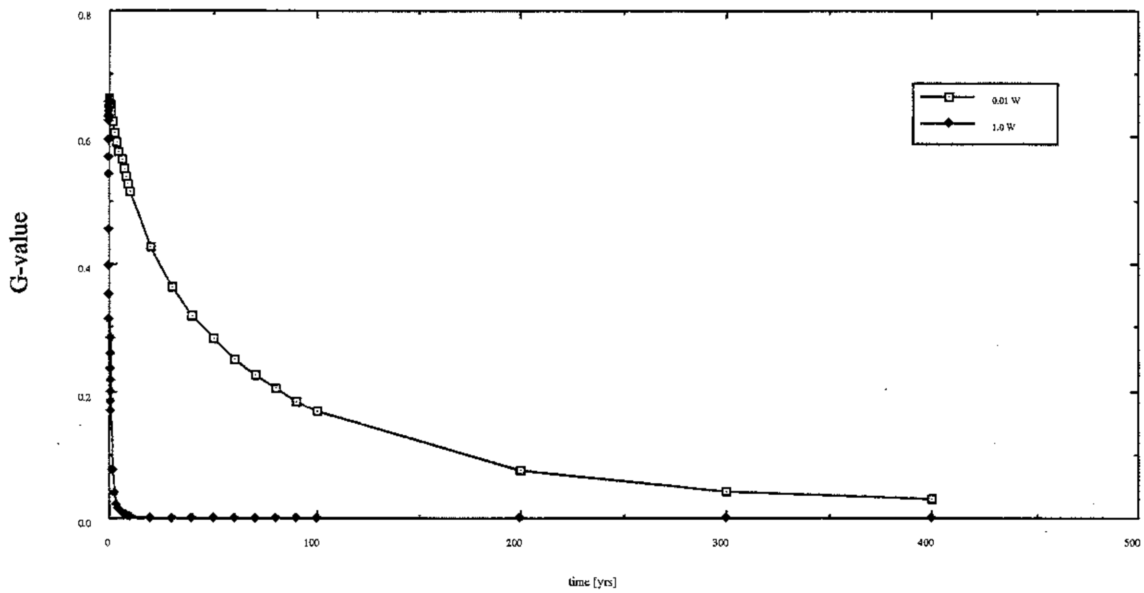


Figure B-14. Comparison of hypothetical 0.01 W and 1.0 W G-values vs. time.

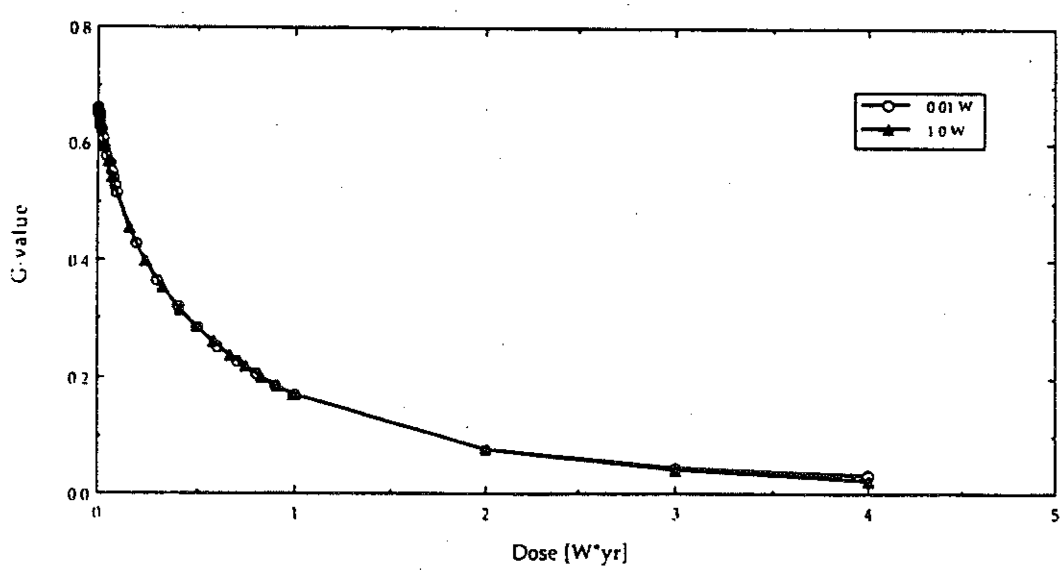


Figure B-15. Comparison of hypothetical 0.01 W and 1.0 W G-values vs. dose.

Appendix C

NEWGVALS MODEL DESCRIPTION AND EVALUATION RESULTS

C.1 NEWGVALS Code Information

Software Name: NEWGVALS

Category: FORTRAN Code Numerical Simulator - Gas Generation and Transport Across Layers in a Waste Container

Revision Number: 1

Date Revised: August 1, 1998

Descriptive Summary: The rationale for the NEWGVALS code is provided in the TRUPACT-II Matrix Depletion Program Test Plan, INEL-95/0360, Idaho National Engineering Laboratory, Idaho Falls, Idaho. The code mathematically simulates the generation of flammable gas and subsequent transport across layers of confinement in a transuranic waste drum. The code uses experimentally derived bounding effective G-value step functions, and actual TRU waste container decay heat or wattages to predict concentrations within different confinement layers within actual TRU waste containers up to the age of the container when sampled. The bounding effective G-values were obtained from data analysis of the results from the Matrix Depletion testing being performed at LANL. The predicted concentrations using the NEWGVALS code were compared with the respective actual waste drum flammable gas concentrations to show that the selected effective G-values are in fact bounding.

The generation of flammable gas within the innermost confinement layer and subsequent transport across the various confinement layers of an actual container can be simulated by solving the differential equations that describe the unsteady-state mass balances on flammable gas within each confinement layer of the actual container. The program is based on the TRUPACT-II aspiration model that is documented in Appendix 3.6.11 of the *Safety Analysis Report for the TRUPACT-II Shipping Package*, Revision 14, NRC Docket No. 9218, U.S. Nuclear Regulatory Commission, Washington, D.C. To account for the various packaging configurations and container conditions, four sets of ordinary differential equations (ODEs) are solved along with the appropriate initial conditions that represent the initial state of a container. The four sets represent: (1) a sealed container with two void volumes, (2) an aspirating container with two void volumes, (3) a sealed container with three void volumes, and (4) an aspirating container with three void volumes. The concentrations that are predicted in a sealed container at the time of venting serve as initial conditions for the differential equations that describe an aspirating container. This code differs from the aspiration model in that the differential equations are solved numerically because the gas generation rate is based on a step function in G-value.

Related Programs: The program is comprised of the main routine NEWGVALS along with the following subroutines: READAT; DEFINE; ODEINT; DERIVS; SUBGDIM; RKQS/RKCK; BSSTEP; MMID; and PZEXTR.

Operational Demands: IBM PC Compatible 486, 33 MHZ or higher, 8 Mb memory, DOS 5.0 or higher. Fortran source code executable is NEWGVALS.EXE. Size of executable program: 188,996 bytes.

Classification: Limited distribution, developed as part of a government contract, unclassified.

Status: Operational.

Origin/source: Developed by DJINDECO Consulting for Benchmark Environmental Corporation, 4501 Indian School Road NE, Suite 105, Albuquerque, NM 87110 for the Lockheed Idaho Technologies Company under Subcontract No. C90-132787.

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Documentation/References:

Software Users Manual - NEWGVALS (Revision 1) - User's Manual, Benchmark Environmental Corporation, Albuquerque, NM.

Software Configuration Log - Software Configuration Log for NEWGVALS, (copy attached).

C.2 Mathematical Model

The NEWGVALS model was developed to predict flammable gas concentrations in each confinement layer of a drum. The model mathematically simulates the generation of flammable gas and subsequent transport across layers of confinement in a TRU waste drum. The model uses a step function in experimentally determined bounding effective G-values and the drum decay heat or wattage to predict concentrations within each confinement layer of the drum up to the time that the drum is sampled. The predicted gas concentrations using NEWGVALS were compared with sampled flammable gas concentrations to demonstrate that the selected effective G-values are, in fact, bounding. NEWGVALS is based on the aspiration model and equations documented in Appendix 3.6.11 of the SARP (NRC 1996).

Each CH-TRU waste container is designated by a TRUPACT-II shipping category based on waste material type and the packaging (number and type of layers of confinement) of the waste materials within the waste container. The layers of confinement include polymer (i.e., plastic) bags, rigid drum liners, and drum filters. The polymer bags are sealed by either a twist-and-tape or a fold-and-tape method. If the bags are sealed by twist-and-tape, the resulting closure is referred to as a horsetail. Drums of waste type I or waste type IV are referred to as sludge waste drums and may contain absorbed, adsorbed, or solidified inorganic or organic liquids, soils, or solidified particulates and residues. Sludge waste is typically packaged using at most two layered large polymer bags within the rigid drum liner. Drums containing waste type II or waste type III are referred to as solid waste drums that may contain glass, metal, crucibles, plastics, cellulose, or other solid organics and inorganics. Solid waste drums have up to six layers of confinement within the rigid drum liner: a maximum of two layered large polymer bags containing waste wrapped inside one to four layers of small polymer bags.

Besides the packaging configuration, the drums can be either sealed or aspirating. Aspirating drums are those that have been vented (i.e., the rigid drum liners punctured and a carbon composite filter installed in the drum lid). If a container is aspirated for a sufficient period of time (i.e., the aspiration time defined in Appendix 3.6.11 of the SARP) the container attains steady-state or equilibrium conditions between layers of confinement. At steady-state conditions the rate of flammable gas generation by radiolysis equals the release rate of flammable gas across each layer of confinement.

The generation of flammable gas within the innermost confinement layer and subsequent transport across the various confinement layers of an actual container can be simulated by solving the differential equations that describe the unsteady-state mass balances on flammable gas within each confinement layer of the actual container. The same equations that are documented in Appendix 3.6.11 of the SARP were used, except that the gas generation rate is a function of dose. To account for the various packaging configurations and container conditions, four sets of differential equations are solved along with the appropriate initial conditions that represent the initial state of a container. The four sets represent: (1) a sealed container with two void volumes, (2) an aspirating container with two void volumes, (3) a sealed container with three void volumes, and (4) an aspirating container with three void volumes. Data required for each simulation consist of the bounding effective flammable gas G-value functions of dose that were experimentally derived, void volumes within the various confinement layers, and experimentally determined release rates of flammable gas across each confinement layer. The systems of ODEs are solved numerically using either of two available techniques. Flammable gas generation and transport across the confinement layers will be simulated until the time the container was sampled.

C.2.1 Differential Equations for a Container with Two Void Volumes

The first set of differential equations represent a sealed container with two void volumes.

Sealed Container

$$\frac{dC_2}{dt} = R_2(C_1 - C_2) \tag{C-1}$$

$$\frac{dC_1}{dt} = \frac{C_g RT}{PV_1} - R_1(C_1 - C_2) \qquad \text{(C-2)}$$

The following initial conditions represent the initial state of the container:

$$C_1(t=0) = C_2(t=0) = 0 \qquad \text{(C-3)}$$

The second set of differential equations represent an aspirating container with two void volumes.

Aspirating Container

$$\frac{dC_1}{dt} = \frac{C_g RT}{PV_1} - R_1(C_1 - C_2) \qquad \text{(C-4)}$$

$$\frac{dC_2}{dt} = R_2(C_1 - C_2) - R_3 C_2 \qquad \text{(C-5)}$$

The following initial conditions represent the initial state of the container. The actual numerical values of $C_{1,0}$ and $C_{2,0}$ are obtained by solving the first set of equations describing a sealed container at the time of venting.

$$C_2(t=0) = C_{2,0} \qquad \text{(C-6)}$$

$$C_1(t=0) = C_{1,0} \qquad \text{(C-7)}$$

where

$C_1(t)$	=	mole or volume fraction of flammable gas within the drum liner void volume at time t (dimensionless)
$C_2(t)$	=	mole or volume fraction flammable gas within the drum headspace at time t (dimensionless)
R_1	=	effective release rate coefficient of flammable gas from the rigid liner divided by the innermost void volume (1/s)
R_2	=	effective release rate coefficient of flammable gas from the rigid liner divided by the headspace void volume. (One value based on the release rate from an intact liner is used in the equations for the concentration in a sealed container. A different value is used with the aspiration equations based on the release of flammable gas from the punctured rigid liner hole.) (1/s)
R_3	=	effective release rate coefficient of flammable gas from the carbon composite filter divided by the headspace void volume (1/s)
t	=	time (s)
R	=	universal gas constant (82.057 atm cm^3/mol K)
T	=	absolute temperature (K)
V_1	=	void volume within the innermost confinement layer (cm^3)
$C_g(t)$	=	flammable gas generation rate within the innermost confinement layer (mol/s).

The generation rate will be calculated from the bounding effective flammable gas G-values for each time segment. The smallest statistically justifiable time segment will be used in the analyses. The relationship between the bounding effective flammable gas G-value and the flammable gas generation rate is:

$$C_g(t) = \frac{Q\,G_B(dose)}{k\,N_A} \tag{C-8}$$

where

Q	=	wattage or decay heat of the TRU waste container (W)
$G_B(dose)$	=	bounding effective flammable gas G-value step function (molecules/100 eV) G
N_A	=	Avogadro's number (6.022045 x 10^{23} molecules/mol)
k	=	conversion factor (1.602x10^{-19} Ws/eV).

C.2.2 Differential Equations for a Container with Three Void Volumes

The first set of differential equations represent a sealed container with three void volumes.

Sealed Container

$$\frac{dC_2}{dt} = R_2(C_1 - C_2) - R_3(C_2 - C_3) \tag{C-9}$$

$$\frac{dC_3}{dt} = R_4(C_2 - C_3) \tag{C-10}$$

$$\frac{dC_1}{dt} = \frac{C_g RT}{PV_1} - R_1(C_1 - C_2) \tag{C-11}$$

The following initial conditions represent the initial state of the container:

$$C_1(t=0) = C_2(t=0) = C_3(t=0) = 0 \tag{C-12}$$

Aspirating Container

The second set of differential equations represent an aspirating container with three void volumes.

$$\frac{dC_1}{dt} = \frac{C_g RT}{PV_1} - R_1(C_1 - C_2) \tag{C-13}$$

$$\frac{dC_2}{dt} = R_2(C_1 - C_2) - R_3(C_2 - C_3) \tag{C-14}$$

$$\frac{dC_3}{dt} = R_4(C_2 - C_3) - R_5 C_3 \qquad \text{(C-15)}$$

The following initial conditions represent the initial state of the container. The actual numerical values of $C_{1,0}$, $C_{2,0}$, and $C_{3,0}$ are obtained by solving the first set of equations describing a sealed container at the time of venting.

$$C_1(t=0) = C_{1,0} \qquad \text{(C-16)}$$

$$C_2(t=0) = C_{2,0} \qquad \text{(C-17)}$$

$$C_3(t=0) = C_{3,0} \qquad \text{(C-18)}$$

where

$C_1(t)$	=	mole or volume fraction flammable gas within the innermost void volume at time t (dimensionless)
$C_2(t)$	=	mole or volume fraction flammable gas within the rigid drum liner at time t (dimensionless)
$C_3(t)$	=	mole or volume fraction flammable gas within the drum headspace at time t (dimensionless)
R_1	=	effective release rate coefficient of flammable gas from all bags divided by the innermost void volume (1/s)
R_2	=	effective release rate coefficient of flammable gas from all bags divided by the rigid liner void volume (1/s)
R_3	=	effective release rate coefficient of flammable gas from the rigid liner divided by the liner void volume. (One value based on the release from an intact liner is used in the equations for the concentration profiles in a sealed container. A different value is used with the aspiration equations based on the release of flammable gas from the punctured drum liner.) (1/s)
R_4	=	effective release rate coefficient of flammable gas from the rigid liner divided by the container headspace void volume. (One value based on the release from an intact liner is used in the equations for the concentration profiles in a sealed container. A different value is used with the aspiration equations based on the release of flammable gas from the punctured drum liner.) (1/s)
R_5	=	effective release rate coefficient of flammable gas from the carbon composite filter divided by the container headspace void volume. (1/s)

The other variables are as defined earlier.

C.3 Numerical Implementation

The systems of differential equations are solved numerically using either of two available techniques. The user specifies the preferred method in the input file. The two methods included in the code are the fifth-order Runge-Kutta method with adaptive stepsize control, and the Bulirsh-Stoer method with Richardson's extrapolation and adaptive stepsize control. The routines comprising the NEWGVALS program are described below.

C.3.1 Program NEWGVALS Routines

The main program NEWGVALS controls the logic of the code by calling the other subroutines. First, the subroutine READAT is called to read in the input parameters from file NEWGVALS.DAT. For each drum listed in the container data file CONTDATA.DAT, the subroutine READAT reads in the requisite drum parameters. For each drum, the subroutine DEFINE is called to define the values of the confinement layer release rates. Flammable gas generation and transport across layers is simulated up to the time of drum sampling by calls to subroutine ODEINT. Finally, for each drum the predicted concentrations of hydrogen and methane are written to the output file CONTDATA.OUT.

C.3.2 Subroutine READAT

The first time subroutine READAT is called the subroutine reads input parameters from the data file NEWGVALS.DAT. In subsequent calls, the subroutine reads a line from the data file CONTDATA.DAT, which contains actual waste drum data for a single container. Based on the appropriate waste material type, the appropriate bounding effective G-value step function is defined within this routine. The routine also calculates the time when the Watt · yr criteria are satisfied and the lower MDP revised G-values are to be used.

C.3.3 Subroutine DEFINE

Subroutine DEFINE calculates the release rate coefficients of flammable gas across various confinement layers (i.e., values of $R_1, ..., R_5$) defined in Section C.2. The appropriate values are calculated for the flammable gas depending on the waste material type, the number of bag layers, and whether the container is sealed or aspirating.

C.3.4 Subroutine ODEINT

Subroutine ODEINT implements the Runge-Kutta driver with adaptive stepsize control. The subroutine causes integration of the differential equations between two times. In one case, the time is the duration that the container is sealed, while during aspiration, the time corresponds to the elapsed time between drum venting and sampling. Accuracy, initial stepsize, and minimum stepsize for the integration are specified by the user in the file NEWGVALS.DAT. The subroutine makes successive calls to the subroutine DERIVS, which calculates the right-hand-side derivative. RKQS is the stepper routine to be used if the Runge-Kutta method is to be used, and BSSTEP is the name of the stepper routine to be used if the Bulirsch-Stoer method is to be used.

C.3.5 Subroutine DERIVS

Subroutine DERIVS is the subroutine that defines or allows calculation of the right-hand sides of Equations C-1, C-2, C-4, C-5, C-9, C-10, C-11, C-13, C-14, and C-15. The assignment of values to array of derivatives DYDT is based on the number of void volumes for that container and whether the container is sealed or aspirating.

C.3.6 Subroutine SUBGDIM

Subroutine SUBGDIM calculates the flammable gas generation rate using the initial bounding effective

G-value and the matrix depleted G-value after the Watt · yr criteria is satisfied, the wattage of the drum and Equation C-8. The subroutine then calculates the term $C_gRT/(PV_1)$ that is used in Equations C-1, C-4, C-9, and C-13. The subroutine is called by the DERIVS subroutine.

C.3.7 Subroutines RKQS/RKCK

This routine is the stepper routine for the numerical integration of the differential equations if the Runge-Kutta solver is to be used. RKQS/RKCK uses the fifth-order Runge-Kutta solver to advance the solution over a time step interval and returns the incremented dependent variables (i.e., the concentrations in each confinement layer). Fifth-order Runge-Kutta solver with monitoring of local truncation error ensures accuracy and adjusts the stepsize. Inputs to the routine are the dependent variable vector (i.e., flammable gas concentrations in each confinement layer) and its derivative at the starting value of the independent variable (i.e., time). Also input are the time stepsize to be attempted, required accuracy, and vector against which the error is scaled. On output, the dependent variable vector and independent variable (i.e., time) are replaced by their new values. The routine also estimates the next time stepsize. The DERIVS subroutine computes the right-hand-side derivatives.

C.3.8 Subroutine BSSTEP

This routine is the stepper routine for the numerical integration of the differential equations if the Bulirsch-Stoer solver is to be used. Bulirsch-Stoer step with monitoring of local truncation error ensures accuracy and adjusts the stepsize. Inputs to the routine are the dependent variable vector (i.e., flammable gas concentrations in each confinement layer) and its derivative at the starting value of the independent variable (i.e., time). Also input are the time stepsize to be attempted, required accuracy, and vector against which the error is scaled. On output, the dependent variable vector and independent variable (i.e., time) are replaced by their new values. The routine also estimates the next time stepsize. The DERIVS subroutine computes the right-hand side derivatives.

C.3.9 Subroutine MMID

Subroutine MMID implements the modified midpoint method as part of the Bulirsch-Stoer technique. The method advances a vector of dependent variables, y(x) from a point x to a point x + H by a sequence of n substeps each of size h, where h = H/n. Specifically, within the subroutine the dependent variable vector Y (i.e., flammable gas concentrations in each confinement layer) and its derivative vector are input. Also input are the total steps to be made and the number of substeps to be used.

C.3.10 Subroutine PZEXTR

Subroutine PZEXTR makes use of polynomial extrapolation to evaluate NV functions at x=0 by fitting a polynomial to a sequence of estimates with progressively smaller values and corresponding function vectors. Extrapolated values and their estimated errors are the outputs from the subroutine.

C.3 Input Data Files

Table C-1 lists the parameters used in the NEWGVALS simulations for each waste type including flammable gas release rate coefficients, void volumes, and the G-value step functions. Table C-2 lists the data supplied to the NEWGVALS code for containers sampled under the TWCP at the INEEL. Table C-3 lists the data supplied to the NEWGVALS code for containers sampled under the TWCP at the RFETS.

Table C-1. Waste type parameters for NEWGVALS simulations.

Parameter	Waste Type I	Waste Type II	Waste Type III
Drum filter flammable gas release rate coefficient (mole/s/mole fraction)	1.37E-6	1.90E-6	1.90E-6
Inner bag flammable gas release rate coefficient (mole/s/mole fraction)	4.17E-7	5.58E-7	5.58E-7
Liner bag flammable gas release rate coefficient (mole/s/mole fraction)	4.67E-6	4.67E-6	4.67E-6
Intact rigid drum liner release rate coefficient (mole/s/mole fraction)	1.83E-8	1.83E-8	1.83E-8
Punctured rigid drum liner release rate coefficient (mole/s/mole fraction)	5.09E-5	5.09E-5	5.09E-5
Multiple bag innermost void volume (L)	34.0	125.1	107.0
Rigid drum liner void volume (L)	26.7	13.9	20.4
Annular (i.e., drum headspace) void volume (L)	28.0	28.0	28.0
Initial G-value for dose $<$ 0.006 Watt · yr (molecules/ 100 eV)	1.6 (for I.1) 1.3 (for I.2) 0.4 (for I.3)	1.7	3.4
MDP revised, matrix depleted G-value for dose $>$ 0.006 Watt · yr (molecules/100 eV)	0.25 (for I.1) 0.25 (for I.2) 0.4 (for I.3)	0.23	0.44

Table C-2. INEEL TWCP data supplied as input to the NEWGVALS code.

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Wattage	Waste material type	Number of layers of confinement	Sampling location[b]	Flammable gas concentration (Vol%)
I	371	300	3009	552	0.007973	II.1	4	DH	0.04
I	373	300	3012	273	0.07535	II.1	4	DH	0.04
I	393	480	2564	552	0.03465	II.1	5	DH	0.04
I	401	371	3323	223	0.1017	III.1	5	DH	0.03
I	405	480	3778	217	0.06002	II.1	5	DH	0.07
I	501	300	2749	389	0.06624	II.1	4	DH	0.06
I	558	440	3463	7	0.008164	II.1	6	DH	0.09
I	567	371	3402	177	0.1711	III.1	5	DH	0.03
I	613	300	2875	559	0.02414	II.1	4	DH	0.126
I	827	303	2413	686	0.04185	II.1	4	DH	0.09
I	828	300	2415	273	0.01058	II.1	4	DH	0.04
I	1016	300	2412	389	0.01399	II.1	4	DH	0.1
I	1024	300	2386	389	0.04148	II.1	4	DH	0.06
I	1157	339	2701	303	0.04022	III.1	4	DH	0.08
I	1161	300	2852	273	0.0467	II.1	4	DH	0.04
I	1346	292	3165	1036	0.008292	I.1	0	DH	0.02
I	1361	339	2359	288	0.01349	III.1	4	DH	0.07
I	1370	339	2368	282	0.05901	III.1	4	DH	0.1
I	1493	1	3633	278	0.02945	I.2	2	DH	0.03
I	1498	480	2883	561	0.3989	II.1	5	DH	0.05
I	1521	292	3100	1043	0.005621	I.1	0	DH	0.06
I	1619	300	2606	562	0.03655	II.1	4	DH	0.05
I	1633	432	2609	645	0.04992	III.1	4	DH	0.16
I	1635	303	2413	686	0.02516	II.1	4	DH	0.09
I	1636	320	3610	236	0.1327	II.1	4	DH	0.03
I	1655	339	2702	310	0.02185	III.1	4	DH	0.13
I	1662	300	2539	555	0.01323	II.1	4	DH	0.04
I	1663	432	3323	12	0.03193	III.1	4	DH	5.11
I	1667	300	2516	395	0.03481	II.1	4	DH	0.126
I	1677	302	2574	385	0.01653	III.1	4	DH	0.125
I	1689	302	2444	657	0.02207	III.1	4	DH	0.09
I	1692	432	3191	12	0.03419	III.1	4	DH	0.09
I	1694	374	3215	243	0.001588	III.1	4	DH	0.03
I	1695	339	2814	310	0.0881	III.1	4	DH	0.14
I	1697	300	2464	395	0.02194	II.1	4	DH	0.04
I	1752	300	2872	395	0.04648	II.1	4	DH	0.04
I	1753	339	3236	236	0.01295	III.1	4	DH	0.03
I	1754	320	2468	22	0.004689	II.1	4	DH	0.02
I	1779	300	2241	391	0.03519	II.1	4	DH	0.08
I	1784	339	2705	310	0.02014	III.1	4	DH	0.14
I	2077	339	3085	236	0.0147	III.1	4	DH	0.03
I	2338	371	2582	663	0.004527	III.1	5	DH	0.13
I	2363	371	2348	656	0.5601	III.1	5	DH	0.13
I	2365	480	2884	565	0.3807	II.1	5	DH	0.06
I	2368	480	3617	265	0.2225	II.1	5	DH	0.06
I	2678	432	3338	12	0.007939	III.1	4	DH	0.125
I	2712	292	4349	60	0.0694	I.1	0	DH	0.15

Table C-2. (continued).

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Wattage	Waste material type	Number of layers of confinement	Sampling location[b]	Flammable gas concentration (Vol%)
I	2791	371	2693	663	0.1209	III.1	5	DH	0.13
I	2797	432	3327	12	0.05572	III.1	4	DH	0.09
I	2814	7	3351	278	0.004017	I.2	2	DH	0.03
I	3088	371	2686	663	0.1694	III.1	5	DH	0.13
I	3091	371	2557	663	0.06201	III.1	5	DH	0.14
I	3268	1	3470	1000	0.031812	I.2	2	DH	0.02
I	3277	1	3416	278	0.003302	I.2	2	DH	0.03
I	3547	7	3420	237	0.004941	I.2	2	DH	0.03
I	3991	339	2278	288	0.08234	III.1	4	DH	0.08
I	3997	339	2283	309	0.1595	III.1	4	DH	0.28
I	4112	300	2852	386	0.03475	II.1	4	DH	0.05
I	4118	480	2991	565	0.003902	II.1	5	DH	0.04
I	4119	371	2686	663	0.2874	III.1	5	DH	0.14
I	4123	339	2355	288	0.04346	III.1	4	DH	0.11
I	4150	300	2329	540	0.04347	II.1	4	DH	0.04
I	4160	339	2328	375	0.02159	III.1	4	DH	0.17
I	4166	371	2693	663	0.01765	III.1	5	IB	0.036
I	4186	339	2387	304	0.02938	III.1	4	DH	0.08
I	4196	300	2381	267	0.08248	II.1	4	DH	0.04
I	4208	300	2635	379	0.1221	II.1	4	DH	0.16
I	4456	7	3834	16	0.08813	I.2	2	DH	0.02
I	4799	7	3858	28	0.02393	I.2	2	DH	0.02
I	4963	339	2420	375	0.383	III.1	4	DH	0.11
I	5012	339	2284	379	0.03121	III.1	4	DH	0.04
I	5234	303	2460	676	0.08321	II.1	4	DH	0.09
I	5235	432	2452	630	0.08881	III.1	4	DH	0.07
I	5415	1	2997	208	0.1464	I.2	2	DH	0.06
I	5530	303	2490	262	0.03342	II.1	4	DH	0.04
I	5535	432	2573	631	0.1125	III.1	4	DH	0.06
I	5607	432	3330	251	0.1324	III.1	4	DH	0.04
I	5697	7	2694	217	0.03169	I.2	2	DH	0.03
I	5698	7	3550	13	0.002064	I.2	2	DH	0.02
I	5880	481	2815	629	0.4193	II.1	5	DH	0.04
I	6252	339	3059	172	0.01799	III.1	4	DH	0.03
I	6711	7	4168	28	0.000296	I.2	2	DH	0.02
I	6857	339	2492	324	0.02605	III.1	4	DH	0.04
I	6875	303	3195	11	0.0106	II.1	4	DH	0.93
I	6879	432	2463	630	0.05867	III.1	4	DH	0.05
I	6918	292	3190	1051	0.03991	I.1	0	DH	0.11
I	7034	337	5603	1903	0.007931	III.1	5	DH	0.126
I	7061	490	5319	3106	0.002552	III.1	4	DH	0.014
I	7104	338	5433	1685	0.000586	III.1	4	DH	0.02
I	7170	337	5503	1803	0.000614	III.1	5	DH	0.086
I	7231	338	5502	1925	0.04999	III.1	4	DH	0.05
I	7262	817	3710	47	0.043376	I.3	2	DH	0.08
I	7491	817	3670	47	0.012549	I.3	2	DH	0.03
I	7518	330	2702	90	0.02956	III.1	5	DH	0.05

Table C-2. (continued).

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Wattage	Waste material type	Number of layers of confinement	Sampling location[b]	Flammable gas concentration (Vol%)
I	7594	822	3975	54	0.002945	I.3	2	DH	0.03
I	7667	7	2806	229	0.08166	I.2	2	DH	0.03
I	8161	822	3742	47	0.011346	I.3	2	DH	0.02
I	8203	440	2996	84	0.16	II.1	6	DH	0.09
I	8207	336	3136	84	0.1101	III.1	4	DH	0.09
I	8218	330	3136	84	0.09855	III.1	5	DH	0.09
I	8250	822	2781	208	0.01	I.3	2	DH	0.03
I	8262	818	3740	53	0.000924	I.3	2	DH	0.02
I	8287	374	2756	90	0.000011	III.1	4	DH	0.05
I	8288	818	2760	208	0.0013	I.3	2	DH	0.03
I	8355	1	3600	91	0.016443	I.2	2	DH	0.02
I	8383	339	2756	229	0.01518	III.1	4	DH	0.034
I	8403	817	3655	53	0.077	I.3	2	DH	0.05
I	8473	1	3643	35	0.039591	I.2	2	DH	0.04
I	8569	807	3489	7	0.0008	I.2	2	DH	0.02
I	8683	807	2583	68	0.001	I.2	2	DH	0.05
I	8848	440	3019	391	0.01323	II.1	6	DH	0.1
I	8859	440	3553	14	0.01187	II.1	6	DH	1.09
I	8864	480	3009	552	0.001484	II.1	5	DH	0.04
I	8878	480	2990	552	0.016	II.1	5	DH	0.2
I	8993	312	3019	676	0.1098	II.1	4	DH	0.09
I	9011	7	3729	237	0.00412	I.2	2	DH	0.03
I	9180	339	2927	283	0.137	III.1	4	DH	0.29
I	9225	481	3099	629	0.1311	II.1	5	DH	0.05
I	9252	339	3262	310	0.1235	III.1	4	DH	0.65
I	9294	480	3103	548	0.01037	II.1	5	DH	0.05
I	9296	440	2967	632	0.00561	II.1	6	DH	0.04
I	9299	339	2926	375	0.07217	III.1	4	DH	0.08
I	9423	337	3210	508	0.01422	III.1	5	DH	0.034
I	9435	337	3205	611	0.003197	III.1	5	DH	0.103
I	9449	440	2949	622	0.005978	II.1	6	DH	0.04
I	9465	292	3915	1043	0.2306	I.1	0	DH	0.19
I	9471	337	3217	227	0.008701	III.1	5	DH	0.03
I	9489	337	3206	228	0.004796	III.1	5	DH	0.03
I	9587	320	3116	229	0.001615	II.1	4	DH	0.03
I	9591	440	3152	83	0.1824	II.1	6	DH	0.12
I	9592	440	2947	83	0.1696	II.1	6	DH	0.09
I	9599	440	3160	83	0.05952	II.1	6	DH	0.09
I	9602	442	3171	618	0.01369	II.1	5	DH	0.05
I	9653	480	2994	561	0.05315	II.1	5	DH	0.04
I	9694	300	2995	381	0.0562	II.1	4	DH	0.1
I	9773	339	6949	380	0.02104	III.1	4	DH	0.09
I	10216	338	1376	1855	0.00144	III.1	4	DH	0.086
I	10224	338	5488	1925	0.03923	III.1	4	DH	0.07
I	10228	1	5483	3014	0.02667	I.2	2	DH	0.06
I	10230	330	5391	1925	0.01697	III.1	5	DH	0.09
I	10270	337	2355	1756	0.01226	III.1	5	DH	0.05

Table C-2. (continued).

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Wattage	Waste material type	Number of layers of confinement	Sampling location[b]	Flammable gas concentration (Vol%)
I	10273	337	2268	1411	0.005739	III.1	5	DH	0.03
I	10276	337	2321	2184	0.02554	III.1	5	DH	0.03
I	10305	442	1977	2410	0.000461	II.1	5	DH	0.03
I	10364	337	2253	2197	0.006677	III.1	5	DH	0.04
I	10365	337	2253	2265	0.01742	III.1	5	DH	0.02
I	10370	337	2337	2153	0.02405	III.1	5	DH	0.03
I	10371	337	2293	1620	0.006318	III.1	5	DH	0.02
I	10387	337	2309	1400	0.005651	III.1	5	DH	0.03
I	10411	337	2059	1965	0.004242	III.1	5	DH	0.05
I	10416	337	2059	1672	0.01085	III.1	5	DH	0.04
I	10449	300	2034	2551	0.05971	II.1	4	DH	0.014
I	10480	374	2021	2581	0.004171	III.1	4	DH	0.014
I	10492	480	2033	2008	0.000432	II.1	5	DH	0.04
I	10498	480	2064	2003	0.1455	II.1	5	DH	0.05
I	10512	337	5573	1573	0.003843	III.1	5	DH	0.02
I	10578	432	5608	2105	0.01142	III.1	4	DH	0.097
I	10578	432	5608	2105	0.01142	III.1	4	IB	0.181
I	10604	2	5566	2853	0.003582	I.2	2	DH	0.014
I	10606	330	5463	2131	0.02106	III.1	5	DH	0.09
I	10617	336	5476	2468	0.000061	III.1	4	DH	0.03
I	10655	330	5481	2468	0.01738	III.1	5	DH	0.06
I	10663	337	5596	1712	0.00042	III.1	5	DH	0.086
I	10699	330	7698	231	0.01302	III.1	5	DH	0.03
I	10705	336	5566	2453	0.0106	III.1	4	DH	0.03
I	10734	1	5499	3055	0.077234	I.2	2	DH	0.05
I	10739	1	5573	3034	0.042088	I.2	2	DH	0.03
I	10797	1	5503	3055	0.06254	I.2	2	DH	0.08
I	10800	338	5573	1785	0.024	III.1	4	DH	0.04
I	10808	337	5454	1967	0.00481	III.1	5	IB	0.034
I	10808	337	5454	1967	0.00481	III.1	5	DH	0.034
I	10837	432	5607	2105	0.0173	III.1	4	DH	0.14
I	10848	338	5578	1769	0.05097	III.1	4	DH	0.04
I	10883	432	5589	2091	0.02182	III.1	4	DH	0.05
I	10910	441	5280	3022	0.000595	III.1	5	DH	0.014
I	10921	371	5596	2084	0.03025	III.1	5	DH	0.05
I	10922	432	5609	3245	0.02633	III.1	4	DH	0.05
I	10976	2	5450	2983	0.001039	I.2	2	DH	0.014
I	11042	442	1864	2170	0.01809	II.1	5	DH	0.04
I	11044	440	1980	2169	0.003545	II.1	6	DH	0.05
I	11156	376	2150	2680	0.02043	III.1	4	DH	0.02
I	11162	432	2150	2951	0.1259	III.1	4	DH	0.324
I	11173	480	2164	2041	0.03429	II.1	5	DH	0.13
I	11224	300	590	4232	0.01839	II.1	4	DH	0.014
I	11259	330	5480	2468	0.03326	III.1	5	DH	0.03
I	11274	440	5620	2453	0.005625	II.1	6	DH	0.03
I	11393	480	2986	552	0.00237	II.1	5	DH	0.05
I	11415	480	5590	2020	0.002579	II.1	5	DH	0.125

Table C-2. (continued).

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Wattage	Waste material type	Number of layers of confinement	Sampling location[b]	Flammable gas concentration (Vol%)
I	11416	337	5594	2057	0.004033	III.1	5	DH	0.04
I	11433	330	5597	1712	0.000527	III.1	5	DH	0.086
I	11482	371	5562	2468	0.001296	III.1	5	DH	0.03
I	11498	432	5633	2091	0.02963	III.1	4	DH	0.09
I	11607	330	5576	1764	0.000907	III.1	5	DH	0.06
I	11637	338	5573	1840	0.02325	III.1	4	DH	0.05
I	11638	336	5491	2468	0.002951	III.1	4	DH	0.03
I	11653	432	5633	2091	0.02757	III.1	4	DH	0.07
I	11695	336	5579	2468	0.000464	III.1	4	DH	0.03
I	11699	480	5574	2453	0.007889	II.1	5	DH	0.03
I	11735	330	5581	2057	0.005497	III.1	5	DH	0.034
I	11749	441	5490	2098	0.007546	III.1	5	DH	0.04
I	11799	292	3038	236	0.0127	I.1	0	DH	0.04
I	11801	292	3048	226	0.0208	I.1	0	DH	0.06
I	12108	292	2290	2313	0.04051	I.1	0	DH	0.09
I	12111	337	1717	1791	0.007315	III.1	5	DH	0.03
I	12266	1	5571	3037	0.053961	I.2	2	DH	0.05
I	12300	970	5598	2468	0.006108	III.1	4	DH	0.03
I	12313	336	5580	1712	0.001622	III.1	4	DH	0.03
I	12317	1	5595	3062	0.015738	I.2	2	DH	0.02
I	12320	336	5586	2057	0.007294	III.1	4	DH	0.04
I	12324	335	5561	1573	0.01257	III.1	4	DH	0.02
I	12357	480	5581	2433	0.001861	II.1	5	DH	0.04
I	12433	338	5489	1785	0.02195	III.1	4	DH	0.04
I	12469	1	1967	2502	0.02495	I.2	2	DH	0.04
I	12471	338	5579	1840	0.07667	III.1	4	DH	0.05
I	12480	2	5353	2983	0.000664	I.2	2	DH	0.014
I	12487	440	5489	1916	0.004524	II.1	6	DH	0.04
I	12541	442	5476	2164	0.003935	II.1	5	DH	0.04
I	12683	1	2354	3153	0.266131	I.2	2	DH	0.09
I	12802	337	2387	1840	0.000455	III.1	5	DH	0.08
I	12809	480	5599	2020	0.01463	II.1	5	DH	0.04
I	12873	2	5566	3141	0.003844	I.2	2	DH	0.02
I	12874	336	5594	2131	0.002588	III.1	4	DH	0.09
I	12875	432	5597	2091	0.01113	III.1	4	DH	0.097
I	12878	480	5597	2000	0.0077	II.1	5	DH	0.126
I	12881	432	5580	2468	0.0297	III.1	4	DH	0.08
I	12885	330	5588	2468	0.001328	III.1	5	DH	0.03
I	12891	330	5496	2057	0.009838	III.1	5	DH	0.034
I	12898	490	5289	3014	0.01859	III.1	4	DH	0.014
I	12902	338	5587	1743	0.054	III.1	4	DH	0.04
I	12914	374	5287	3014	0.000129	III.1	4	DH	0.014
I	12986	302	5579	1846	0.002531	III.1	4	DH	0.034
I	12998	337	5587	2057	0.01068	III.1	5	DH	0.05
I	13003	823	3612	53	0.001	I.3	2	DH	0.02
I	13040	823	3597	47	0.001295	I.3	2	DH	0.02
I	13042	823	3612	53	0.002361	I.3	2	DH	0.02

Table C-2. (continued).

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Wattage	Waste material type	Number of layers of confinement	Sampling location[b]	Flammable gas concentration (Vol%)
I	13171	822	3612	53	0.03969	I.3	2	DH	0.26
I	13182	817	3656	53	0.041653	I.3	2	DH	0.09
I	13184	817	3656	53	0.040472	I.3	2	DH	0.06
I	13188	823	3635	53	0.002698	I.3	2	DH	0.02
I	13197	823	3639	53	0.002518	I.3	2	DH	0.02
I	13204	823	3639	53	0.00519	I.3	2	DH	0.03
I	13229	432	3029	12	0.003608	III.1	4	DH	0.125
I	13231	300	2380	379	0.1261	II.1	4	DH	0.06
I	13252	371	2686	663	0.1422	III.1	5	DH	0.13
I	13266	339	2621	303	0.0941	III.1	4	DH	0.12
I	13269	440	2797	508	0.003416	II.1	6	DH	0.06
I	13313	440	2872	632	0.006308	II.1	6	DH	0.04
I	13342	440	2786	392	0.001773	II.1	6	DH	0.05
I	13361	292	4095	54	0.006058	I.1	0	DH	0.02
I	13527	336	5585	2084	0.001062	III.1	4	DH	0.04
I	13531	440	5584	2537	0.009778	II.1	6	DH	0.02
I	13620	970	5600	2832	0.0197	III.1	4	DH	0.014
I	13661	336	5566	2468	0.000697	III.1	4	DH	0.03
I	13677	338	5579	1785	0.09592	III.1	4	DH	0.04
I	13696	480	2462	1551	0.002051	II.1	5	DH	0.02
I	13751	480	5485	2007	0.00153	II.1	5	DH	0.125
I	13763	339	2406	1	0.02838	III.1	4	DH	0.13
I	13818	1	3573	278	0.05129	I.2	2	DH	0.04
I	13847	300	2666	385	0.02832	II.1	4	DH	0.04
I	13860	339	2284	324	0.08593	III.1	4	DH	0.08
I	13876	7	3626	302	0.001195	I.2	2	DH	0.03
I	13885	292	3087	1042	0.06201	I.1	0	DH	0.21
I	14007	1	3113	3	0.6162	I.2	2	DH	0.26
I	14330	303	2578	266	0.07183	II.1	4	DH	0.07
I	14339	432	2446	650	0.03313	III.1	4	DH	0.13
I	14342	303	2596	262	0.1233	II.1	4	DH	0.04
I	14345	432	2461	632	0.01963	III.1	4	DH	0.05
I	14346	339	2462	374	0.09625	III.1	4	DH	0.12
I	14357	339	2585	112	0.01839	III.1	4	DH	0.02
I	14362	490	2429	612	0.07629	III.1	4	DH	0.09
I	14466	302	2610	670	0.00622	III.1	4	DH	0.314
I	14484	300	2693	545	0.149025	II.1	4	DH	0.04
I	15241	442	3107	618	0.008252	II.1	5	DH	0.05
I	15249	300	3020	262	0.08344	II.1	4	DH	0.04
I	15675	480	3023	548	0.08593	II.1	5	DH	0.06
I	16597	481	3099	629	0.04594	II.1	5	DH	0.05
I	16612	442	3096	629	0.06395	II.1	5	DH	0.04
I	16790	300	3063	380	0.005498	II.1	4	DH	0.07
I	16986	442	3166	629	0.002706	II.1	5	DH	0.04
I	17148	432	3105	630	0.007292	III.1	4	DH	0.05
I	17444	300	3062	559	0.01043	II.1	4	DH	0.04
I	17491	300	3409	172	0.02066	II.1	4	DH	0.126

Table C-2. (continued).

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Wattage	Waste material type	Number of layers of confinement	Sampling location[b]	Flammable gas concentration (Vol%)
I	17495	442	3096	650	0.03958	II.1	5	DH	0.04
I	17698	292	3935	182	0.3867	I.1	0	DH	0.77
I	17709	1	3439	121	0.005946	I.2	2	DH	0.04
I	17742	440	3118	629	0.007796	II.1	6	DH	0.04
I	17759	432	3104	645	0.003707	III.1	4	IB	0.274
I	17759	432	3104	645	0.003707	III.1	4	DH	0.126
I	18152	1	3858	643	0.02707	I.2	2	DH	0.024
I	18181	292	3849	1041	0.001399	I.1	0	DH	0.02
I	18195	292	3875	1040	0.01964	I.1	0	DH	0.06
I	18229	292	3875	1040	0.1118	I.1	0	DH	0.08
I	18299	376	2505	89	0.01875	III.1	4	DH	0.05
I	18413	300	2830	230	0.03744	II.1	4	DH	0.03
I	18441	300	3101	83	0.1462	II.1	4	DH	0.09
I	18456	822	3937	53	0.007286	I.3	2	DH	0.02
I	18476	292	3000	208	0.00824	I.1	0	DH	0.03
I	18491	300	2925	84	0.06244	II.1	4	DH	0.09
I	18806	800	3710	139	0.050657	I.2	2	DH	0.02
I	19410	339	2996	208	0.002744	III.1	4	DH	0.034
I	19413	339	2974	229	0.00662	III.1	4	DH	0.044
I	19413	339	2974	229	0.00662	III.1	4	IB	0.047
I	19413	339	2974	229	0.00662	III.1	4	IB	0.047
I	19572	339	3069	83	0.05664	III.1	4	DH	0.11
I	19664	803	3723	7	0.0045	I.2	2	DH	0.05
I	20903	807	3153	35	0.001875	I.2	2	DH	0.02
I	20937	481	2319	2237	0.005337	II.1	5	DH	0.02
I	20969	440	2296	2191	0.009684	II.1	6	DH	0.014
I	21392	292	3892	307	0.2092	I.1	0	DH	0.34
I	21442	1	1783	1717	0.01926	I.2	2	DH	0.08
I	21622	480	2366	1783	0.01118	II.1	5	DH	0.04
I	21661	374	2402	2297	9.54E-05	III.1	4	DH	0.014
I	21740	440	2519	2259	0.1255	II.1	6	DH	0.03
I	21806	440	2351	1670	0.01156	II.1	6	DH	0.05
I	22023	442	2539	2365	0.000996	II.1	5	DH	0.014
I	22102	432	2520	1982	0.04998	III.1	4	DH	0.18
I	22119	371	2378	1805	0.134	III.1	5	DH	0.09
I	22226	371	2358	2140	0.3812	III.1	5	DH	0.03
I	22228	371	2267	1896	0.2113	III.1	5	DH	0.09
I	22230	371	2253	1910	0.117	III.1	5	DH	0.09
I	22271	480	2319	1733	0.01663	II.1	5	DH	0.05
I	22275	480	2134	1877	0.06749	II.1	5	DH	0.05
I	22290	376	2269	2574	3.57E-05	III.1	4	DH	0.014
I	22291	376	2280	2379	6.27E-05	III.1	4	DH	0.014
I	22293	480	2146	1896	0.009918	II.1	5	DH	0.125
I	22296	1	2321	1644	0.06173	I.2	2	DH	0.08
I	22306	440	2372	1812	0.003201	II.1	6	DH	0.04
I	22347	440	2366	1643	0.0649	II.1	6	DH	0.04
I	22358	480	2392	1709	0.003205	II.1	5	DH	0.04

Table C-2. (continued).

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Wattage	Waste material type	Number of layers of confinement	Sampling location[b]	Flammable gas concentration (Vol%)
I	22416	320	2479	2141	0.0484	II.1	4	DH	0.07
I	22434	432	2506	1744	0.127	III.1	4	DH	0.15
I	22450	320	2645	2134	0.057	II.1	4	DH	0.03
I	22511	480	2372	1841	0.00265	II.1	5	DH	0.05
I	22517	432	2408	1807	0.0482	III.1	4	DH	0.16
I	22539	432	2459	1756	0.1084	III.1	4	DH	0.32
I	22549	480	2372	1764	0.003253	II.1	5	IB	0.125
I	22552	442	2424	1778	0.008079	II.1	5	DH	0.04
I	22790	292	2283	1587	0.02391	I.1	0	DH	0.09
I	22803	371	2321	1842	0.1386	III.1	5	DH	0.09
I	22811	7	2206	1629	0.001492	I.2	2	DH	0.034
I	22874	371	2358	1798	0.1159	III.1	5	DH	0.14
I	22880	376	2251	2364	0.000228	III.1	4	DH	0.014
I	22920	292	2239	3018	0.07323	I.1	0	DH	0.16
I	22923	440	2243	1846	0.004188	II.1	6	DH	0.04
I	23005	7	2190	1966	0.001015	I.2	2	DH	0.09
I	23033	292	2373	2933	0.04545	I.1	0	DH	0.13
I	23041	371	2358	2170	0.2705	III.1	5	DH	0.04
I	23048	432	2193	1868	0.0717	III.1	4	DH	0.13
I	23211	376	2187	83	0.000025	III.1	4	DH	0.09
I	23212	480	2061	2387	0.04851	II.1	5	DH	0.03
I	23227	480	2056	1964	0.02176	II.1	5	DH	0.05
I	23235	336	2124	2387	0.05278	III.1	4	DH	0.12
I	23246	481	2336	2280	0.1793	II.1	5	DH	0.07
I	23266	7	2206	2301	0.001179	I.2	2	DH	0.02
I	23285	7	2281	1887	0.008244	I.2	2	DH	0.09
I	23290	371	2335	2198	0.1409	III.1	5	DH	0.03
I	23301	337	2126	1556	0.006745	III.1	5	DH	0.03
I	23384	339	1933	1646	0.07953	III.1	4	DH	0.06
I	23388	330	2389	1564	0.002529	III.1	5	DH	0.03
I	23662	442	2407	1870	0.007999	II.1	5	DH	0.04
I	23739	440	2530	2279	0.05366	II.1	6	DH	0.02
I	23771	330	2499	2225	0.1163	III.1	5	DH	0.16
I	23805	480	2680	1722	0.0385	II.1	5	DH	0.04
I	23840	337	2520	1408	0.03826	III.1	5	DH	0.03
I	23844	480	2677	1741	0.1482	II.1	5	DH	0.04
I	23901	330	2416	1423	0.000042	III.1	5	DH	0.086
I	23929	440	2307	2193	0.01352	II.1	6	DH	0.04
I	23959	480	2320	1832	0.08892	II.1	5	DH	0.04
I	23984	300	2316	2286	0.0628	II.1	4	DH	0.02
I	24028	440	2275	2254	0.1405	II.1	6	DH	0.03
I	24029	480	2252	1577	0.046	II.1	5	DH	0.04
I	24057	292	18281	3058	0.08208	I.1	0	DH	0.19
I	24059	292	2584	1945	0.1272	I.1	0	DH	0.38
I	24086	337	2507	2176	0.07016	III.1	5	DH	0.06
I	24088	337	2288	1863	0.003458	III.1	5	DH	0.04
I	24090	337	2313	1499	0.01942	III.1	5	DH	0.03

Table C-2. (continued).

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Wattage	Waste material type	Number of layers of confinement	Sampling location[b]	Flammable gas concentration (Vol%)
I	24092	337	2289	1868	0.01136	III.1	5	IB	0.126
I	24092	337	2289	1868	0.01136	III.1	5	DH	0.126
I	24095	337	2381	1510	0.02475	III.1	5	DH	0.03
I	24102	337	2366	1870	0.01499	III.1	5	DH	0.05
I	24106	337	2403	1864	0.01802	III.1	5	DH	0.04
I	24113	337	2344	1869	0.03259	III.1	5	DH	0.05
I	24159	336	2501	1232	0.007108	III.1	4	DH	0.03
I	24165	337	2330	1821	0.01284	III.1	5	DH	0.04
I	24168	330	2480	1736	0.08586	III.1	5	DH	0.04
I	24190	480	2845	1098	0.009825	II.1	5	DH	0.03
I	24273	442	2380	1897	0.004586	II.1	5	DH	0.04
I	24279	442	2505	2310	0.007361	II.1	5	DH	0.014
I	24289	440	2382	2285	0.00454	II.1	6	DH	0.03
I	24358	480	2751	1699	0.008657	II.1	5	DH	0.05
I	24506	374	2121	84	0.000033	III.1	4	DH	0.09
I	24662	480	2627	1810	0.006986	II.1	5	DH	0.04
I	24786	480	2677	1737	0.008052	II.1	5	DH	0.086
I	24807	480	2631	1350	0.004975	II.1	5	DH	0.08
I	24862	480	2431	1930	0.01922	II.1	5	DH	0.05
I	24884	480	2430	1916	0.016	II.1	5	DH	0.05
I	24920	1	2655	2095	0.06473	I.2	2	DH	0.09
I	27455	1	2877	2793	0.052005	I.2	2	DH	0.03
I	27540	1	2628	2574	0.187952	I.2	2	DH	0.1
I	27877	481	2916	2443	0.1293	II.1	5	DH	0.014
I	29152	1	3137	2780	0.875811	I.2	2	DH	0.12
I	29699	292	3322	2800	0.060003	I.1	0	DH	0.14
I	30585	440	3259	2414	0.004579	II.1	6	DH	0.014
I	31128	7	2205	2604	0.003228	I.2	2	DH	0.02
I	31502	432	2267	2757	0.001342	III.1	4	DH	0.02
I	31507	7	2227	2595	0.003311	I.2	2	DH	0.02
I	31546	7	49	4787	0.000788	I.2	2	DH	0.02
I	31689	7	2268	2412	0.001379	I.2	2	DH	0.014
I	31711	1	2296	2532	0.059739	I.2	2	DH	0.02
I	31806	7	2360	2661	0.002121	I.2	2	DH	0.02
I	32284	339	2237	1358	0.1012	III.1	4	DH	0.26
I	32287	7	2013	2299	0.001138	I.2	2	DH	0.03
I	32467	337	2334	1638	0.005336	III.1	5	DH	0.04
I	32469	337	2326	2083	0.005999	III.1	5	DH	0.03
I	32471	337	2340	1148	0.008494	III.1	5	DH	0.02
I	32473	337	2326	1632	0.003387	III.1	5	DH	0.04
I	32485	337	2334	1632	0.00653	III.1	5	DH	0.04
I	32517	339	2288	2065	0.04699	III.1	4	DH	0.11
I	32521	339	2288	1416	0.1454	III.1	4	DH	0.33
I	32525	339	2289	1324	0.07472	III.1	4	DH	0.2
I	32526	339	2326	1344	0.08137	III.1	4	DH	0.1
I	32529	336	2088	1540	0.002605	III.1	4	DH	0.086
I	32540	480	2293	1667	0.05009	II.1	5	DH	0.05

Table C-2. (continued).

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Wattage	Waste material type	Number of layers of confinement	Sampling location[b]	Flammable gas concentration (Vol%)
I	32669	480	2265	2086	0.0329	II.1	5	DH	0.04
I	32715	337	2226	2091	0.008001	III.1	5	DH	0.03
I	32741	480	2246	1609	0.008277	II.1	5	DH	0.04
I	32748	339	2264	1182	0.02229	III.1	4	DH	0.08
I	33091	339	2251	1432	0.03681	III.1	4	DH	0.1

a. I = INEEL
b. DH = Drum headspace; IB = Inner bag (Innermost confinement layer)

Table C-3. RFETS TWCP data supplied as input to the NEWGVALS code.

Site ID[(a)]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Wattage	Waste material type	Number of layers of confinement	Sampling location[(b)]	Flammable gas concentration (Vol%)
R	D17184	800	2192	0	0.254885	I.2	2	DH	0.603
R	D35301	800	2227	0	0.366808	I.2	2	DH	0.0033
R	D60290	800	2324	0	0.123053	I.2	2	DH	0.3577
R	D61005	800	2698	0	0.087548	I.2	2	DH	4.9286
R	D61005	800	2698	15	0.087548	I.2	2	RL	0.1464
R	D61471	800	2527	0	0.254885	I.2	2	DH	3.5007
R	D63330	800	2702	0	0.087548	I.2	2	DH	7.7303
R	D63330	800	2702	0	0.087548	I.2	2	RL	5.1857
R	D63341	800	2670	0	0.087548	I.2	2	DH	7.2299
R	D63341	800	2670	0	0.087548	I.2	2	RL	6.859
R	D63344	800	2668	0	0.087548	I.2	2	DH	6.3753
R	D63344	800	2668	0	0.087548	I.2	2	RL	5.4401
R	D63484	800	2640	0	0.130186	I.2	2	DH	0.0513
R	D63484	800	2640	0	0.130186	I.2	2	RL	0.0498
R	D64197	800	2635	0	0.130186	I.2	2	DH	0.0033
R	D64197	800	2635	0	0.130186	I.2	2	RL	0.0353
R	D64383	800	2648	0	0.199001	I.2	2	DH	1.0475
R	D64383	800	2648	1	0.199001	I.2	2	RL	0.8172
R	D64631	800	2646	0	0.199001	I.2	2	DH	3.8746
R	D64631	800	2646	0	0.199001	I.2	2	RL	1.9622
R	D64632	800	2261	0	0.250653	I.2	2	DH	3.0205
R	D64997	800	2605	0	0.254885	I.2	2	DH	14.5676
R	D64997	800	2605	0	0.254885	I.2	2	RL	11.9154
R	D66525	800	1485	163	0.001176	I.2	2	DH	0.0097
R	D66525	800	1485	0	0.001176	I.2	2	DH	3.4368
R	D66525	800	1485	163	0.001176	I.2	2	IB	0.0497
R	D67434	800	1492	134	0.001176	I.2	2	DH	0.0035
R	D67434	800	1492	0	0.001176	I.2	2	DH	1.9198
R	D67434	800	1492	134	0.001176	I.2	2	IB	0.0083
R	D67436	800	1492	184	0.016302	I.2	2	DH	0.0038
R	D67436	800	1492	0	0.016302	I.2	2	DH	3.1291
R	D67436	800	1492	184	0.016302	I.2	2	IB	0.025
R	D67441	800	1493	134	0.015127	I.2	2	DH	0.0035
R	D67441	800	1493	0	0.015127	I.2	2	DH	1.4476
R	D67441	800	1493	134	0.015127	I.2	2	IB	0.0095
R	D67654	800	1493	169	0.015127	I.2	2	DH	0.0035
R	D67654	800	1493	0	0.015127	I.2	2	DH	2.5138
R	D67654	800	1493	169	0.015127	I.2	2	IB	0.0258
R	D67656	800	2178	0	0.013951	I.2	2	DH	1.3536
R	D67657	800	1493	170	0.015127	I.2	2	DH	0.0046
R	D67657	800	1493	0	0.015127	I.2	2	DH	1.7896
R	D67657	800	1493	170	0.015127	I.2	2	IB	0.0196
R	D67670	800	2473	0	0.015127	I.2	2	DH	1.2173
R	D67670	800	2473	1	0.015127	I.2	2	RL	1.2681
R	D68241	800	2351	0	0.024611	I.2	2	DH	0.1003
R	D68247	800	1485	167	0.001176	I.2	2	DH	0.0035
R	D68247	800	1485	0	0.001176	I.2	2	DH	0.0593

Table C-3. (continued).

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Wattage	Waste material type	Number of layers of confinement	Sampling location[b]	Flammable gas concentration (Vol%)
R	D68247	800	1485	167	0.001176	I.2	2	IB	0.0101
R	D68254	800	1488	169	0.001176	I.2	2	DH	0.0035
R	D68254	800	1488	0	0.001176	I.2	2	DH	0.0593
R	D68254	800	1488	169	0.001176	I.2	2	IB	0.0123
R	D68255	800	2466	0	0.013951	I.2	2	DH	0.1091
R	D68255	800	2466	0	0.013951	I.2	2	RL	0.2778
R	D68256	800	1491	183	0.002351	I.2	2	DH	0.005
R	D68256	800	1491	0	0.002351	I.2	2	DH	0.6887
R	D68256	800	1491	183	0.002351	I.2	2	IB	0.0226
R	D68261	800	2460	0	0.002351	I.2	2	DH	0.1706
R	D68261	800	2460	0	0.002351	I.2	2	RL	0.1706
R	D68480	800	1456	182	0.062702	I.2	2	DH	0.0321
R	D68480	800	1456	0	0.062702	I.2	2	DH	0.1798
R	D68480	800	1456	182	0.062702	I.2	2	IB	0.1799
R	D68483	800	2439	0	0.256376	I.2	2	DH	0.2947
R	D68606	800	2240	0	0.005643	I.2	2	DH	0.0033
R	D68983	800	2429	0	0.062702	I.2	2	DH	0.0133
R	D68983	800	2429	15	0.062702	I.2	2	RL	0.0087
R	D68992	800	2423	0	0.283257	I.2	2	DH	9.1399
R	D68992	800	2423	14	0.283257	I.2	2	RL	3.125
R	D69299	800	2407	0	0.149465	I.2	2	DH	12.9093
R	D69299	800	2407	0	0.149465	I.2	2	RL	12.8742
R	D69310	800	2212	0	0.202683	I.2	2	DH	2.2688
R	D69312	800	1427	135	0.149465	I.2	2	DH	0.0153
R	D69312	800	1427	0	0.149465	I.2	2	DH	10.0655
R	D69312	800	1427	135	0.149465	I.2	2	IB	0.019
R	D70213	800	2333	0	0.531714	I.2	2	DH	0.528
R	D70213	800	2333	0	0.531714	I.2	2	RL	0.7441
R	D70335	800	2350	0	0.003291	I.2	2	DH	3.0993
R	D70335	800	2350	1	0.003291	I.2	2	RL	1.0795
R	D70422	800	2052	0	0.051102	I.2	2	DH	0.7185
R	D72267	800	1287	191	0.010471	I.2	2	DH	0.0035
R	D72267	800	1287	0	0.010471	I.2	2	DH	0.0593
R	D72267	800	1287	191	0.010471	I.2	2	IB	0.022
R	D72545	800	1278	183	0.009868	I.2	2	DH	0.0035
R	D72545	800	1278	0	0.009868	I.2	2	DH	0.0593
R	D72545	800	1278	183	0.009868	I.2	2	IB	0.0232
R	D76138	1	3136	126	0.120702	I.2	2	DH	0.0165
R	D76138	1	3136	0	0.120702	I.2	2	DH	0.0147
R	D76138	1	3136	126	0.120702	I.2	2	IB	0.0803
R	D76142	1	2755	70	0.123053	I.2	2	DH	0.0129
R	D76142	1	2755	0	0.123053	I.2	2	DH	0.0078
R	D76142	1	2755	70	0.123053	I.2	2	IB	0.0488
R	D76144	1	3755	126	0.134808	I.2	2	DH	0.0341
R	D76144	1	3755	0	0.134808	I.2	2	DH	0.0097
R	D76144	1	3755	126	0.134808	I.2	2	IB	0.0838
R	D76182	1	4486	0	0.257861	I.2	2	DH	0.0762

Table C-3. (continued).

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Wattage	Waste material type	Number of layers of confinement	Sampling location[b]	Flammable gas concentration (Vol%)
R	D76183	1	2861	309	0.148914	I.2	2	DH	0.0374
R	D76183	1	2861	0	0.148914	I.2	2	DH	0.0349
R	D76183	1	2861	309	0.148914	I.2	2	IB	0.1373
R	D76185	1	1071	63	0.123053	I.2	2	DH	0.0111
R	D76185	1	1071	0	0.123053	I.2	2	DH	0.0059
R	D76185	1	1071	63	0.123053	I.2	2	IB	0.0353
R	D76194	1	3253	0	0.120702	I.2	2	DH	0.021
R	D76199	1	3001	309	0.132457	I.2	2	DH	0.028
R	D76199	1	3001	309	0.132457	I.2	2	IB	0.1075
R	D76205	1	2869	63	0.123053	I.2	2	DH	0.0285
R	D76205	1	2869	0	0.123053	I.2	2	DH	0.0035
R	D76205	1	2869	63	0.123053	I.2	2	IB	0.1267
R	D76287	1	4229	146	0.002351	I.2	2	DH	0.0092
R	D76287	1	4229	0	0.002351	I.2	2	DH	0.0081
R	D76287	1	4229	146	0.002351	I.2	2	IB	0.0235
R	D76302	1	3079	126	0.120702	I.2	2	DH	0.0126
R	D76302	1	3079	0	0.120702	I.2	2	DH	0.0076
R	D76302	1	3079	126	0.120702	I.2	2	IB	0.0215
R	D76305	1	4165	0	0.000235	I.2	2	DH	0.0057
R	D13364	480	2122	0	0.132457	II.1	4	DH	1.5656
R	D36606	480	1238	0	0.019632	II.1	4	DH	0.0593
R	D46848	320	2858	0	0.350303	II.1	4	DH	0.0033
R	D53211	442	2852	0	0.070531	II.1	4	DH	0.0168
R	D53211	442	2852	0	0.070531	II.1	4	RL	0.0368
R	D53886	320	3245	0	0.376964	II.1	4	DH	0.0798
R	D53886	320	3245	0	0.376964	II.1	4	RL	0.0033
R	D54192	480	2211	0	3.48E-06	II.1	4	DH	0.0117
R	D57847	480	1082	0	0.002351	II.1	4	DH	0.0593
R	D58347	321	3605	0	0.027361	II.1	4	DH	0.0024
R	D59077	438	2903	0	0.011755	II.1	4	RL	4.5287
R	D59568	377	3012	331	0.002628	II.1	4	DH	0.0018
R	D59663	438	2988	0	0.025861	II.1	4	DH	0.0872
R	D60463	444	1140	0	0.007053	II.1	4	DH	0.0137
R	D60525	440	2562	0	0.011755	II.1	4	RL	1.4303
R	D60684	300	3115	252	0.016613	II.1	4	DH	0.0018
R	D61905	377	3011	330	0.001596	II.1	4	DH	0.0018
R	D61961	377	3012	330	0.002494	II.1	4	DH	0.0021
R	D62018	377	3007	335	0.004426	II.1	4	DH	0.0018
R	D62049	442	2741	0	0.021159	II.1	4	RL	0.1508
R	D62179	440	3184	0	0.002288	II.1	4	RL	0.0018
R	D62545	480	2506	0	0.349551	II.1	4	DH	2.0743
R	D62545	480	2506	0	0.349551	II.1	4	RL	4.3922
R	D62579	377	3348	0	0.005538	II.1	4	RL	0.003
R	D62759	442	2742	0	0.007053	II.1	4	RL	0.0454
R	D63441	442	2733	0	0.002351	II.1	4	DH	0.0838
R	D63441	442	2733	0	0.002351	II.1	4	RL	0.0859
R	D63442	442	2733	0	0.018808	II.1	4	DH	1.1065

Table C-3. (continued).

Site ID[(a)]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Wattage	Waste material type	Number of layers of confinement	Sampling location[(b)]	Flammable gas concentration (Vol%)
R	D63442	442	2733	0	0.018808	II.1	4	RL	0.6914
R	D63446	442	2734	0	0.122253	II.1	4	DH	19.4369
R	D63446	442	2734	0	0.122253	II.1	4	RL	18.7192
R	D64480	480	2624	0	3.6E-07	II.1	4	DH	0.0033
R	D64538	442	2697	0	0.000268	II.1	4	RL	0.0116
R	D64562	442	2690	0	0.00047	II.1	4	DH	0.0439
R	D64562	442	2690	0	0.00047	II.1	4	RL	0.0443
R	D64720	312	2877	203	0.024233	II.1	4	DH	0.0018
R	D64752	480	1321	0	0.003615	II.1	4	DH	0.0593
R	D65734	480	2071	0	0.032914	II.1	4	DH	0.0059
R	D65738	300	2878	200	0.037353	II.1	4	DH	0.0018
R	D65957	312	2844	287	0.002923	II.1	4	DH	0.0018
R	D66090	300	2835	200	0.027358	II.1	4	DH	0.0037
R	D66157	480	1526	0	0.002351	II.1	4	DH	0.2771
R	D66670	442	2566	0	4.51E-05	II.1	4	RL	0.0569
R	D66679	442	2560	0	0.007053	II.1	4	DH	0.4567
R	D66682	442	2567	0	0.000801	II.1	4	RL	0.3742
R	D66709	442	2558	0	0.000364	II.1	4	DH	0.1507
R	D66709	442	2558	0	0.000364	II.1	4	RL	0.1095
R	D66773	480	1984	80	0.070531	II.1	4	DH	0.032
R	D66788	300	2837	229	0.017919	II.1	4	DH	0.0018
R	D66936	480	2383	0	0.001005	II.1	4	DH	0.3913
R	D66936	480	2383	0	0.001005	II.1	4	RL	0.1611
R	D67066	438	2527	0	0.131657	II.1	4	RL	10.9203
R	D67251	480	1490	0	0.000394	II.1	4	DH	0.0593
R	D67317	480	1471	0	0.011755	II.1	4	DH	0.4982
R	D67455	480	2056	0	0.063478	II.1	4	DH	0.4451
R	D67463	300	2796	229	0.023253	II.1	4	DH	0.0018
R	D67605	480	2461	0	0.116656	II.1	4	DH	4.3649
R	D67605	480	2461	0	0.116656	II.1	4	RL	2.3279
R	D67735	825	1745	0	0.000248	II.1	4	DH	0.0035
R	D67902	300	2759	200	0.031364	II.1	4	DH	0.0018
R	D67905	300	2934	0	0.034418	II.1	4	RL	0.0039
R	D68085	300	2899	0	0.025616	II.1	4	RL	0.0065
R	D68277	480	1743	0	0.043945	II.1	4	DH	0.0058
R	D68368	480	2308	0	0.1152	II.1	4	DH	0.6217
R	D68377	480	1475	0	0.000514	II.1	4	DH	0.0593
R	D68514	480	2054	0	0.002798	II.1	4	DH	0.3098
R	D68929	300	2920	0	0.017972	II.1	4	RL	0.0025
R	D68930	300	3001	0	0.023955	II.1	4	RL	0.0041
R	D69414	300	2904	0	0.018132	II.1	4	RL	0.0021
R	D69442	300	2903	0	0.033246	II.1	4	RL	0.0018
R	D70446	480	1316	0	0.030583	II.1	4	DH	0.0593
R	D71351	480	1352	0	0.025998	II.1	4	DH	0.0593
R	D71354	480	1347	0	0.005596	II.1	4	DH	0.0593
R	D71638	480	1312	0	0.002966	II.1	4	DH	0.0593
R	D72079	480	1506	0	0.03937	II.1	4	DH	0.0119

Table C-3. (continued).

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Wattage	Waste material type	Number of layers of confinement	Sampling location[b]	Flammable gas concentration (Vol%)
R	D72371	300	2780	0	0.014535	II.1	4	RL	0.0035
R	D72384	300	2751	0	0.029319	II.1	4	RL	0.0067
R	D72831	480	1279	0	0.009404	II.1	4	DH	0.0593
R	D75978	824	1626	0	0.002313	II.1	4	RL	0.0115
R	D76714	321	2319	0	0.035921	II.1	4	RL	0.0081
R	D76716	321	2335	0	0.025865	II.1	4	RL	0.0073
R	D78336	444	1433	0	0.000743	II.1	4	DH	0.0018
R	D85299	321	0	813	0.013568	II.1	4	DH	0.0063
R	D85389	824	0	870	0.007434	II.1	4	DH	0.007
R	D85406	824	0	870	0.011845	II.1	4	DH	0.0115
R	D85670	440	0	377	0.001196	II.1	4	DH	0.0133
R	D86658	480	0	352	0.000989	II.1	4	DH	0.0168
R	D86663	480	0	349	0.002645	II.1	4	DH	0.0042
R	D55521	825	2942	0	0.005061	III.1	4	RL	0.0073
R	D56036	832	2907	0	0.008834	III.1	4	RL	0.0218
R	D57202	832	2814	0	0.011201	III.1	4	RL	0.0222
R	D58972	822	2989	0	0.001933	III.1	4	RL	0.0018
R	D59898	825	3039	0	0.000771	III.1	4	RL	0.0027
R	D60704	822	2926	0	0.001685	III.1	4	RL	0.0056
R	D61288	825	2972	0	0.001625	III.1	4	RL	0.0753
R	D61804	825	2962	0	0.000332	III.1	4	RL	0.0018
R	D62184	825	2893	0	9.11E-05	III.1	4	RL	0.0063
R	D62353	831	3068	0	0.000225	III.1	4	RL	0.0018
R	D62548	822	2990	0	0.003728	III.1	4	RL	0.0282
R	D63572	825	3030	0	0.000338	III.1	4	RL	0.0018
R	D64270	832	3058	0	0.000595	III.1	4	RL	0.0026
R	D64413	825	3010	0	0.001123	III.1	4	RL	0.0035
R	D64708	339	2818	0	0.001656	III.1	4	RL	0.0037
R	D65122	822	3037	0	0.000384	III.1	4	RL	0.0018
R	D65123	831	3135	0	0.011231	III.1	4	RL	0.0396
R	D65302	831	3085	0	0.000864	III.1	4	RL	0.0023
R	D65448	825	3003	0	0.005294	III.1	4	RL	0.0018
R	D65515	822	3003	0	8.59E-05	III.1	4	RL	0.0018
R	D65721	833	3101	0	0.003027	III.1	4	RL	0.0108
R	D65722	831	3076	0	0.000238	III.1	4	RL	0.0018
R	D65768	822	2942	0	0.001337	III.1	4	RL	0.0018
R	D66126	822	3055	0	0.000733	III.1	4	RL	0.0482
R	D66464	832	3061	0	0.004	III.1	4	RL	0.0051
R	D66498	825	2926	0	0.00758	III.1	4	RL	0.0121
R	D66629	825	3039	0	0.00531	III.1	4	RL	0.0147
R	D66646	831	3056	0	0.001993	III.1	4	RL	0.0025
R	D66648	822	2995	0	0.001122	III.1	4	RL	0.0363
R	D66653	831	3070	0	0.002088	III.1	4	RL	0.0076
R	D66660	833	3079	0	0.003369	III.1	4	RL	0.0131
R	D66675	825	3058	0	0.000643	III.1	4	RL	0.0018
R	D66745	825	2980	0	0.000116	III.1	4	RL	0.0018
R	D66749	825	2968	0	0.000463	III.1	4	RL	0.0018

Table C-3. (continued).

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Wattage	Waste material type	Number of layers of confinement	Sampling location[b]	Flammable gas concentration (Vol%)
R	D66754	822	3021	0	9.24E-05	III.1	4	RL	0.0018
R	D66755	825	2961	0	0.000153	III.1	4	RL	0.0018
R	D66794	832	3132	0	0.000335	III.1	4	RL	0.0063
R	D66825	825	3107	0	0.006342	III.1	4	RL	0.0767
R	D66837	831	3129	0	0.006778	III.1	4	RL	0.0476
R	D66844	832	3038	0	0.000763	III.1	4	RL	0.0086
R	D66846	831	3068	0	0.000146	III.1	4	RL	0.0026
R	D66848	825	2799	0	0.000913	III.1	4	RL	0.0018
R	D66891	832	3092	0	0.000195	III.1	4	RL	0.008
R	D66923	825	3060	0	0.003123	III.1	4	RL	0.0593
R	D66924	822	2421	0	0.004471	III.1	4	RL	0.0065
R	D66927	825	3000	0	0.010745	III.1	4	RL	0.0342
R	D66980	822	2988	0	0.003802	III.1	4	RL	0.0061
R	D66990	821	2967	0	0.000497	III.1	4	RL	0.0023
R	D67054	831	3104	0	0.003489	III.1	4	RL	0.0064
R	D67057	831	3047	0	0.000737	III.1	4	RL	0.0019
R	D67082	831	3053	0	0.009509	III.1	4	RL	0.0197
R	D67110	822	2974	0	0.004064	III.1	4	RL	0.0162
R	D67132	832	3074	0	0.000364	III.1	4	RL	0.0067
R	D67157	822	3032	0	0.000647	III.1	4	RL	0.0018
R	D67233	832	3037	0	0.013823	III.1	4	RL	0.0495
R	D67305	831	3019	0	0.003539	III.1	4	RL	0.0107
R	D67328	831	3051	0	0.000272	III.1	4	RL	0.0044
R	D67377	822	3043	0	0.001896	III.1	4	RL	0.0018
R	D67380	822	3022	0	0.000743	III.1	4	RL	0.0018
R	D67385	825	2980	0	0.000702	III.1	4	RL	0.0018
R	D67444	832	3037	0	0.000627	III.1	4	RL	0.0045
R	D67456	831	2990	0	0.006499	III.1	4	RL	0.0118
R	D67537	825	2983	0	0.001128	III.1	4	RL	0.0018
R	D67544	825	3031	0	0.000361	III.1	4	RL	0.0018
R	D67647	832	2999	0	0.001569	III.1	4	RL	0.0018
R	D67714	822	3074	0	8.71E-05	III.1	4	RL	0.0063
R	D67874	825	2912	0	0.015278	III.1	4	RL	0.0178
R	D67901	832	3006	0	0.002643	III.1	4	RL	0.005
R	D67939	822	3015	0	0.000623	III.1	4	RL	0.0047
R	D67945	822	2979	0	0.000479	III.1	4	RL	0.0018
R	D67956	822	2925	0	0.001646	III.1	4	RL	0.0022
R	D68066	832	3004	0	0.009061	III.1	4	RL	0.004
R	D68072	832	2978	0	0.005086	III.1	4	RL	0.0019
R	D68080	832	3049	0	0.001326	III.1	4	RL	0.0075
R	D68149	832	3012	0	0.00281	III.1	4	RL	0.0032
R	D68157	825	3046	0	0.004185	III.1	4	RL	0.0285
R	D68171	832	3068	0	0.000647	III.1	4	RL	0.017
R	D68362	832	3060	0	0.001157	III.1	4	RL	0.002
R	D68366	831	3076	0	0.002849	III.1	4	RL	0.0104
R	D68379	831	3072	0	0.000815	III.1	4	RL	0.0063
R	D68448	832	2987	0	0.006757	III.1	4	RL	0.017

Table C-3. (continued).

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Wattage	Waste material type	Number of layers of confinement	Sampling location[b]	Flammable gas concentration (Vol%)
R	D68511	832	3063	0	0.001396	III.1	4	RL	0.0084
R	D68518	825	2878	0	0.000616	III.1	4	RL	0.0031
R	D68532	832	3060	0	0.001942	III.1	4	RL	0.0092
R	D68533	832	3054	0	0.000621	III.1	4	RL	0.0063
R	D68544	832	2982	0	0.000532	III.1	4	RL	0.0055
R	D68624	832	3070	0	0.002042	III.1	4	RL	0.0063
R	D68632	832	3063	0	0.000827	III.1	4	RL	0.0063
R	D68637	832	3058	0	0.003446	III.1	4	RL	0.007
R	D68640	832	2990	0	0.008571	III.1	4	RL	0.0252
R	D68665	832	3026	0	0.011766	III.1	4	RL	0.0298
R	D68676	825	2918	0	0.001928	III.1	4	RL	0.0067
R	D68711	833	2970	0	0.006794	III.1	4	RL	0.0201
R	D68740	832	2983	0	0.000615	III.1	4	RL	0.0018
R	D68748	833	2972	0	0.017386	III.1	4	RL	0.1028
R	D68769	825	2960	0	0.002253	III.1	4	RL	0.1118
R	D68784	832	3041	0	0.000665	III.1	4	RL	0.0063
R	D68787	822	3049	0	0.00071	III.1	4	RL	0.0063
R	D68790	822	2942	0	0.00922	III.1	4	RL	0.0259
R	D68794	822	2914	0	0.008217	III.1	4	RL	0.0263
R	D68807	832	2984	0	0.00641	III.1	4	RL	0.0075
R	D68821	832	3050	0	0.000689	III.1	4	RL	0.0063
R	D68826	825	2953	0	0.003255	III.1	4	RL	0.0018
R	D68838	825	2939	0	0.001954	III.1	4	RL	0.002
R	D68855	825	2955	0	0.001119	III.1	4	RL	0.0018
R	D68871	825	2962	0	0.005255	III.1	4	RL	0.0138
R	D68879	832	2990	0	0.005974	III.1	4	RL	0.0155
R	D68880	832	3049	0	0.00112	III.1	4	RL	0.0063
R	D68953	825	2941	0	0.003099	III.1	4	RL	0.0039
R	D68968	832	2962	0	0.013659	III.1	4	RL	0.0318
R	D69008	825	2976	0	0.003821	III.1	4	RL	0.0047
R	D69022	832	3034	0	0.00248	III.1	4	RL	0.0151
R	D69154	832	3038	0	0.001299	III.1	4	RL	0.0076
R	D69157	832	3025	0	0.000921	III.1	4	RL	0.0068
R	D69179	832	2949	0	0.002874	III.1	4	RL	0.0043
R	D69180	832	2974	0	0.002977	III.1	4	RL	0.0109
R	D69182	832	3027	0	0.002024	III.1	4	RL	0.0063
R	D69197	825	2977	0	0.00309	III.1	4	RL	0.0189
R	D69198	832	2958	0	0.011912	III.1	4	RL	0.0185
R	D69240	825	2332	0	0.00254	III.1	4	RL	0.0147
R	D69337	832	2963	0	0.002977	III.1	4	RL	0.0122
R	D69370	822	2884	0	0.000843	III.1	4	RL	0.0018
R	D69375	831	2841	0	0.005221	III.1	4	RL	0.01
R	D69480	822	2849	0	0.001234	III.1	4	RL	0.0036
R	D69511	825	2883	0	0.005116	III.1	4	RL	0.0018
R	D69516	832	2943	0	0.001008	III.1	4	RL	0.005
R	D69517	822	2874	0	0.001076	III.1	4	RL	0.0041
R	D69518	825	2926	0	0.001871	III.1	4	RL	0.0023

Table C-3. (continued).

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Wattage	Waste material type	Number of layers of confinement	Sampling location[b]	Flammable gas concentration (Vol%)
R	D69534	825	2985	0	0.000267	III.1	4	RL	0.0063
R	D69536	825	2914	0	0.000118	III.1	4	RL	0.0018
R	D69623	832	2951	0	0.011705	III.1	4	RL	0.0019
R	D69638	832	2966	0	0.009709	III.1	4	RL	0.0204
R	D69656	832	2923	0	0.001207	III.1	4	RL	0.0053
R	D69657	832	2943	0	0.003293	III.1	4	RL	0.0187
R	D69676	339	2850	0	0.015485	III.1	4	RL	0.0606
R	D69740	825	2939	0	0.000294	III.1	4	RL	0.0018
R	D69747	822	2855	0	0.006269	III.1	4	RL	0.0103
R	D69769	825	2182	0	0.001107	III.1	4	RL	0.0049
R	D69996	831	2985	0	0.002759	III.1	4	RL	0.0295
R	D70019	825	2861	0	0.002347	III.1	4	RL	0.0036
R	D70025	821	2867	0	0.001388	III.1	4	RL	0.0023
R	D70026	822	2847	0	0.001011	III.1	4	RL	0.0028
R	D70139	832	2900	0	0.001423	III.1	4	RL	0.0028
R	D70150	832	2928	0	0.000609	III.1	4	RL	0.0098
R	D70263	822	2827	0	0.001669	III.1	4	RL	0.0095
R	D70317	832	2954	0	0.000942	III.1	4	RL	0.0039
R	D70319	825	2884	0	0.0017	III.1	4	RL	0.002
R	D70332	825	2984	0	0.00234	III.1	4	RL	0.0099
R	D70378	825	2877	0	0.000525	III.1	4	RL	0.0018
R	D70387	822	2974	0	0.00051	III.1	4	RL	0.0063
R	D70392	822	2877	0	0.000682	III.1	4	RL	0.0018
R	D70460	832	2943	0	0.003934	III.1	4	RL	0.0163
R	D70464	822	2860	0	0.012126	III.1	4	RL	0.0018
R	D70501	822	2834	0	0.000826	III.1	4	RL	0.005
R	D70598	832	2948	0	0.001595	III.1	4	RL	0.0063
R	D70659	822	2850	0	0.007755	III.1	4	RL	0.0351
R	D70683	831	2820	0	0.015005	III.1	4	RL	0.0514
R	D70751	831	2890	0	0.0024	III.1	4	RL	0.0022
R	D70781	832	2841	0	0.004078	III.1	4	RL	0.0054
R	D70791	832	2891	0	0.001836	III.1	4	RL	0.0095
R	D70900	832	2894	0	0.00573	III.1	4	RL	0.0186
R	D70930	822	2882	0	0.011504	III.1	4	RL	0.0031
R	D70932	832	2863	0	0.00761	III.1	4	RL	0.015
R	D71072	825	2825	0	0.000171	III.1	4	RL	0.0393
R	D71118	832	2793	0	0.004122	III.1	4	RL	0.0035
R	D71168	832	2898	0	0.002702	III.1	4	RL	0.03
R	D71184	822	2797	0	0.000371	III.1	4	RL	0.1179
R	D71191	822	2828	0	0.000661	III.1	4	RL	0.0018
R	D71211	831	2920	0	0.011922	III.1	4	RL	0.0386
R	D71214	831	2931	0	0.001537	III.1	4	RL	0.0063
R	D71218	831	2884	0	0.004392	III.1	4	RL	0.0205
R	D71230	825	2914	0	0.00218	III.1	4	RL	0.0038
R	D71260	831	2854	0	0.00555	III.1	4	RL	0.0133
R	D71289	832	2926	0	0.001973	III.1	4	RL	0.0063
R	D71493	832	2929	0	0.002466	III.1	4	RL	0.0063

Table C-3. (continued).

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Wattage	Waste material type	Number of layers of confinement	Sampling location[b]	Flammable gas concentration (Vol%)
R	D71495	832	2906	0	0.001604	III.1	4	RL	0.0038
R	D71511	822	2765	0	0.000985	III.1	4	RL	0.0026
R	D71519	822	2757	0	0.000137	III.1	4	RL	0.0018
R	D71621	832	2859	0	0.003021	III.1	4	RL	0.0132
R	D71622	832	2830	0	0.00317	III.1	4	RL	0.0036
R	D71640	832	2840	0	0.000327	III.1	4	RL	0.0018
R	D71687	825	2136	0	0.002612	III.1	4	RL	0.0269
R	D71832	832	2842	0	0.001882	III.1	4	RL	0.0061
R	D71846	831	2820	0	0.013513	III.1	4	RL	0.0151
R	D71930	825	2150	0	0.001489	III.1	4	RL	0.0018
R	D71978	832	2899	0	0.000945	III.1	4	RL	0.0063
R	D71980	832	2806	0	0.00082	III.1	4	RL	0.0044
R	D72009	825	2813	0	0.003105	III.1	4	RL	0.0019
R	D72022	825	2761	0	0.000235	III.1	4	RL	0.0018
R	D72088	832	2799	0	0.000164	III.1	4	RL	0.0018
R	D72137	825	2711	0	0.000256	III.1	4	RL	0.0018
R	D72143	822	2850	0	0.000151	III.1	4	RL	0.0018
R	D72145	825	2731	0	0.000307	III.1	4	RL	0.0018
R	D72159	821	2859	0	0.012496	III.1	4	RL	0.0161
R	D72198	822	2770	0	0.00012	III.1	4	RL	0.0018
R	D72247	832	2783	0	9.61E-05	III.1	4	RL	0.0063
R	D72252	832	2884	0	0.001292	III.1	4	RL	0.0065
R	D72404	825	2765	0	0.000316	III.1	4	RL	0.0018
R	D72450	832	2883	0	0.000766	III.1	4	RL	0.0111
R	D72600	832	2814	0	0.001251	III.1	4	RL	0.0095
R	D72610	832	2853	0	0.001005	III.1	4	RL	0.0032
R	D72652	832	2859	0	0.000368	III.1	4	RL	0.0063
R	D72672	832	2843	0	0.001446	III.1	4	RL	0.0054
R	D72780	832	2852	0	0.00095	III.1	4	RL	0.0101
R	D72820	832	2842	0	0.000379	III.1	4	RL	0.0019
R	D72843	832	2822	0	0.000401	III.1	4	RL	0.0018
R	D72850	832	2827	0	0.003467	III.1	4	RL	0.0137
R	D72893	832	2847	0	0.005846	III.1	4	RL	0.0128
R	D72924	825	2719	0	0.000824	III.1	4	RL	0.0024
R	D72927	825	2757	0	0.002025	III.1	4	RL	0.0033
R	D72930	825	2710	0	0.000556	III.1	4	RL	0.0018
R	D73038	825	2764	0	0.001659	III.1	4	RL	0.0039
R	D73058	339	2852	0	0.011747	III.1	4	RL	0.0789
R	D73201	822	2658	0	0.001933	III.1	4	RL	0.0055
R	D73225	832	2816	0	0.001785	III.1	4	RL	0.0142
R	D73228	832	2756	0	0.003942	III.1	4	RL	0.008
R	D73236	832	2765	0	0.001712	III.1	4	RL	0.0127
R	D73289	825	2698	0	0.003453	III.1	4	RL	0.0107
R	D73292	822	2720	0	0.000504	III.1	4	RL	0.0018
R	D73298	825	2720	0	0.000755	III.1	4	RL	0.0032
R	D73303	825	2753	0	0.00145	III.1	4	RL	0.0046
R	D73307	825	2720	0	0.001674	III.1	4	RL	0.0027

Table C-3. (continued).

Site ID[(a)]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Wattage	Waste material type	Number of layers of confinement	Sampling location[(b)]	Flammable gas concentration (Vol%)
R	D73349	825	2609	0	0.003623	III.1	4	RL	0.0065
R	D73363	825	2631	0	0.007096	III.1	4	RL	0.01
R	D73369	822	2631	0	0.000713	III.1	4	RL	0.0369
R	D73581	825	2576	0	0.000844	III.1	4	RL	0.0026
R	D73825	825	2622	0	0.009705	III.1	4	RL	0.0024
R	D73879	825	2634	0	0.000713	III.1	4	RL	0.0018
R	D73909	832	2373	0	0.003387	III.1	4	RL	0.0063
R	D74029	832	2710	0	0.000589	III.1	4	RL	0.0135
R	D74133	822	2508	0	0.000598	III.1	4	RL	0.0018
R	D74428	832	2582	0	0.000147	III.1	4	RL	0.0023
R	D74646	831	2619	0	0.000944	III.1	4	RL	0.0033
R	D74659	822	2503	0	0.000362	III.1	4	RL	0.0032
R	D74727	832	2620	0	0.000568	III.1	4	RL	0.0023
R	D74749	822	2165	0	0.000464	III.1	4	RL	0.0063
R	D75196	825	2239	0	0.008016	III.1	4	RL	0.024
R	D75266	832	2556	0	0.001097	III.1	4	RL	0.0063
R	D75272	339	2307	0	0.005352	III.1	4	RL	0.0188
R	D75280	339	2462	0	0.006135	III.1	4	RL	0.0167
R	D75605	832	2445	0	0.000482	III.1	4	RL	0.0018
R	D75759	822	2338	0	0.016509	III.1	4	RL	0.0188
R	D75894	825	2474	0	0.001288	III.1	4	RL	0.0063
R	D76176	339	2303	0	0.00175	III.1	4	RL	0.0103
R	D76446	825	2269	0	0.00124	III.1	4	RL	0.0019
R	D76451	825	2268	0	0.000711	III.1	4	RL	0.0018
R	D76455	825	2361	0	0.000495	III.1	4	RL	0.0018
R	D76576	825	2238	0	0.000615	III.1	4	RL	0.002
R	D76639	825	2250	0	0.001997	III.1	4	RL	0.0045
R	D76776	825	2235	0	0.000423	III.1	4	RL	0.0018
R	D76831	822	2188	0	0.002864	III.1	4	RL	0.0046
R	D76934	831	2319	0	0.000838	III.1	4	RL	0.0063
R	D77114	832	2219	0	0.000733	III.1	4	RL	0.0139
R	D77225	825	2192	0	0.000856	III.1	4	RL	0.0027
R	D85061	822	693	0	0.001149	III.1	4	RL	0.0029
R	D85338	822	584	0	0.010141	III.1	4	RL	0.0118

a. R = RFETS

b. RL = Rigid drum liner; DH = Drum headspace; IB = Inner bag (Innermost confinement layer)

C.4. Output Data Files

The results of the NEWGVALS simulations are summarized in Tables C-4 and C-5. Table C-4 lists NEWGVALS predicted flammable gas concentrations in each layer of confinement and the sampled concentration of flammable gas for each gas sample obtained under the TWCP at the INEEL. Table C-5 lists NEWGVALS predicted flammable gas concentrations in each layer of confinement and the sampled concentration of flammable gas for each gas sample obtained under the TWCP at the RFETS.

Table C-4. NEWGVALS predicted confinement layer flammable gas concentrations using INEEL TWCP sampling data.

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Predicted flammable gas concentration in innermost layer (Vol%)	Predicted flammable gas concentration in rigid drum liner (Vol%)	Predicted hydrogen concentration in drum headspace (Vol%)	Sampled flammable gas concentration (Vol%)	Sampling location[b]
I	371	300	3009.	552.	.3586	.0325	.0313	.0400	DH
I	373	300	3012.	273.	4.2382	.3845	.3708	.0400	DH
I	393	480	2564.	552.	1.4789	.1030	.0993	.0400	DH
I	401	371	3323.	223.	15.0200	1.0566	1.0190	.0300	DH
I	405	480	3778.	217.	5.2231	.3655	.3525	.0700	DH
I	501	300	2749.	389.	2.8151	.2548	.2458	.0600	DH
I	558	440	3463.	7.	1.2943	.6049	.5964	.0900	DH
I	567	371	3402.	177.	27.6888	1.9490	1.8797	.0300	DH
I	613	300	2875.	559.	.8578	.0775	.0747	.1260	DH
I	827	303	2413.	686.	1.0913	.0982	.0947	.0900	DH
I	828	300	2415.	273.	.6796	.0617	.0595	.0400	DH
I	1016	300	2412.	389.	.6628	.0601	.0579	.1000	DH
I	1024	300	2386.	389.	1.6578	.1500	.1446	.0600	DH
I	1157	339	2701.	303.	3.8413	.3505	.3381	.0800	DH
I	1161	300	2852.	273.	2.5956	.2354	.2271	.0400	DH
I	1346	292	3165.	1036.	.0000	.0161	.0157	.0200	DH
I	1361	339	2359.	288.	1.4653	.1339	.1291	.0700	DH
I	1370	339	2368.	282.	5.2188	.4759	.4590	.1000	DH
I	1493	1	3633.	278.	.0924	.0593	.0577	.0300	DH

Table C-4. (continued).

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Predicted flammable gas concentration in innermost layer (Vol%)	Predicted flammable gas concentration in rigid drum liner (Vol%)	Predicted hydrogen concentration in drum headspace (Vol%)	Sampled flammable gas concentration (Vol%)	Sampling location[b]
I	1498	480	2883.	561.	16.6572	1.1602	1.1187	.0500	DH
I	1521	292	3100.	1043.	.0000	.0109	.0106	.0600	DH
I	1619	300	2606.	562.	1.1795	.1065	.1027	.0500	DH
I	1633	432	2609.	645.	2.4731	.2235	.2155	.1600	DH
I	1635	303	2413.	686.	.6827	.0615	.0593	.0900	DH
I	1636	320	3610.	236.	9.1541	.8315	.8020	.0300	DH
I	1655	339	2702.	310.	2.2169	.2024	.1952	.1300	DH
I	1662	300	2539.	555.	.4865	.0440	.0424	.0400	DH
I	1663	432	3323.	12.	7.6248	2.7530	2.7002	5.1100	DH
I	1667	300	2516.	395.	1.4485	.1311	.1264	.1260	DH
I	1677	302	2574.	385.	1.4484	.1321	.1274	.1250	DH
I	1689	302	2444.	657.	1.1120	.1005	.0969	.0900	DH
I	1692	432	3191.	12.	7.8319	2.8117	2.7578	.0900	DH
I	1694	374	3215.	243.	.6156	.0566	.0546	.0300	DH
I	1695	339	2814.	310.	8.1051	.7393	.7131	.1400	DH
I	1697	300	2464.	395.	.9558	.0865	.0835	.0400	DH
I	1752	300	2872.	395.	2.0584	.1864	.1798	.0400	DH
I	1753	339	3236.	236.	1.9512	.1787	.1724	.0300	DH
I	1754	320	2468.	22.	.7596	.1334	.1303	.0200	DH
I	1779	300	2241.	391.	1.3704	.1240	.1195	.0800	DH
I	1784	339	2705.	310.	2.0728	.1893	.1826	.1400	DH
I	2077	339	3085.	236.	2.0896	.1914	.1846	.0300	DH
I	2338	371	2582.	663.	.4699	.0330	.0318	.1300	DH
I	2363	371	2348.	656.	34.1134	2.3763	2.2914	.1300	DH
I	2365	480	2884.	565.	15.8345	1.1029	1.0634	.0600	DH
I	2368	480	3617.	265.	16.6277	1.1629	1.1214	.0600	DH

Table C-4. (continued).

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Predicted flammable gas concentration in innermost layer (Vol%)	Predicted flammable gas concentration in rigid drum liner (Vol%)	Predicted hydrogen concentration in drum headspace (Vol%)	Sampled flammable gas concentration (Vol%)	Sampling location[b]
I	2678	432	3338.	12.	2.5723	.9606	.9424	.1250	DH
I	2712	292	4349.	60.	.0000	2.9688	2.9137	.1500	DH
I	2791	371	2693.	663.	7.9755	.5563	.5364	.1300	DH
I	2797	432	3327.	12.	12.6575	4.5393	4.4522	.0900	DH
I	2814	7	3351.	278.	.0128	.0082	.0080	.0300	DH
I	3088	371	2686.	663.	11.0870	.7733	.7456	.1300	DH
I	3091	371	2557.	663.	4.0756	.2843	.2741	.1400	DH
I	3268	1	3470.	1000.	.0971	.0618	.0602	.0200	DH
I	3277	1	3416.	278.	.0105	.0068	.0066	.0300	DH
I	3547	7	3420.	237.	.0170	.0111	.0108	.0300	DH
I	3991	339	2278.	288.	6.8501	.6242	.6020	.0800	DH
I	3997	339	2283.	309.	12.3908	1.1281	1.0880	.2800	DH
I	4112	300	2852.	386.	1.5948	.1444	.1393	.0500	DH
I	4118	480	2991.	565.	.2952	.0206	.0199	.0400	DH
I	4119	371	2686.	663.	18.6838	1.3030	1.2563	.1400	DH
I	4123	339	2355.	288.	3.8782	.3537	.3411	.1100	DH
I	4150	300	2329.	540.	1.3452	.1214	.1170	.0400	DH
I	4160	339	2328.	375.	1.7427	.1587	.1531	.1700	DH
I	4166	371	2693.	663.	1.3215	.0923	.0890	.0360	IB
I	4186	339	2387.	304.	2.6724	.2438	.2351	.0800	DH
I	4196	300	2381.	267.	3.9019	.3535	.3409	.0400	DH
I	4208	300	2635.	379.	4.9985	.4523	.4362	.1600	DH
I	4456	7	3834.	16.	15.2505	12.1692	11.9383	.0200	DH
I	4799	7	3858.	28.	3.1760	2.5227	2.4746	.0200	DH
I	4963	339	2420.	375.	26.7852	2.4351	2.3485	.1100	DH
I	5012	339	2284.	379.	2.3457	.2135	.2059	.0400	DH

Table C-4. (continued).

Site ID[(a)]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Predicted flammable gas concentration in innermost layer (Vol%)	Predicted flammable gas concentration in rigid drum liner (Vol%)	Predicted hydrogen concentration in drum headspace (Vol%)	Sampled flammable gas concentration (Vol%)	Sampling location[(b)]
I	5234	303	2460.	676.	2.1474	.1933	.1864	.0900	DH
I	5235	432	2452.	630.	4.2718	.3859	.3721	.0700	DH
I	5415	1	2997.	208.	.5215	.3440	.3354	.0600	DH
I	5530	303	2490.	262.	1.7758	.1610	.1553	.0400	DH
I	5535	432	2573.	631.	5.4878	.4958	.4781	.0600	DH
I	5607	432	3330.	251.	15.6686	1.4327	1.3820	.0400	DH
I	5697	7	2694.	217.	.1089	.0712	.0694	.0300	DH
I	5698	7	3550.	13.	.7836	.6303	.6185	.0200	DH
I	5880	481	2815.	629.	15.9968	1.1132	1.0734	.0400	DH
I	6252	339	3059.	172.	2.8793	.2639	.2545	.0300	DH
I	6711	7	4168.	28.	.2009	.1596	.1565	.0200	DH
I	6857	339	2492.	324.	2.3706	.2162	.2085	.0400	DH
I	6875	303	3195.	11.	1.4569	.5040	.4956	.9300	DH
I	6879	432	2463.	630.	2.8711	.2594	.2502	.0500	DH
I	6918	292	3190.	1051.	.0000	.0775	.0755	.1100	DH
I	7034	337	5603.	1903.	.3199	.0221	.0213	.1260	DH
I	7061	490	5319.	3106.	.0715	.0064	.0061	.0140	DH
I	7104	338	5433.	1685.	.0219	.0020	.0019	.0200	DH
I	7170	337	5503.	1803.	.0358	.0025	.0024	.0860	DH
I	7231	338	5502.	1925.	1.4387	.1281	.1235	.0500	DH
I	7262	817	3710.	47.	4.7505	3.7560	3.6835	.0800	DH
I	7491	817	3670.	47.	1.3601	1.0753	1.0546	.0300	DH
I	7518	330	2702.	90.	5.2361	.3706	.3574	.0500	DH
I	7594	822	3975.	54.	.2841	.2243	.2200	.0300	DH
I	7667	7	2806.	229.	.2709	.1759	.1714	.0300	DH
I	8161	822	3742.	47.	1.2529	.9907	.9716	.0200	DH

Table C-4. (continued).

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Predicted flammable gas concentration in innermost layer (Vol%)	Predicted flammable gas concentration in rigid drum liner (Vol%)	Predicted hydrogen concentration in drum headspace (Vol%)	Sampled flammable gas concentration (Vol%)	Sampling location[b]
I	8203	440	2996.	84.	14.0820	.8036	.7750	.0900	DH
I	8207	336	3136.	84.	19.0349	1.7549	1.6928	.0900	DH
I	8218	330	3136.	84.	18.0971	1.2852	1.2397	.0900	DH
I	8250	822	2781.	208.	.0563	.0370	.0361	.0300	DH
I	8262	818	3740.	53.	.0864	.0682	.0669	.0200	DH
I	8287	374	2756.	90.	.0124	.0011	.0011	.0500	DH
I	8288	818	2760.	208.	.0073	.0048	.0047	.0300	DH
I	8355	1	3600.	91.	.3878	.3013	.2954	.0200	DH
I	8383	339	2756.	229.	2.0302	.1858	.1792	.0340	DH
I	8403	817	3655.	53.	7.0477	5.5620	5.4550	.0500	DH
I	8473	1	3643.	35.	3.9484	3.1308	3.0708	.0400	DH
I	8569	807	3489.	7.	.6656	.5511	.5413	.0200	DH
I	8683	807	2583.	68.	.1170	.0928	.0910	.0500	DH
I	8848	440	3019.	391.	1.0188	.0579	.0558	.1000	DH
I	8859	440	3553.	14.	1.7162	.4459	.4386	1.0900	DH
I	8864	480	3009.	552.	.1989	.0139	.0134	.0400	DH
I	8878	480	2990.	552.	.8202	.0572	.0552	.2000	DH
I	8993	312	3019.	676.	3.1129	.2805	.2705	.0900	DH
I	9011	7	3729.	237.	.0143	.0094	.0092	.0300	DH
I	9180	339	2927.	283.	13.5753	1.2393	1.1953	.2900	DH
I	9225	481	3099.	629.	5.3835	.3749	.3615	.0500	DH
I	9252	339	3262.	310.	12.5389	1.1450	1.1044	.6500	DH
I	9294	480	3103.	548.	.5932	.0414	.0399	.0500	DH
I	9296	440	2967.	632.	.4101	.0233	.0225	.0400	DH
I	9299	339	2926.	375.	5.9896	.5457	.5264	.0800	DH
I	9423	337	3210.	508.	1.5039	.1055	.1017	.0340	DH

Table C-4. (continued).

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Predicted flammable gas concentration in innermost layer (Vol%)	Predicted flammable gas concentration in rigid drum liner (Vol%)	Predicted hydrogen concentration in drum headspace (Vol%)	Sampled flammable gas concentration (Vol%)	Sampling location[b]
I	9435	337	3205.	611.	.4493	.0316	.0305	.1030	DH
I	9449	440	2949.	622.	.4316	.0245	.0236	.0400	DH
I	9465	292	3915.	1043.	.0000	.4479	.4362	.1900	DH
I	9471	337	3217.	227.	1.7296	.1219	.1176	.0300	DH
I	9489	337	3206.	228.	1.1895	.0839	.0809	.0300	DH
I	9587	320	3116.	229.	.3291	.0300	.0289	.0300	DH
I	9591	440	3152.	83.	16.7738	.9578	.9237	.1200	DH
I	9592	440	2947.	83.	14.7071	.8395	.8096	.0900	DH
I	9599	440	3160.	83.	5.7344	.3275	.3158	.0900	DH
I	9602	442	3171.	618.	.6821	.0476	.0459	.0500	DH
I	9653	480	2994.	561.	2.3891	.1665	.1606	.0400	DH
I	9694	300	2995.	381.	2.5963	.2352	.2268	.1000	DH
I	9773	339	6949.	380.	3.5420	.3247	.3132	.0900	DH
I	10216	338	1376.	1855.	.0437	.0039	.0038	.0860	DH
I	10224	338	5488.	1925.	1.1294	.1006	.0970	.0700	DH
I	10228	1	5483.	3014.	.0814	.0518	.0504	.0600	DH
I	10230	330	5391.	1925.	.6694	.0462	.0445	.0900	DH
I	10270	337	2355.	1756.	.4762	.0329	.0317	.0500	DH
I	10273	337	2268.	1411.	.2582	.0179	.0172	.0300	DH
I	10276	337	2321.	2184.	.9425	.0649	.0626	.0300	DH
I	10305	442	1977.	2410.	.0654	.0045	.0043	.0300	DH
I	10364	337	2253.	2197.	.2493	.0172	.0166	.0400	DH
I	10365	337	2253.	2265.	.6414	.0442	.0426	.0200	DH
I	10370	337	2337.	2153.	.8893	.0613	.0591	.0300	DH
I	10371	337	2293.	1620.	.2603	.0180	.0173	.0200	DH
I	10387	337	2309.	1400.	.2564	.0178	.0171	.0300	DH

Table C-4. (continued).

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Predicted flammable gas concentration in innermost layer (Vol%)	Predicted flammable gas concentration in rigid drum liner (Vol%)	Predicted hydrogen concentration in drum headspace (Vol%)	Sampled flammable gas concentration (Vol%)	Sampling location[b]
I	10411	337	2059.	1965.	.1646	.0114	.0109	.0500	DH
I	10416	337	2059.	1672.	.4265	.0294	.0284	.0400	DH
I	10449	300	2034.	2551.	.8770	.0780	.0752	.0140	DH
I	10480	374	2021.	2581.	.1171	.0104	.0100	.0140	DH
I	10492	480	2033.	2008.	.0626	.0043	.0042	.0400	DH
I	10498	480	2064.	2003.	2.8613	.1972	.1901	.0500	DH
I	10512	337	5573.	1573.	.1850	.0128	.0124	.0200	DH
I	10578	432	5608.	2105.	.3258	.0290	.0280	.0970	DH
I	10578	432	5608.	2105.	.3258	.0290	.0280	.1810	IB
I	10604	2	5566.	2853.	.0109	.0070	.0068	.0140	DH
I	10606	330	5463.	2131.	.8026	.0554	.0534	.0900	DH
I	10617	336	5476.	2468.	.0133	.0012	.0011	.0300	DH
I	10655	330	5481.	2468.	.6438	.0444	.0428	.0600	DH
I	10663	337	5596.	1712.	.0314	.0022	.0021	.0860	DH
I	10699	330	7698.	231.	4.3872	.3098	.2988	.0300	DH
I	10705	336	5566.	2453.	.2986	.0266	.0256	.0300	DH
I	10734	1	5499.	3055.	.2357	.1500	.1461	.0500	DH
I	10739	1	5573.	3034.	.1285	.0818	.0796	.0300	DH
I	10797	1	5503.	3055.	.1909	.1215	.1183	.0800	DH
I	10800	338	5573.	1785.	.7034	.0627	.0604	.0400	DH
I	10808	337	5454.	1967.	.1937	.0134	.0129	.0340	IB
I	10808	337	5454.	1967.	.1937	.0134	.0129	.0340	DH
I	10837	432	5607.	2105.	.4929	.0439	.0423	.1400	DH
I	10848	338	5578.	1769.	1.4935	.1331	.1283	.0400	DH
I	10883	432	5589.	2091.	.6218	.0554	.0534	.0500	DH
I	10910	441	5280.	3022.	.0222	.0015	.0015	.0140	DH

Table C-4. (continued).

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Predicted flammable gas concentration in innermost layer (Vol%)	Predicted flammable gas concentration in rigid drum liner (Vol%)	Predicted hydrogen concentration in drum headspace (Vol%)	Sampled flammable gas concentration (Vol%)	Sampling location[b]
I	10921	371	5596.	2084.	1.1592	.0800	.0771	.0500	DH
I	10922	432	5609.	3245.	.7373	.0656	.0632	.0500	DH
I	10976	2	5450.	2983.	.0032	.0020	.0020	.0140	DH
I	11042	442	1864.	2170.	.3545	.0244	.0235	.0400	DH
I	11044	440	1980.	2169.	.0962	.0054	.0052	.0500	DH
I	11156	376	2150.	2680.	.5725	.0509	.0491	.0200	DH
I	11162	432	2150.	2951.	3.5250	.3136	.3023	.3240	DH
I	11173	480	2164.	2041.	.6783	.0468	.0451	.1300	DH
I	11224	300	590.	4232.	.2690	.0239	.0231	.0140	DH
I	11259	330	5480.	2468.	1.2299	.0848	.0817	.0300	DH
I	11274	440	5620.	2453.	.1495	.0084	.0081	.0300	DH
I	11393	480	2986.	552.	.2362	.0165	.0160	.0500	DH
I	11415	480	5590.	2020.	.0607	.0042	.0040	.1250	DH
I	11416	337	5594.	2057.	.1603	.0111	.0107	.0400	DH
I	11433	330	5597.	1712.	.0357	.0025	.0024	.0860	DH
I	11482	371	5562.	2468.	.0500	.0035	.0033	.0300	DH
I	11498	432	5633.	2091.	.8440	.0751	.0724	.0900	DH
I	11607	330	5576.	1764.	.0490	.0034	.0033	.0600	DH
I	11637	338	5573.	1840.	.6766	.0603	.0581	.0500	DH
I	11638	336	5491.	2468.	.0834	.0074	.0072	.0300	DH
I	11653	432	5633.	2091.	.7854	.0699	.0674	.0700	DH
I	11695	336	5579.	2468.	.0134	.0012	.0012	.0300	DH
I	11699	480	5574.	2453.	.1587	.0109	.0105	.0300	DH
I	11735	330	5581.	2057.	.2163	.0149	.0144	.0340	DH
I	11749	441	5490.	2098.	.2924	.0202	.0194	.0400	DH
I	11799	292	3038.	236.	.0000	.0264	.0257	.0400	DH

Table C-4. (continued).

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Predicted flammable gas concentration in innermost layer (Vol%)	Predicted flammable gas concentration in rigid drum liner (Vol%)	Predicted hydrogen concentration in drum headspace (Vol%)	Sampled flammable gas concentration (Vol%)	Sampling location[b]
I	11801	292	3048.	226.	.0000	.0439	.0427	.0600	DH
I	12108	292	2290.	2313.	.0000	.0787	.0766	.0900	DH
I	12111	337	1717.	1791.	.2837	.0196	.0189	.0300	DH
I	12266	1	5571.	3037.	.1647	.1048	.1021	.0500	DH
I	12300	970	5598.	2468.	.1722	.0153	.0148	.0300	DH
I	12313	336	5580.	1712.	.0520	.0046	.0045	.0300	DH
I	12317	1	5595.	3062.	.0480	.0306	.0298	.0200	DH
I	12320	336	5586.	2057.	.2092	.0186	.0180	.0400	DH
I	12324	335	5561.	1573.	.3873	.0346	.0333	.0200	DH
I	12357	480	5581.	2433.	.0395.	.0027	.0026	.0400	DH
I	12433	338	5489.	1785.	.6432	.0573	.0553	.0400	DH
I	12469	1	1967.	2502.	.0762	.0485	.0472	.0400	DH
I	12471	338	5579.	1840.	2.2249	.1982	.1911	.0500	DH
I	12480	2	5353.	2983.	.0020	.0013	.0013	.0140	DH
I	12487	440	5489.	1916.	.1460	.0082	.0079	.0400	DH
I	12541	442	5476.	2164.	.0853	.0059	.0057	.0400	DH
I	12683	1	2354.	3153.	.8123	.5169	.5034	.0900	DH
I	12802	337	2387.	1840.	.1319	.0091	.0088	.0800	DH
I	12809	480	5599.	2020.	.3156	.0218	.0210	.0400	DH
I	12873	2	5566.	3141.	.0117	.0075	.0073	.0200	DH
I	12874	336	5594.	2131.	.0746	.0066	.0064	.0900	DH
I	12875	432	5597.	2091.	.3178	.0283	.0273	.0970	DH
I	12878	480	5597.	2000.	.1700	.0117	.0113	.1260	DH
I	12881	432	5580.	2468.	.8357	.0744	.0717	.0800	DH
I	12885	330	5588.	2468.	.0512	.0035	.0034	.0300	DH
I	12891	330	5496.	2057.	.3821	.0264	.0254	.0340	DH

Table C-4. (continued).

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Predicted flammable gas concentration in innermost layer (Vol%)	Predicted flammable gas concentration in rigid drum liner (Vol%)	Predicted hydrogen concentration in drum headspace (Vol%)	Sampled flammable gas concentration (Vol%)	Sampling location[b]
I	12898	490	5289.	3014.	.5208	.0463	.0447	.0140	DH
I	12902	338	5587.	1743.	1.5883	.1416	.1365	.0400	DH
I	12914	374	5287.	3014.	.0279	.0025	.0024	.0140	DH
I	12986	302	5579.	1846.	.0760	.0068	.0065	.0340	DH
I	12998	337	5587.	2057.	.4147	.0286	.0276	.0500	DH
I	13003	823	3612.	53.	.0905	.0714	.0700	.0200	DH
I	13040	823	3597.	47.	.1377	.1088	.1067	.0200	DH
I	13042	823	3612.	53.	.2137	.1686	.1654	.0200	DH
I	13171	822	3612.	53.	3.5922	2.8346	2.7799	.2600	DH
I	13182	817	3656.	53.	3.8134	3.0095	2.9516	.0900	DH
I	13184	817	3656.	53.	3.7053	2.9242	2.8679	.0600	DH
I	13188	823	3635.	53.	.2457	.1939	.1901	.0200	DH
I	13197	823	3639.	53.	.2295	.1811	.1776	.0200	DH
I	13204	823	3639.	53.	.4731	.3733	.3661	.0300	DH
I	13229	432	3029.	12.	1.5880	.6056	.5941	.1250	DH
I	13231	300	2380.	379.	4.8052	.4345	.4190	.0600	DH
I	13252	371	2686.	663.	9.3371	.6512	.6279	.1300	DH
I	13266	339	2621.	303.	8.3228	.7589	.7320	.1200	DH
I	13269	440	2797.	508.	.3532	.0201	.0194	.0600	DH
I	13313	440	2872.	632.	.4362	.0248	.0239	.0400	DH
I	13342	440	2786.	392.	.3201	.0182	.0176	.0500	DH
I	13361	292	4095.	54.	.0000	.4133	.4056	.0200	DH
I	13527	336	5585.	2084.	.0315	.0028	.0027	.0400	DH
I	13531	440	5584.	2537.	.2512	.0141	.0136	.0200	DH
I	13620	970	5600.	2832.	.5523	.0491	.0474	.0140	DH
I	13661	336	5566.	2468.	.0200	.0018	.0017	.0300	DH

Table C-4. (continued).

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Predicted flammable gas concentration in innermost layer (Vol%)	Predicted flammable gas concentration in rigid drum liner (Vol%)	Predicted hydrogen concentration in drum headspace (Vol%)	Sampled flammable gas concentration (Vol%)	Sampling location[b]
I	13677	338	5579.	1785.	2.8015	.2496	.2407	.0400	DH
I	13696	480	2462.	1551.	.0602	.0042	.0040	.0200	DH
I	13751	480	5485.	2007.	.0387	.0027	.0026	.1250	DH
I	13763	339	2406.	1.	5.3732	4.1208	4.0538	.1300	DH
I	13818	1	3573.	278.	.1608	.1030	.1003	.0400	DH
I	13847	300	2666.	385.	1.2732	.1153	.1112	.0400	DH
I	13860	339	2284.	324.	6.6353	.6040	.5826	.0800	DH
I	13876	7	3626.	302.	.0038	.0024	.0024	.0300	DH
I	13885	292	3087.	1042.	.0000	.1205	.1173	.2100	DH
I	14007	1	3113.	3.	119.6149	100.7374	98.9827	.2600	DH
I	14330	303	2578.	266.	3.6430	.3302	.3185	.0700	DH
I	14339	432	2446.	650.	1.6267	.1470	.1417	.1300	DH
I	14342	303	2596.	262.	6.1838	.5605	.5406	.0400	DH
I	14345	432	2461.	632.	1.0422	.0943	.0910	.0500	DH
I	14346	339	2462.	374.	7.0382	.6402	.6175	.1200	DH
I	14357	339	2585.	112.	3.0503	.2797	.2698	.0200	DH
I	14362	490	2429.	612.	3.7617	.3400	.3278	.0900	DH
I	14466	302	2610.	670.	.3964	.0360	.0347	.3140	DH
I	14484	300	2693.	545.	4.7204	.4260	.4108	.0400	DH
I	15241	442	3107.	618.	.4533	.0316	.0305	.0500	DH
I	15249	300	3020.	262.	4.7864	.4343	.4188	.0400	DH
I	15675	480	3023.	548.	3.8647	.2694	.2597	.0600	DH
I	16597	481	3099.	629.	1.9602	.1365	.1317	.0500	DH
I	16612	442	3096.	629.	2.6830	.1869	.1802	.0400	DH
I	16790	300	3063.	380.	.3968	.0361	.0348	.0700	DH
I	16986	442	3166.	629.	.2244	.0157	.0151	.0400	DH

Table C-4. (continued).

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Predicted flammable gas concentration in innermost layer (Vol%)	Predicted flammable gas concentration in rigid drum liner (Vol%)	Predicted hydrogen concentration in drum headspace (Vol%)	Sampled flammable gas concentration (Vol%)	Sampling location[b]
I	17148	432	3105.	630.	.5094	.0463	.0447	.0500	DH
I	17444	300	3062.	559.	.4376	.0396	.0382	.0400	DH
I	17491	300	3409.	172.	1.7847	.1623	.1565	.1260	DH
I	17495	442	3096.	650.	1.6624	.1158	.1117	.0400	DH
I	17698	292	3935.	182.	.0000	1.0375	1.0126	.7700	DH
I	17709	1	3439.	121.	.0796	.0606	.0593	.0400	DH
I	17742	440	3118.	629.	.5271	.0299	.0289	.0400	DH
I	17759	432	3104.	645.	.3119	.0284	.0274	.2740	IB
I	17759	432	3104.	645.	.3119	.0284	.0274	.1260	DH
I	18152	1	3858.	643.	.0826	.0526	.0512	.0240	DH
I	18181	292	3849.	1041.	.0000	.0027	.0026	.0200	DH
I	18195	292	3875.	1040.	.0000	.0381	.0371	.0600	DH
I	18229	292	3875.	1040.	.0000	.2172	.2115	.0800	DH
I	18299	376	2505.	89.	3.2152	.2958	.2854	.0500	DH
I	18413	300	2830.	230.	2.3022	.2090	.2015	.0300	DH
I	18441	300	3101.	83.	12.3138	1.1216	1.0818	.0900	DH
I	18456	822	3937.	53.	.7158	.5653	.5545	.0200	DH
I	18476	292	3000.	208.	.0000	.0190	.0185	.0300	DH
I	18491	300	2925.	84.	5.1753	.4713	.4546	.0900	DH
I	18806	800	3710.	139.	.3970	.2918	.2856	.0200	DH
I	19410	339	2996.	208.	.8061	.0741	.0715	.0340	DH
I	19413	339	2974.	229.	1.1861	.1088	.1049	.0440	DH
I	19413	339	2974.	229.	1.1861	.1088	.1049	.0470	IB
I	19413	339	2974.	229.	1.1861	.1088	.1049	.0470	IB
I	19572	339	3069.	83.	9.9824	.9208	.8884	.1100	DH
I	19664	803	3723.	7.	1.4469	1.1926	1.1711	.0500	DH

Table C-4. (continued).

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Predicted flammable gas concentration in innermost layer (Vol%)	Predicted flammable gas concentration in rigid drum liner (Vol%)	Predicted hydrogen concentration in drum headspace (Vol%)	Sampled flammable gas concentration (Vol%)	Sampling location[b]
I	20903	807	3153.	35.	.3838	.3053	.2995	.0200	DH
I	20937	481	2319.	2237.	.1075	.0074	.0071	.0200	DH
I	20969	440	2296.	2191.	.2461	.0138	.0133	.0140	DH
I	21392	292	3892.	307.	.0000	.4093	.3985	.3400	DH
I	21442	1	1783.	1717.	.0588	.0374	.0364	.0800	DH
I	21622	480	2366.	1783.	.2367	.0163	.0157	.0400	DH
I	21661	374	2402.	2297.	.0207	.0018	.0018	.0140	DH
I	21740	440	2519.	2259.	3.0688	.1725	.1663	.0300	DH
I	21806	440	2351.	1670.	.3273	.0184	.0178	.0500	DH
I	22023	442	2539.	2365.	.0224	.0015	.0015	.0140	DH
I	22102	432	2520.	1982.	1.4140	.1259	.1213	.1800	DH
I	22119	371	2378.	1805.	5.0554	.3485	.3360	.0900	DH
I	22226	371	2358.	2140.	14.0355	.9670	.9322	.0300	DH
I	22228	371	2267.	1896.	7.8862	.5436	.5240	.0900	DH
I	22230	371	2253.	1910.	4.3650	.3008	.2900	.0900	DH
I	22271	4[illegible]0	2319.	1733.	.3502	.0242	.0233	.0500	DH
I	22275	480	2134.	1877.	1.3501	.0931	.0897	.0500	DH
I	22290	376	2269.	2574.	.0077	.0007	.0007	.0140	DH
I	22291	376	2280.	2379.	.0136	.0012	.0012	.0140	DH
I	22293	480	2146.	1896.	.2049	.0141	.0136	.1250	DH
I	22296	1	2321.	1644.	.1884	.1199	.1168	.0800	DH
I	22306	440	2372.	1812.	.1010	.0057	.0055	.0400	DH
I	22347	440	2366.	1643.	1.7364	.0978	.0942	.0400	DH
I	22358	480	2392.	1709.	.0777	.0054	.0052	.0400	DH
I	22416	320	2479.	2141.	.7190	.0640	.0617	.0700	DH
I	22434	432	2506.	1744.	3.6299	.3232	.3116	.1500	DH

Table C-4. (continued).

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Predicted flammable gas concentration in innermost layer (Vol%)	Predicted flammable gas concentration in rigid drum liner (Vol%)	Predicted hydrogen concentration in drum headspace (Vol%)	Sampled flammable gas concentration (Vol%)	Sampling location[b]
I	22450	320	2645.	2134.	.8476	.0754	.0727	.0300	DH
I	22511	480	2372.	1841.	.0624	.0043	.0042	.0500	DH
I	22517	432	2408.	1807.	1.3734	.1223	.1179	.1600	DH
I	22539	432	2459.	1756.	3.0951	.2756	.2657	.3200	DH
I	22549	480	2372.	1764.	.0767	.0053	.0051	.1250	IB
I	22552	442	2424.	1778.	.1745	.0120	.0116	.0400	DH
I	22790	292	2283.	1587.	.0000	.0464	.0452	.0900	DH
I	22803	371	2321.	1842.	5.2044	.3588	.3458	.0900	DH
I	22811	7	2206.	1629.	.0046	.0029	.0028	.0340	DH
I	22874	371	2358.	1798.	4.3755	.3017	.2908	.1400	DH
I	22880	376	2251.	2364.	.0493	.0044	.0042	.0140	DH
I	22920	292	2239.	3018.	.0000	.1422	.1385	.1600	DH
I	22923	440	2243.	1846.	.1240	.0070	.0067	.0400	DH
I	23005	7	2190.	1966.	.0031	.0020	.0019	.0900	DH
I	23033	292	2373.	2933.	.0000	.0883	.0860	.1300	DH
I	23041	371	2358.	2170.	9.9483	.6854	.6607	.0400	DH
I	23048	432	2193.	1868.	2.0327	.1809	.1744	.1300	DH
I	23211	376	2187.	83.	.0232	.0021	.0021	.0900	DH
I	23212	480	2061.	2387.	.9354	.0644	.0621	.0300	DH
I	23227	480	2056.	1964.	.4352	.0300	.0289	.0500	DH
I	23235	336	2124.	2387.	1.4809	.1318	.1270	.1200	DH
I	23246	481	2336.	2280.	3.4773	.2396	.2309	.0700	DH
I	23266	7	2206.	2301.	.0036	.0023	.0022	.0200	DH
I	23285	7	2281.	1887.	.0252	.0160	.0156	.0900	DH
I	23290	371	2335.	2198.	5.1773	.3567	.3438	.0300	DH
I	23301	337	2126.	1556.	.2807	.0194	.0187	.0300	DH

Table C-4. (continued).

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Predicted flammable gas concentration in innermost layer (Vol%)	Predicted flammable gas concentration in rigid drum liner (Vol%)	Predicted hydrogen concentration in drum headspace (Vol%)	Sampled flammable gas concentration (Vol%)	Sampling location[b]
I	23384	339	1933.	1646.	2.2763	.2027	.1954	.0600	DH
I	23388	330	2389.	1564.	.1186	.0082	.0079	.0300	DH
I	23662	442	2407.	1870.	.1689	.0117	.0112	.0400	DH
I	23739	440	2530.	2279.	1.3151	.0739	.0713	.0200	DH
I	23771	330	2499.	2225.	4.2749	.2945	.2839	.1600	DH
I	23805	480	2680.	1722.	.8087	.0558	.0538	.0400	DH
I	23840	337	2520.	1408.	1.5740	.1088	.1049	.0300	DH
I	23844	480	2677.	1741.	3.0690	.2117	.2041	.0400	DH
I	23901	330	2416.	1423.	.0130	.0009	.0009	.0860	DH
I	23929	440	2307.	2193.	.3396	.0191	.0184	.0400	DH
I	23959	480	2320.	1832.	1.7964	.1239	.1194	.0400	DH
I	23984	300	2316.	2286.	.9274	.0825	.0796	.0200	DH
I	24028	440	2275.	2254.	3.4141	.1919	.1850	.0300	DH
I	24029	480	2252.	1577.	.9757	.0673	.0649	.0400	DH
I	24057	292	18281.	3058.	.0000	.1594	.1553	.1900	DH
I	24059	292	2584.	1945.	.0000	.2471	.2406	.3800	DH
I	24086	337	2507.	2176.	2.5862	.1782	.1718	.0600	DH
I	24088	337	2288.	1863.	.1390	.0096	.0093	.0400	DH
I	24090	337	2313.	1499.	.7850	.0542	.0523	.0300	DH
I	24092	337	2289.	1868.	.4342	.0299	.0289	.1260	IB
I	24092	337	2289.	1868.	.4342	.0299	.0289	.1260	DH
I	24095	337	2381.	1510.	.9938	.0686	.0662	.0300	DH
I	24102	337	2366.	1870.	.5704	.0393	.0379	.0500	DH
I	24106	337	2403.	1864.	.6847	.0472	.0455	.0400	DH
I	24113	337	2344.	1869.	1.2286	.0847	.0817	.0500	DH
I	24159	336	2501.	1232.	.2383	.0213	.0206	.0300	DH

Table C-4. (continued).

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Predicted flammable gas concentration in innermost layer (Vol%)	Predicted flammable gas concentration in rigid drum liner (Vol%)	Predicted hydrogen concentration in drum headspace (Vol%)	Sampled flammable gas concentration (Vol%)	Sampling location[b]
I	24165	337	2330.	1821.	.4930	.0340	.0328	.0400	DH
I	24168	330	2480.	1736.	3.2766	.2260	.2178	.0400	DH
I	24190	480	2845.	1098.	.2990	.0208	.0200	.0300	DH
I	24273	442	2380.	1897.	.0997	.0069	.0066	.0400	DH
I	24279	442	2505.	2310.	.1461	.0101	.0097	.0140	DH
I	24289	440	2382.	2285.	.1186	.0067	.0064	.0300	DH
I	24358	480	2751.	1699.	.1927	.0133	.0128	.0500	DH
I	24506	374	2121.	84.	.0298	.0027	.0026	.0900	DH
I	24662	480	2627.	1810.	.1519	.0105	.0101	.0400	DH
I	24786	480	2677.	1737.	.1774	.0123	.0118	.0860	DH
I	24807	480	2631.	1350.	.1384	.0096	.0093	.0800	DH
I	24862	480	2431.	1930.	.3906	.0269	.0260	.0500	DH
I	24884	480	2430.	1916.	.3272	.0226	.0218	.0500	DH
I	24920	1	2655.	2095.	.1976	.1257	.1224	.0900	DH
I	27455	1	2877.	2793.	.1587	.1010	.0984	.0300	DH
I	27540	1	2628.	2574.	.5737	.3651	.3555	.1000	DH
I	27877	481	2916.	2443.	2.5035	.1725	.1663	.0140	DH
I	29152	1	3137.	2780.	2.6732	1.7012	1.6566	.1200	DH
I	29699	292	3322.	2800.	.0000	.1166	.1135	.1400	DH
I	30585	440	3259.	2414.	.1188	.0067	.0064	.0140	DH
I	31128	7	2205.	2604.	.0099	.0063	.0061	.0200	DH
I	31502	432	2267.	2757.	.0377	.0034	.0032	.0200	DH
I	31507	7	2227.	2595.	.0101	.0064	.0063	.0200	DH
I	31546	7	49.	4787.	.0024	.0015	.0015	.0200	DH
I	31689	7	2268.	2412.	.0042	.0027	.0026	.0140	DH
I	31711	1	2296.	2532.	.1823	.1160	.1130	.0200	DH

Table C-4. (continued).

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Predicted flammable gas concentration in innermost layer (Vol%)	Predicted flammable gas concentration in rigid drum liner (Vol%)	Predicted hydrogen concentration in drum headspace (Vol%)	Sampled flammable gas concentration (Vol%)	Sampling location[b]
I	31806	7	2360.	2661.	.0065	.0041	.0040	.0200	DH
I	32284	339	2237.	1358.	3.0151	.2689	.2592	.2600	DH
I	32287	7	2013.	2299.	.0035	.0022	.0022	.0300	DH
I	32467	337	2334.	1638.	.2214	.0153	.0148	.0400	DH
I	32469	337	2326.	2083.	.2270	.0157	.0151	.0300	DH
I	32471	337	2340.	1148.	.4252	.0295	.0285	.0200	DH
I	32473	337	2326.	1632.	.1471	.0102	.0098	.0400	DH
I	32485	337	2334.	1632.	.2677	.0185	.0178	.0400	DH
I	32517	339	2288.	2065.	1.3252	.1179	.1137	.1100	DH
I	32521	339	2288.	1416.	4.2887	.3823	.3685	.3300	DH
I	32525	339	2289.	1324.	2.2491	.2006	.1934	.2000	DH
I	32526	339	2326.	1344.	2.4402	.2176	.2098	.1000	DH
I	32529	336	2088.	1540.	.0825	.0074	.0071	.0860	DH
I	32540	480	2293.	1667.	1.0433	.0720	.0694	.0500	DH
I	32669	480	2265.	2086.	.6497	.0448	.0432	.0400	DH
I	32715	337	2226.	2091.	.3003	.0207	.0200	.0300	DH
I	32741	480	2246.	1609.	.1864	.0129	.0124	.0400	DH
I	32748	339	2264.	1182.	.7125	.0637	.0614	.0800	DH
I	33091	339	2251.	1432.	1.0897	.0971	.0936	.1000	DH

Notes:

a. I = INEEL
b. DH = Drum headspace; IB = Inner bag (Innermost confinement layer)

Table C-5 lists NEWGVALS predicted flammable gas concentrations in each layer of confinement and the sampled concentration of flammable gas for each gas sample obtained under the TWCP at the RFETS.

Table C-5. NEWGVALS predicted confinement layer flammable gas concentrations using RFETS TWCP sampling data.

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Predicted flammable gas concentration in innermost layer (Vol%)	Predicted flammable gas concentration in rigid drum liner (Vol%)	Predicted hydrogen concentration in drum headspace (Vol%)	Sampled flammable gas concentration (Vol%)	Sampling location[b]
R	D17184	800	2192.	0.	38.2441	38.0639	26.8108	.6030	DH
R	D35301	800	2227.	0.	55.5718	55.3198	39.1124	.0033	DH
R	D60290	800	2324.	0.	19.7465	19.6616	14.2080	.3577	DH
R	D61005	800	2698.	0.	16.2090	16.1483	12.2499	4.9286	DH
R	D61005	800	2698.	15.	11.1535	8.8853	8.7166	.1464	RL
R	D61471	800	2527.	0.	43.4625	43.2866	31.9644	3.5007	DH
R	D63330	800	2702.	0.	16.2301	16.1699	12.2711	7.7303	DH
R	D63330	800	2702.	0.	16.2301	16.1699	12.2711	5.1857	RL
R	D63341	800	2670.	0.	16.0594	15.9988	12.1012	7.2299	DH
R	D63341	800	2670.	0.	16.0594	15.9988	12.1012	6.8590	RL
R	D63344	800	2668.	0.	16.0485	15.9883	12.0906	6.3753	DH
R	D63344	800	2668.	0.	16.0485	15.9883	12.0906	5.4401	RL
R	D63484	800	2640.	0.	23.3698	23.2803	17.4877	.0513	DH
R	D63484	800	2640.	0.	23.3698	23.2803	17.4877	.0498	RL
R	D64197	800	2635.	0.	23.3302	23.2404	17.4483	.0033	DH
R	D64197	800	2635.	0.	23.3302	23.2404	17.4483	.0353	RL
R	D64383	800	2648.	0.	35.5255	35.3869	26.5351	1.0475	DH
R	D64383	800	2648.	1.	34.9532	29.9516	29.4434	.8172	RL
R	D64631	800	2646.	0.	35.5023	35.3612	26.5110	3.8746	DH
R	D64631	800	2646.	0.	35.5023	35.3612	26.5110	1.9622	RL
R	D64632	800	2261.	0.	38.6758	38.5026	27.4166	3.0205	DH
R	D64997	800	2605.	0.	44.6819	44.4933	33.1681	14.5676	DH

Table C-5. (continued).

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Predicted flammable gas concentration in innermost layer (Vol%)	Predicted flammable gas concentration in rigid drum liner (Vol%)	Predicted hydrogen concentration in drum headspace (Vol%)	Sampled flammable gas concentration (Vol%)	Sampling location[b]
R	D64997	800	2605.	0.	44.6819	44.4933	33.1681	11.9154	RL
R	D66525	800	1485.	163.	.0242	.0163	.0159	.0097	DH
R	D66525	800	1485.	0.	.6369	.6329	.3740	3.4368	DH
R	D66525	800	1485.	163.	.0242	.0163	.0159	.0497	IB
R	D67434	800	1492.	134.	.0315	.0221	.0216	.0035	DH
R	D67434	800	1492.	0.	.6396	.6356	.3765	1.9198	DH
R	D67434	800	1492.	134.	.0315	.0221	.0216	.0083	IB
R	D67436	800	1492.	184.	.0609	.0406	.0396	.0038	DH
R	D67436	800	1492.	0.	2.2815	2.2699	1.5307	3.1291	DH
R	D67436	800	1492.	184.	.0609	.0406	.0396	.0250	IB
R	D67441	800	1493.	134.	.0912	.0653	.0639	.0035	DH
R	D67441	800	1493.	0.	2.1604	2.1495	1.4595	1.4476	DH
R	D67441	800	1493.	134.	.0912	.0653	.0639	.0095	IB
R	D67654	800	1493.	169.	.0625	.0424	.0414	.0035	DH
R	D67654	800	1493.	0.	2.1604	2.1495	1.4595	2.5138	DH
R	D67654	800	1493.	169.	.0625	.0424	.0414	.0258	IB
R	D67656	800	2178.	0.	2.6138	2.6041	1.9761	1.3536	DH
R	D67657	800	1493.	170.	.0621	.0421	.0410	.0046	DH
R	D67657	800	1493.	0.	2.1604	2.1495	1.4595	1.7896	DH
R	D67657	800	1493.	170.	.0621	.0421	.0410	.0196	IB
R	D67670	800	2473.	0.	3.0590	3.0486	2.3705	1.2173	DH
R	D67670	800	2473.	1.	3.0143	2.6180	2.5745	1.2681	RL
R	D68241	800	2351.	0.	4.4400	4.4222	3.3246	.1003	DH
R	D68247	800	1485.	167.	.0236	.0158	.0154	.0035	DH
R	D68247	800	1485.	0.	.6370	.6329	.3740	.0593	DH
R	D68247	800	1485.	167.	.0236	.0158	.0154	.0101	IB

Table C-5. (continued).

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Predicted flammable gas concentration in innermost layer (Vol%)	Predicted flammable gas concentration in rigid drum liner (Vol%)	Predicted hydrogen concentration in drum headspace (Vol%)	Sampled flammable gas concentration (Vol%)	Sampling location[b]
R	D68254	800	1488.	169.	.0233	.0156	.0152	.0035	DH
R	D68254	800	1488.	0.	.6381	.6340	.3751	.0593	DH
R	D68254	800	1488.	169.	.0233	.0156	.0152	.0123	IB
R	D68255	800	2466.	0.	2.8579	2.8481	2.2221	.1091	DH
R	D68255	800	2466.	0.	2.8579	2.8481	2.2221	.2778	RL
R	D68256	800	1491.	183.	.0116	.0081	.0079	.0050	DH
R	D68256	800	1491.	0.	.8462	.8440	.6208	.6887	DH
R	D68256	800	1491.	183.	.0116	.0081	.0079	.0226	IB
R	D68261	800	2460.	0.	.9527	.9510	.8287	.1706	DH
R	D68261	800	2460.	0.	.9527	.9510	.8287	.1706	RL
R	D68480	800	1456.	182.	.2268	.1500	.1463	.0321	DH
R	D68480	800	1456.	0.	6.9969	6.9542	4.2607	.1798	DH
R	D68480	800	1456.	182.	.2268	.1500	.1463	.1799	IB
R	D68483	800	2439.	0.	42.3360	42.1599	30.7846	.2947	DH
R	D68606	800	2240.	0.	1.4162	1.4122	1.1485	.0033	DH
R	D68983	800	2429.	0.	10.7415	10.6985	7.9116	.0133	DH
R	D68983	800	2429.	15.	7.3553	5.8547	5.7435	.0087	RL
R	D68992	800	2423.	0.	46.4386	46.2444	33.6799	9.1399	DH
R	D68992	800	2423.	14.	32.6017	25.9603	25.4671	3.1250	RL
R	D69299	800	2407.	0.	24.6244	24.5212	17.8901	12.9093	DH
R	D69299	800	2407.	0.	24.6244	24.5212	17.8901	12.8742	RL
R	D69310	800	2212.	0.	30.7708	30.6318	21.6747	2.2688	DH
R	D69312	800	1427.	135.	.7612	.5337	.5214	.0153	DH
R	D69312	800	1427.	0.	15.6108	15.5091	9.1746	10.0655	DH
R	D69312	800	1427.	135.	.7612	.5337	.5214	.0190	IB
R	D70213	800	2333.	0.	83.7521	83.3878	59.8451	.5280	DH

Table C-5. (continued).

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Predicted flammable gas concentration in innermost layer (Vol%)	Predicted flammable gas concentration in rigid drum liner (Vol%)	Predicted hydrogen concentration in drum headspace (Vol%)	Sampled flammable gas concentration (Vol%)	Sampling location[b]
R	D70213	800	2333.	0.	83.7521	83.3878	59.8451	.7441	RL
R	D70335	800	2350.	0.	1.0843	1.0818	.9201	3.0993	DH
R	D70335	800	2350.	1.	1.0726	.9642	.9491	1.0795	RL
R	D70422	800	2052.	0.	7.6808	7.6455	5.3859	.7185	DH
R	D72267	800	1287.	191.	.0381	.0253	.0246	.0035	DH
R	D72267	800	1287.	0.	1.5467	1.5393	1.0287	.0593	DH
R	D72267	800	1287.	191.	.0381	.0253	.0246	.0220	IB
R	D72545	800	1278.	183.	.0376	.0252	.0245	.0035	DH
R	D72545	800	1278.	0.	1.4869	1.4799	.9922	.0593	DH
R	D72545	800	1278.	183.	.0376	.0252	.0245	.0232	IB
R	D76138	1	3136.	126.	1.0625	.7882	.7715	.0165	DH
R	D76138	1	3136.	0.	25.3608	25.2775	19.8914	.0147	DH
R	D76138	1	3136.	126.	1.0625	.7882	.7715	.0803	IB
R	D76142	1	2755.	70.	3.5256	2.7522	2.6983	.0129	DH
R	D76142	1	2755.	0.	22.9842	22.8996	17.4191	.0078	DH
R	D76142	1	2755.	70.	3.5256	2.7522	2.6983	.0488	IB
R	D76144	1	3755.	126.	1.3348	.9986	.9776	.0341	DH
R	D76144	1	3755.	0.	33.3425	33.2471	27.2258	.0097	DH
R	D76144	1	3755.	126.	1.3348	.9986	.9776	.0838	IB
R	D76182	1	4486.	0.	74.7482	74.5646	63.0434	.0762	DH
R	D76183	1	2861.	309.	.4584	.2924	.2847	.0374	DH
R	D76183	1	2861.	0.	28.6617	28.5589	21.9228	.0349	DH
R	D76183	1	2861.	309.	.4584	.2924	.2847	.1373	IB
R	D76185	1	1071.	63.	1.9214	1.4723	1.4426	.0111	DH
R	D76185	1	1071.	0.	10.1944	10.1117	5.1720	.0059	DH
R	D76185	1	1071.	63.	1.9214	1.4723	1.4426	.0353	IB

Table C-5. (continued).

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Predicted flammable gas concentration in innermost layer (Vol%)	Predicted flammable gas concentration in rigid drum liner (Vol%)	Predicted hydrogen concentration in drum headspace (Vol%)	Sampled flammable gas concentration (Vol%)	Sampling location[b]
R	D76194	1	3253.	0.	26.2219	26.1371	20.7501	.0210	DH
R	D76199	1	3001.	309.	.4079	.2602	.2534	.0280	DH
R	D76199	1	3001.	309.	.4079	.2602	.2534	.1075	IB
R	D76205	1	2869.	63.	4.3894	3.4414	3.3742	.0285	DH
R	D76205	1	2869.	0.	23.8398	23.7550	18.2705	.0035	DH
R	D76205	1	2869.	63.	4.3894	3.4414	3.3742	.1267	IB
R	D76287	1	4229.	146.	.0265	.0199	.0195	.0092	DH
R	D76287	1	4229.	0.	1.2007	1.1989	1.0934	.0081	DH
R	D76287	1	4229.	146.	.0265	.0199	.0195	.0235	IB
R	D76302	1	3079.	126.	1.0501	.7783	.7619	.0126	DH
R	D76302	1	3079.	0.	24.9416	24.8581	19.4733	.0076	DH
R	D76302	1	3079.	126.	1.0501	.7783	.7619	.0215	IB
R	D76305	1	4165.	0.	.3278	.3270	.2723	.0057	DH
R	D13364	480	2122.	0.	9.3532	8.9202	6.1317	1.5656	DH
R	D36606	480	1238.	0.	1.2301	1.1633	.7228	.0593	DH
R	D46848	320	2858.	0.	31.7634	30.5971	23.0521	.0033	DH
R	D53211	442	2852.	0.	6.7170	6.4825	4.9573	.0168	DH
R	D53211	442	2852.	0.	6.7170	6.4825	4.9573	.0368	RL
R	D53886	320	3245.	0.	38.4983	37.2430	29.0713	.0798	DH
R	D53886	320	3245.	0.	38.4983	37.2430	29.0713	.0033	RL
R	D54192	480	2211.	0.	.0018	.0017	.0012	.0117	DH
R	D57847	480	1082.	0.	.5414	.5143	.2660	.0593	DH
R	D58347	321	3605.	0.	3.4735	3.3820	2.7849	.0024	DH
R	D59077	438	2903.	0.	1.4858	1.4461	1.1858	4.5287	RL
R	D59568	377	3012.	331.	.3010	.0274	.0264	.0018	DH
R	D59663	438	2988.	0.	2.8328	2.7462	2.1823	.0872	DH

Table C-5. (continued).

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Predicted flammable gas concentration in innermost layer (Vol%)	Predicted flammable gas concentration in rigid drum liner (Vol%)	Predicted hydrogen concentration in drum headspace (Vol%)	Sampled flammable gas concentration (Vol%)	Sampling location[b]
R	D60463	444	1140.	0.	.7015	.6701	.4350	.0137	DH
R	D60525	440	2562.	0.	1.3670	1.3271	1.0643	1.4303	RL
R	D60684	300	3115.	252.	1.1700	.1063	.1025	.0018	DH
R	D61905	377	3011.	330.	.2530	.0231	.0222	.0018	DH
R	D61961	377	3012.	330.	.2957	.0269	.0260	.0021	DH
R	D62018	377	3007.	335.	.3829	.0348	.0336	.0018	DH
R	D62049	442	2741.	0.	2.2387	2.1678	1.7051	.1508	RL
R	D62179	440	3184.	0.	.6448	.6363	.5778	.0018	RL
R	D62545	480	2506.	0.	28.0207	26.8678	19.4064	2.0743	DH
R	D62545	480	2506.	0.	28.0207	26.8678	19.4064	4.3922	RL
R	D62579	377	3348.	0.	.9945	.9756	.8512	.0030	RL
R	D62759	442	2742.	0.	1.0236	.9993	.8379	.0454	RL
R	D63441	442	2733.	0.	.6222	.6128	.5450	.0838	DH
R	D63441	442	2733.	0.	.6222	.6128	.5450	.0859	RL
R	D63442	442	2733.	0.	2.0319	1.9688	1.5564	1.1065	DH
R	D63442	442	2733.	0.	2.0319	1.9688	1.5564	.6914	RL
R	D63446	442	2734.	0.	10.9037	10.4979	7.8659	19.4369	DH
R	D63446	442	2734.	0.	10.9037	10.4979	7.8659	18.7192	RL
R	D64480	480	2624.	0.	.0002	.0002	.0002	.0033	DH
R	D64538	442	2697.	0.	.1674	.1609	.1185	.0116	RL
R	D64562	442	2690.	0.	.2935	.2821	.2075	.0439	DH
R	D64562	442	2690.	0.	.2935	.2821	.2075	.0443	RL
R	D64720	312	2877.	203.	1.6837	.1529	.1475	.0018	DH
R	D64752	480	1321.	0.	.5919	.5705	.3955	.0593	DH
R	D65734	480	2071.	0.	2.5919	2.4828	1.7748	.0059	DH
R	D65738	300	2878.	200.	2.4770	.2249	.2169	.0018	DH

Table C-5. (continued).

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Predicted flammable gas concentration in innermost layer (Vol%)	Predicted flammable gas concentration in rigid drum liner (Vol%)	Predicted hydrogen concentration in drum headspace (Vol%)	Sampled flammable gas concentration (Vol%)	Sampling location[b]
R	D65957	312	2844.	287.	.3427	.0312	.0301	.0018	DH
R	D66090	300	2835.	200.	1.8598	.1689	.1629	.0037	DH
R	D66157	480	1526.	0.	.5540	.5364	.3840	.2771	DH
R	D66670	442	2566.	0.	.0269	.0258	.0187	.0569	RL
R	D66679	442	2560.	0.	.9858	.9613	.7977	.4567	DH
R	D66682	442	2567.	0.	.4783	.4588	.3323	.3742	RL
R	D66709	442	2558.	0.	.2166	.2077	.1503	.1507	DH
R	D66709	442	2558.	0.	.2166	.2077	.1503	.1095	RL
R	D66773	480	1984.	80.	4.2143	.3833	.3697	.0320	DH
R	D66788	300	2837.	229.	1.2271	.1115	.1075	.0018	DH
R	D66936	480	2383.	0.	.5131	.4996	.3733	.3913	DH
R	D66936	480	2383.	0.	.5131	.4996	.3733	.1611	RL
R	D67066	438	2527.	0.	10.8979	10.4630	7.6436	10.9203	RL
R	D67251	480	1490.	0.	.1410	.1319	.0754	.0593	DH
R	D67317	480	1471.	0.	.9903	.9479	.6597	.4982	DH
R	D67455	480	2056.	0.	4.5771	4.3690	3.0259	.4451	DH
R	D67463	300	2796.	229.	1.5071	.1368	.1320	.0018	DH
R	D67605	480	2461.	0.	9.4717	9.0866	6.5925	4.3649	DH
R	D67605	480	2461.	0.	9.4717	9.0866	6.5925	2.3279	RL
R	D67735	825	1745.	0.	.1029	.0971	.0601	.0035	DH
R	D67902	300	2759.	200.	2.0535	.1865	.1798	.0018	DH
R	D67905	300	2934.	0.	3.5761	3.4613	2.7130	.0039	RL
R	D68085	300	2899.	0.	2.7426	2.6570	2.0983	.0065	RL
R	D68277	480	1743.	0.	2.8873	2.7439	1.8206	.0058	DH
R	D68368	480	2308.	0.	8.8339	8.4548	6.0053	.6217	DH
R	D68377	480	1475.	0.	.1820	.1702	.0967	.0593	DH

Table C-5. (continued).

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Predicted flammable gas concentration in innermost layer (Vol%)	Predicted flammable gas concentration in rigid drum liner (Vol%)	Predicted hydrogen concentration in drum headspace (Vol%)	Sampled flammable gas concentration (Vol%)	Sampling location[b]
R	D68514	480	2054.	0.	.6072	.5941	.4941	.3098	DH
R	D68929	300	2920.	0.	2.0582	1.9978	1.6040	.0025	RL
R	D68930	300	3001.	0.	2.6638	2.5836	2.0608	.0041	RL
R	D69414	300	2904.	0.	2.0642	2.0033	1.6059	.0021	RL
R	D69442	300	2903.	0.	3.4384	3.3274	2.6045	.0018	RL
R	D70446	480	1316.	0.	1.7476	1.6478	1.0060	.0593	DH
R	D71351	480	1352.	0.	1.5769	1.4909	.9337	.0593	DH
R	D71354	480	1347.	0.	.6797	.6542	.4622	.0593	DH
R	D71638	480	1312.	0.	.5686	.5476	.3689	.0593	DH
R	D72079	480	1506.	0.	2.3512	2.2235	1.4047	.0119	DH
R	D72371	300	2780.	0.	1.6845	1.6355	1.3150	.0035	RL
R	D72384	300	2751.	0.	2.9486	2.8507	2.2129	.0067	RL
R	D72831	480	1279.	0.	.8277	.7910	.5326	.0593	DH
R	D75978	824	1626.	0.	.5569	.5405	.4016	.0115	RL
R	D76714	321	2319.	0.	3.0546	2.9354	2.1605	.0081	RL
R	D76716	321	2335.	0.	2.3303	2.2440	1.6813	.0073	RL
R	D78336	444	1433.	0.	.2561	.2392	.1337	.0018	DH
R	D85299	321	0.	813.	.2535	.0227	.0219	.0063	DH
R	D85389	824	0.	870.	.1790	.0161	.0155	.0070	DH
R	D85406	824	0.	870.	.2252	.0202	.0194	.0115	DH
R	D85670	440	0.	377.	.0827	.0073	.0070	.0133	DH
R	D86658	480	0.	352.	.0657	.0057	.0055	.0168	DH
R	D86663	480	0.	349.	.1749	.0153	.0147	.0042	DH
R	D55521	825	2942.	0.	1.8702	1.8286	1.5873	.0073	RL
R	D56036	832	2907.	0.	2.5688	2.4975	2.0907	.0218	RL
R	D57202	832	2814.	0.	2.9448	2.8549	2.3425	.0222	RL

Table C-5. (continued).

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Predicted flammable gas concentration in innermost layer (Vol%)	Predicted flammable gas concentration in rigid drum liner (Vol%)	Predicted hydrogen concentration in drum headspace (Vol%)	Sampled flammable gas concentration (Vol%)	Sampling location[b]
R	D58972	822	2989.	0.	1.2819	1.2638	1.1484	.0018	RL
R	D59898	825	3039.	0.	1.0907	1.0677	.8524	.0027	RL
R	D60704	822	2926.	0.	1.2304	1.2135	1.1002	.0056	RL
R	D61288	825	2972.	0.	1.2239	1.2075	1.0976	.0753	RL
R	D61804	825	2962.	0.	.4919	.4716	.3576	.0018	RL
R	D62184	825	2893.	0.	.1320	.1264	.0952	.0063	RL
R	D62353	831	3068.	0.	.3441	.3304	.2531	.0018	RL
R	D62548	822	2990.	0.	1.6250	1.5938	1.4106	.0282	RL
R	D63572	825	3030.	0.	.5113	.4907	.3746	.0018	RL
R	D64270	832	3058.	0.	.9079	.8717	.6672	.0026	RL
R	D64413	825	3010.	0.	1.1361	1.1209	1.0031	.0035	RL
R	D64708	339	2818.	0.	1.2137	1.1963	1.0766	.0037	RL
R	D65122	822	3037.	0.	.5827	.5593	.4273	.0018	RL
R	D65123	831	3135.	0.	3.1723	3.0825	2.5724	.0396	RL
R	D65302	831	3085.	0.	1.0988	1.0810	.9249	.0023	RL
R	D65448	825	3003.	0.	1.9329	1.8897	1.6396	.0018	RL
R	D65515	822	3003.	0.	.1288	.1236	.0941	.0018	RL
R	D65721	833	3101.	0.	1.5104	1.4849	1.3334	.0108	RL
R	D65722	831	3076.	0.	.3651	.3506	.2688	.0018	RL
R	D65768	822	2942.	0.	1.1690	1.1534	1.0406	.0018	RL
R	D66126	822	3055.	0.	1.0905	1.0618	.8211	.0482	RL
R	D66464	832	3061.	0.	1.6911	1.6580	1.4649	.0051	RL
R	D66498	825	2926.	0.	2.3412	2.2799	1.9284	.0121	RL
R	D66629	825	3039.	0.	1.9471	1.9039	1.6537	.0147	RL
R	D66646	831	3056.	0.	1.3023	1.2841	1.1696	.0025	RL
R	D66648	822	2995.	0.	1.1344	1.1192	.9999	.0363	RL

Table C-5. (continued).

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Predicted flammable gas concentration in innermost layer (Vol%)	Predicted flammable gas concentration in rigid drum liner (Vol%)	Predicted hydrogen concentration in drum headspace (Vol%)	Sampled flammable gas concentration (Vol%)	Sampling location[b]
R	D66653	831	3070.	0.	1.3190	1.3002	1.1835	.0076	RL
R	D66660	833	3079.	0.	1.5720	1.5438	1.3778	.0131	RL
R	D66675	825	3058.	0.	.9807	.9415	.7207	.0018	RL
R	D66745	825	2980.	0.	.1735	.1664	.1264	.0018	RL
R	D66749	825	2968.	0.	.6873	.6590	.5000	.0018	RL
R	D66754	822	3021.	0.	.1395	.1338	.1021	.0018	RL
R	D66755	825	2961.	0.	.2264	.2170	.1646	.0018	RL
R	D66794	832	3132.	0.	.5237	.5033	.3879	.0063	RL
R	D66825	825	3107.	0.	2.1772	2.1259	1.8317	.0767	RL
R	D66837	831	3129.	0.	2.2730	2.2183	1.9052	.0476	RL
R	D66844	832	3038.	0.	1.0922	1.0682	.8450	.0086	RL
R	D66846	831	3068.	0.	.2237	.2148	.1646	.0026	RL
R	D66848	825	2799.	0.	1.1016	1.0799	.8830	.0018	RL
R	D66891	832	3092.	0.	.3008	.2889	.2218	.0080	RL
R	D66923	825	3060.	0.	1.5239	1.4976	1.3411	.0593	RL
R	D66924	822	2421.	0.	1.6192	1.5804	1.3458	.0065	RL
R	D66927	825	3000.	0.	2.9904	2.9041	2.4143	.0342	RL
R	D66980	822	2988.	0.	1.6391	1.6074	1.4210	.0061	RL
R	D66990	821	2967.	0.	.7367	.7064	.5360	.0023	RL
R	D67054	831	3104.	0.	1.6050	1.5760	1.4053	.0064	RL
R	D67057	831	3047.	0.	1.0930	1.0640	.8219	.0019	RL
R	D67082	831	3053.	0.	2.7807	2.7043	2.2698	.0197	RL
R	D67110	822	2974.	0.	1.6870	1.6533	1.4555	.0162	RL
R	D67132	832	3074.	0.	.5591	.5369	.4116	.0067	RL
R	D67157	822	3032.	0.	.9794	.9400	.7177	.0018	RL
R	D67233	832	3037.	0.	3.6131	3.5026	2.8769	.0495	RL

Table C-5. (continued).

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Predicted flammable gas concentration in innermost layer (Vol%)	Predicted flammable gas concentration in rigid drum liner (Vol%)	Predicted hydrogen concentration in drum headspace (Vol%)	Sampled flammable gas concentration (Vol%)	Sampling location[b]
R	D67305	831	3019.	0.	1.5933	1.5637	1.3892	.0107	RL
R	D67328	831	3051.	0.	.4146	.3980	.3044	.0044	RL
R	D67377	822	3043.	0.	1.2800	1.2624	1.1504	.0018	RL
R	D67380	822	3022.	0.	1.0926	1.0638	.8208	.0018	RL
R	D67385	825	2980.	0.	1.0456	1.0028	.7618	.0018	RL
R	D67444	832	3037.	0.	.9512	.9129	.6974	.0045	RL
R	D67456	831	2990.	0.	2.1625	2.1098	1.8068	.0118	RL
R	D67537	825	2983.	0.	1.1358	1.1204	1.0002	.0018	RL
R	D67544	825	3031.	0.	.5470	.5249	.4008	.0018	RL
R	D67647	832	2999.	0.	1.2141	1.1981	1.0906	.0018	RL
R	D67714	822	3074.	0.	.1336	.1283	.0983	.0063	RL
R	D67874	825	2912.	0.	3.7850	3.6631	2.9716	.0178	RL
R	D67901	832	3006.	0.	1.4205	1.3975	1.2587	.0050	RL
R	D67939	822	3015.	0.	.9379	.9000	.6860	.0047	RL
R	D67945	822	2979.	0.	.7132	.6840	.5196	.0018	RL
R	D67956	822	2925.	0.	1.2222	1.2055	1.0927	.0022	RL
R	D68066	832	3004.	0.	2.6632	2.5903	2.1749	.0040	RL
R	D68072	832	2978.	0.	1.8835	1.8418	1.6003	.0019	RL
R	D68080	832	3049.	0.	1.1723	1.1575	1.0527	.0075	RL
R	D68149	832	3012.	0.	1.4490	1.4250	1.2799	.0032	RL
R	D68157	825	3046.	0.	1.7271	1.6925	1.4912	.0285	RL
R	D68171	832	3068.	0.	.9902	.9507	.7284	.0170	RL
R	D68362	832	3060.	0.	1.1443	1.1296	1.0193	.0020	RL
R	D68366	831	3076.	0.	1.4719	1.4476	1.3026	.0104	RL
R	D68379	831	3072.	0.	1.0948	1.0750	.8943	.0063	RL
R	D68448	832	2987.	0.	2.2110	2.1563	1.8419	.0170	RL

Table C-5. (continued).

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Predicted flammable gas concentration in innermost layer (Vol%)	Predicted flammable gas concentration in rigid drum liner (Vol%)	Predicted hydrogen concentration in drum headspace (Vol%)	Sampled flammable gas concentration (Vol%)	Sampling location[b]
R	D68511	832	3063.	0.	1.1880	1.1731	1.0697	.0084	RL
R	D68518	825	2878.	0.	.8880	.8506	.6393	.0031	RL
R	D68532	832	3060.	0.	1.2914	1.2735	1.1609	.0092	RL
R	D68533	832	3054.	0.	.9465	.9086	.6952	.0063	RL
R	D68544	832	2982.	0.	.7927	.7602	.5777	.0055	RL
R	D68624	832	3070.	0.	1.3135	1.2950	1.1795	.0063	RL
R	D68632	832	3063.	0.	1.0940	1.0746	.8992	.0063	RL
R	D68637	832	3058.	0.	1.5839	1.5551	1.3853	.0070	RL
R	D68640	832	2990.	0.	2.5602	2.4913	2.0972	.0252	RL
R	D68665	832	3026.	0.	3.2067	3.1125	2.5776	.0298	RL
R	D68676	825	2918.	0.	1.2713	1.2530	1.1345	.0067	RL
R	D68711	833	2970.	0.	2.2119	2.1569	1.8406	.0201	RL
R	D68740	832	2983.	0.	.9162	.8787	.6678	.0018	RL
R	D68748	833	2972.	0.	4.2490	4.1103	3.3260	.1028	RL
R	D68769	825	2960.	0.	1.3357	1.3154	1.1892	.1118	RL
R	D68784	832	3041.	0.	1.0102	.9698	.7410	.0063	RL
R	D68787	822	3049.	0.	1.0808	1.0375	.7935	.0063	RL
R	D68790	822	2942.	0.	2.6611	2.5868	2.1635	.0259	RL
R	D68794	822	2914.	0.	2.4531	2.3868	2.0072	.0263	RL
R	D68807	832	2984.	0.	2.1429	2.0910	1.7918	.0075	RL
R	D68821	832	3050.	0.	1.0485	1.0065	.7698	.0063	RL
R	D68826	825	2953.	0.	1.5296	1.5020	1.3373	.0018	RL
R	D68838	825	2939.	0.	1.2819	1.2635	1.1452	.0020	RL
R	D68855	825	2955.	0.	1.1326	1.1168	.9929	.0018	RL
R	D68871	825	2962.	0.	1.9088	1.8658	1.6166	.0138	RL
R	D68879	832	2990.	0.	2.0579	2.0094	1.7294	.0155	RL

Table C-5. (continued).

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Predicted flammable gas concentration in innermost layer (Vol%)	Predicted flammable gas concentration in rigid drum liner (Vol%)	Predicted hydrogen concentration in drum headspace (Vol%)	Sampled flammable gas concentration (Vol%)	Sampling location[b]
R	D68880	832	3049.	0.	1.1374	1.1226	1.0086	.0063	RL
R	D68953	825	2941.	0.	1.4945	1.4680	1.3093	.0039	RL
R	D68968	832	2962.	0.	3.5226	3.4135	2.7942	.0318	RL
R	D69008	825	2976.	0.	1.6426	1.6107	1.4231	.0047	RL
R	D69022	832	3034.	0.	1.3919	1.3702	1.2384	.0151	RL
R	D69154	832	3038.	0.	1.1685	1.1537	1.0473	.0076	RL
R	D69157	832	3025.	0.	1.1058	1.0885	.9396	.0068	RL
R	D69179	832	2949.	0.	1.4557	1.4310	1.2813	.0043	RL
R	D69180	832	2974.	0.	1.4805	1.4551	1.3021	.0109	RL
R	D69182	832	3027.	0.	1.3018	1.2833	1.1670	.0063	RL
R	D69197	825	2977.	0.	1.4970	1.4706	1.3135	.0189	RL
R	D69198	832	2958.	0.	3.1819	3.0862	2.5445	.0185	RL
R	D69240	825	2332.	0.	1.3010	1.2753	1.1022	.0147	RL
R	D69337	832	2963.	0.	1.4788	1.4533	1.2999	.0122	RL
R	D69370	822	2884.	0.	1.0963	1.0736	.8631	.0018	RL
R	D69375	831	2841.	0.	1.8695	1.8265	1.5759	.0100	RL
R	D69480	822	2849.	0.	1.1460	1.1296	1.0033	.0036	RL
R	D69511	825	2883.	0.	1.8597	1.8175	1.5726	.0018	RL
R	D69516	832	2943.	0.	1.1129	1.0960	.9555	.0050	RL
R	D69517	822	2874.	0.	1.1226	1.1055	.9659	.0041	RL
R	D69518	825	2926.	0.	1.2648	1.2468	1.1299	.0023	RL
R	D69534	825	2985.	0.	.3976	.3814	.2899	.0063	RL
R	D69536	825	2914.	0.	.1723	.1651	.1246	.0018	RL
R	D69623	832	2951.	0.	3.1398	3.0461	2.5131	.0019	RL
R	D69638	832	2966.	0.	2.7662	2.6882	2.2437	.0204	RL
R	D69656	832	2923.	0.	1.1456	1.1299	1.0096	.0053	RL

Table C-5. (continued).

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Predicted flammable gas concentration in innermost layer (Vol%)	Predicted flammable gas concentration in rigid drum liner (Vol%)	Predicted hydrogen concentration in drum headspace (Vol%)	Sampled flammable gas concentration (Vol%)	Sampling location[b]
R	D69657	832	2943.	0.	1.5356	1.5076	1.3410	.0187	RL
R	D69676	339	2850.	0.	3.7662	3.6425	2.9414	.0606	RL
R	D69740	825	2939.	0.	.4319	.4140	.3132	.0018	RL
R	D69747	822	2855.	0.	2.0677	2.0166	1.7210	.0103	RL
R	D69769	825	2182.	0.	1.1127	1.0808	.7838	.0049	RL
R	D69996	831	2985.	0.	1.4399	1.4161	1.2720	.0295	RL
R	D70019	825	2861.	0.	1.3418	1.3204	1.1869	.0036	RL
R	D70025	821	2867.	0.	1.1708	1.1546	1.0371	.0023	RL
R	D70026	822	2847.	0.	1.1119	1.0936	.9381	.0028	RL
R	D70139	832	2900.	0.	1.1810	1.1650	1.0505	.0028	RL
R	D70150	832	2928.	0.	.8923	.8551	.6462	.0098	RL
R	D70263	822	2827.	0.	1.2175	1.2001	1.0808	.0095	RL
R	D70317	832	2954.	0.	1.1070	1.0891	.9342	.0039	RL
R	D70319	825	2884.	0.	1.2291	1.2119	1.0959	.0020	RL
R	D70332	825	2984.	0.	1.3601	1.3393	1.2107	.0099	RL
R	D70378	825	2877.	0.	.7559	.7239	.5441	.0018	RL
R	D70387	822	2974.	0.	.7585	.7274	.5523	.0063	RL
R	D70392	822	2877.	0.	.9820	.9405	.7069	.0018	RL
R	D70460	832	2943.	0.	1.6519	1.6191	1.4261	.0163	RL
R	D70464	822	2860.	0.	3.1501	3.0530	2.5003	.0018	RL
R	D70501	822	2834.	0.	1.0955	1.0703	.8351	.0050	RL
R	D70598	832	2948.	0.	1.2157	1.1994	1.0884	.0063	RL
R	D70659	822	2850.	0.	2.3340	2.2711	1.9108	.0351	RL
R	D70683	831	2820.	0.	3.6508	3.5310	2.8507	.0514	RL
R	D70751	831	2890.	0.	1.3538	1.3322	1.1982	.0022	RL
R	D70781	832	2841.	0.	1.6555	1.6214	1.4195	.0054	RL

Table C-5. (continued).

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Predicted flammable gas concentration in innermost layer (Vol%)	Predicted flammable gas concentration in rigid drum liner (Vol%)	Predicted hydrogen concentration in drum headspace (Vol%)	Sampled flammable gas concentration (Vol%)	Sampling location[b]
R	D70791	832	2891.	0.	1.2542	1.2363	1.1184	.0095	RL
R	D70900	832	2894.	0.	1.9812	1.9344	1.6631	.0186	RL
R	D70930	822	2882.	0.	3.0520	2.9599	2.4349	.0031	RL
R	D70932	832	2863.	0.	2.3148	2.2528	1.8993	.0150	RL
R	D71072	825	2825.	0.	.2418	.2314	.1730	.0393	RL
R	D71118	832	2793.	0.	1.6511	1.6165	1.4114	.0035	RL
R	D71168	832	2898.	0.	1.4144	1.3907	1.2459	.0300	RL
R	D71184	822	2797.	0.	.5205	.4979	.3710	.1179	RL
R	D71191	822	2828.	0.	.9365	.8963	.6701	.0018	RL
R	D71211	831	2920.	0.	3.1568	3.0612	2.5184	.0386	RL
R	D71214	831	2931.	0.	1.2035	1.1873	1.0756	.0063	RL
R	D71218	831	2884.	0.	1.7269	1.6904	1.4764	.0205	RL
R	D71230	825	2914.	0.	1.3204	1.3004	1.1744	.0038	RL
R	D71260	831	2854.	0.	1.9333	1.8876	1.6234	.0133	RL
R	D71289	832	2926.	0.	1.2810	1.2624	1.1431	.0063	RL
R	D71493	832	2929.	0.	1.3749	1.3530	1.2180	.0063	RL
R	D71495	832	2906.	0.	1.2143	1.1977	1.0840	.0038	RL
R	D71511	822	2765.	0.	1.1068	1.0866	.9089	.0026	RL
R	D71519	822	2757.	0.	.1897	.1814	.1345	.0018	RL
R	D71621	832	2859.	0.	1.4645	1.4384	1.2801	.0132	RL
R	D71622	832	2830.	0.	1.4901	1.4627	1.2975	.0036	RL
R	D71640	832	2840.	0.	.4651	.4452	.3333	.0018	RL
R	D71687	825	2136.	0.	1.2835	1.2555	1.0605	.0269	RL
R	D71832	832	2842.	0.	1.2583	1.2399	1.1182	.0061	RL
R	D71846	831	2820.	0.	3.3747	3.2666	2.6523	.0151	RL
R	D71930	825	2150.	0.	1.1455	1.1198	.9035	.0018	RL

Table C-5. (continued).

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Predicted flammable gas concentration in innermost layer (Vol%)	Predicted flammable gas concentration in rigid drum liner (Vol%)	Predicted hydrogen concentration in drum headspace (Vol%)	Sampled flammable gas concentration (Vol%)	Sampling location[b]
R	D71978	832	2899.	0.	1.1041	1.0854	.9222	.0063	RL
R	D71980	832	2806.	0.	1.0956	1.0686	.8206	.0044	RL
R	D72009	825	2813.	0.	1.4738	1.4468	1.2836	.0019	RL
R	D72022	825	2761.	0.	.3250	.3108	.2306	.0018	RL
R	D72088	832	2799.	0.	.2302	.2202	.1641	.0018	RL
R	D72137	825	2711.	0.	.3484	.3328	.2455	.0018	RL
R	D72143	822	2850.	0.	.2154	.2062	.1545	.0018	RL
R	D72145	825	2731.	0.	.4205	.4018	.2971	.0018	RL
R	D72159	821	2859.	0.	3.2165	3.1165	2.5475	.0161	RL
R	D72198	822	2770.	0.	.1674	.1600	.1189	.0018	RL
R	D72247	832	2783.	0.	.1342	.1283	.0955	.0063	RL
R	D72252	832	2884.	0.	1.1576	1.1415	1.0220	.0065	RL
R	D72404	825	2765.	0.	.4384	.4192	.3112	.0018	RL
R	D72450	832	2883.	0.	1.0968	1.0574	.7963	.0111	RL
R	D72600	832	2814.	0.	1.1471	1.1304	1.0013	.0095	RL
R	D72610	832	2853.	0.	1.1123	1.0940	.9377	.0032	RL
R	D72652	832	2859.	0.	.5269	.5045	.3785	.0063	RL
R	D72672	832	2843.	0.	1.1794	1.1629	1.0444	.0054	RL
R	D72780	832	2852.	0.	1.1039	1.0845	.9138	.0101	RL
R	D72820	832	2842.	0.	.5400	.5169	.3870	.0019	RL
R	D72843	832	2822.	0.	.5677	.5432	.4059	.0018	RL
R	D72850	832	2827.	0.	1.5386	1.5091	1.3321	.0137	RL
R	D72893	832	2847.	0.	1.9827	1.9348	1.6575	.0128	RL
R	D72924	825	2719.	0.	1.0976	1.0645	.7939	.0024	RL
R	D72927	825	2757.	0.	1.2713	1.2516	1.1221	.0033	RL
R	D72930	825	2710.	0.	.7574	.7236	.5337	.0018	RL

Table C-5. (continued).

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Predicted flammable gas concentration in innermost layer (Vol%)	Predicted flammable gas concentration in rigid drum liner (Vol%)	Predicted hydrogen concentration in drum headspace (Vol%)	Sampled flammable gas concentration (Vol%)	Sampling location[b]
R	D73038	825	2764.	0.	1.2113	1.1935	1.0696	.0039	RL
R	D73058	339	2852.	0.	3.0800	2.9856	2.4497	.0789	RL
R	D73201	822	2658.	0.	1.2469	1.2271	1.0926	.0055	RL
R	D73225	832	2816.	0.	1.2376	1.2195	1.0981	.0142	RL
R	D73228	832	2756.	0.	1.6113	1.5778	1.3790	.0080	RL
R	D73236	832	2765.	0.	1.2212	1.2032	1.0790	.0127	RL
R	D73289	825	2698.	0.	1.5131	1.4832	1.3019	.0107	RL
R	D73292	822	2720.	0.	.6884	.6578	.4857	.0018	RL
R	D73298	825	2720.	0.	1.0316	.9857	.7278	.0032	RL
R	D73303	825	2753.	0.	1.1728	1.1556	1.0294	:0046	RL
R	D73307	825	2720.	0.	1.2098	1.1916	1.0643	.0027	RL
R	D73349	825	2609.	0.	1.5243	1.4928	1.3009	.0065	RL
R	D73363	825	2631.	0.	2.1221	2.0640	1.7271	.0100	RL
R	D73369	822	2631.	0.	.9439	.9006	.6577	.0369	RL
R	D73581	825	2576.	0.	1.0955	1.0443	.7572	.0026	RL
R	D73825	825	2622.	0.	2.5622	2.4837	2.0332	.0024	RL
R	D73879	825	2634.	0.	.9446	.9013	.6586	.0018	RL
R	D73909	832	2373.	0.	1.4399	1.4089	1.2126	.0063	RL
R	D74029	832	2710.	0.	.8014	.7656	.5646	.0135	RL
R	D74133	822	2508.	0.	.7562	.7199	.5172	.0018	RL
R	D74428	832	2582.	0.	.1910	.1821	.1322	.0023	RL
R	D74646	831	2619.	0.	1.1037	1.0788	.8483	.0033	RL
R	D74659	822	2503.	0.	.4576	.4356	.3127	.0032	RL
R	D74727	832	2620.	0.	.7485	.7140	.5208	.0023	RL
R	D74749	822	2165.	0.	.5112	.4834	.3285	.0063	RL
R	D75196	825	2239.	0.	2.0904	2.0238	1.6331	.0240	RL

Table C-5. (continued).

Site ID[a]	Drum ID no.	IDC	Sealed time (days)	Aspiration time (days)	Predicted flammable gas concentration in innermost layer (Vol%)	Predicted flammable gas concentration in rigid drum liner (Vol%)	Predicted hydrogen concentration in drum headspace (Vol%)	Sampled flammable gas concentration (Vol%)	Sampling location[b]
R	D75266	832	2556.	0.	1.1161	1.0942	.9021	.0063	RL
R	D75272	339	2307.	0.	1.7198	1.6739	1.3976	.0188	RL
R	D75280	339	2462.	0.	1.8963	1.8449	1.5435	.0167	RL
R	D75605	832	2445.	0.	.5957	.5665	.4033	.0018	RL
R	D75759	822	2338.	0.	3.4411	3.3087	2.5561	.0188	RL
R	D75894	825	2474.	0.	1.1359	1.1149	.9406	.0063	RL
R	D76176	339	2303.	0.	1.1831	1.1606	.9895	.0103	RL
R	D76446	825	2269.	0.	1.1238	1.0981	.8708	.0019	RL
R	D76451	825	2268.	0.	.8186	.7757	.5370	.0018	RL
R	D76455	825	2361.	0.	.5921	.5621	.3951	.0018	RL
R	D76576	825	2238.	0.	.6997	.6627	.4563	.0020	RL
R	D76639	825	2250.	0.	1.2127	1.1889	1.0138	.0045	RL
R	D76776	825	2235.	0.	.4803	.4548	.3131	.0018	RL
R	D76831	822	2188.	0.	1.3272	1.2983	1.1032	.0046	RL
R	D76934	831	2319.	0.	.9854	.9348	.6526	.0063	RL
R	D77114	832	2219.	0.	.8270	.7829	.5373	.0139	RL
R	D77225	825	2192.	0.	.9549	.9034	.6170	.0027	RL
R	D85061	822	693.	0.	.4394	.3825	.1304	.0029	RL
R	D85338	822	584.	0.	1.4368	1.3260	.5437	.0118	RL

a. R = RFETS

b. RL = Rigid drum liner; DH = Drum headspace; IB = Inner bag (Innermost confinement layer)

Appendix D

Results of the Gas Generation Testing Program at the Rocky Flats Environmental Technology Site

Table D-1. Shipping category II.1A4 Rocky Flats Environmental Technology Site Gas Generation Testing Program effective G-values.

	Drum no.	IDC	Watts	Hydrogen gas generation rate (moles/sec)	MDP matrix	Hydrogen G_{eff} (molecules/ 100 eV)	UCL_{95} for mean G-value	95[th] percentile G-value	UTL_{95}
1	49536	300	0.0995	1.139E-10	PE/PVC	0.011	0.2600	0.44	0.64
2	52972	300	0.1053	8.707E-11	PE/PVC	0.008	0.2600	0.44	0.64
3	53919	300	0.0956	1.161E-10	PE/PVC	0.012	0.2600	0.44	0.64
4	54583	300	0.1911	0.000E+00	PE/PVC	0.000	0.2600	0.44	0.64
5	54634	300	0.0858	3.386E-11	PE/PVC	0.004	0.2600	0.44	0.64
6	55068	300	0.1697	3.521E-10	PE/PVC	0.020	0.2600	0.44	0.64
7	55073	300	0.0897	3.546E-10	PE/PVC	0.038	0.2600	0.44	0.64
8	55785	300	0.1326	6.681E-10	PE/PVC	0.049	0.2600	0.44	0.64
9	57092	442	0.0830	0.000E+00	PE/PVC	0.000	0.2600	0.44	0.64
10	57972	300	0.0917	-2.589E-11	PE/PVC	-0.003	0.2600	0.44	0.64
11	59917	300	0.2399	0.000E+00	PE/PVC	0.000	0.2600	0.44	0.64
12	63765	300	0.0468	3.418E-10	PE/PVC	0.070	0.2600	0.44	0.64
13	66668	480	0.0975	5.851E-10	PE/PVC	0.058	0.2600	0.44	0.64
14	70081	480	0.0702	1.517E-09	PE/PVC	0.208	0.2600	0.44	0.64
15	71269	480	0.1619	1.213E-09	PE/PVC	0.072	0.2600	0.44	0.64
16	72368	480	0.1443	2.159E-09	PE/PVC	0.144	0.2600	0.44	0.64

Table D-2. Shipping category III.1A4 Rocky Flats Environmental Technology Site Gas Generation Testing Program effective G-values.

	Drum no.	IDC	Watts	Hydrogen gas generation rate (moles/sec)	MDP matrix	Hydrogen G_{eff} (molecules/ 100 eV)	UCL_{95} for mean G-value	95[th] Percentile G-value	UTL_{95}
1	6330	337	0.3530	3.536E-08	PE/PVC/WC/DC	0.967	0.48	0.99	1.09
2	6331	337	0.4660	2.822E-08	PE/PVC/WC/DC	0.584	0.48	0.99	1.09
3	6332	336	0.5586	3.946E-08	PE/PVC/WC/DC	0.682	0.48	0.99	1.09
4	6334	337	0.3958	2.528E-08	PE/PVC/WC/DC	0.616	0.48	0.99	1.09
5	6339	337	1.0626	4.373E-08	PE/PVC/WC/DC	0.397	0.48	0.99	1.09
6	6350	337	0.9622	3.108E-08	PE/PVC/WC/DC	0.312	0.48	0.99	1.09
7	6354	336	1.1065	1.525E-08	PE/PVC/WC/DC	0.133	0.48	0.99	1.09
8	11255	330	0.8287	3.416E-08	PE/PVC/WC/DC	0.398	0.48	0.99	1.09
9	11931	337	0.3178	9.236E-10	PE/PVC/WC/DC	0.028	0.48	0.99	1.09
10	13855	336	0.1229	6.337E-09	PE/PVC/WC/DC	0.498	0.48	0.99	1.09
11	20990	336	0.3003	1.051E-09	PE/PVC/WC/DC	0.034	0.48	0.99	1.09
12	22901	336	0.4339	6.755E-09	PE/PVC/WC/DC	0.150	0.48	0.99	1.09
13	41065	336	0.1112	4.529E-09	PE/PVC/WC/DC	0.393	0.48	0.99	1.09
14	41574	336	0.0819	3.624E-09	PE/PVC/WC/DC	0.427	0.48	0.99	1.09
15	46817	336	0.0527	-2.838E-09	PE/PVC/WC/DC	-0.520	0.48	0.99	1.09
16	49139	336	0.0858	2.350E-09	PE/PVC/WC/DC	0.264	0.48	0.99	1.09

Table D-2. (continued).

	Drum no.	IDC	Watts	Hydrogen gas generation rate (moles/sec)	MDP matrix	Hydrogen G_{eff} (molecules/ 100 eV)	UCL_{95} for mean G-value	95th Percentile G-value	UTL_{95}
17	49295	338	0.3549	1.702E-09	PE/PVC/WC/DC	0.046	0.48	0.99	1.09
18	50189	335	0.2282	6.007E-10	PE/PVC/WC/DC	0.025	0.48	0.99	1.09
19	50475	330	0.4280	2.738E-08	PE/PVC/WC/DC	0.617	0.48	0.99	1.09
20	50480	330	0.6503	3.328E-08	PE/PVC/WC/DC	0.494	0.48	0.99	1.09
21	54018	330	0.0936	-8.257E-11	PE/PVC/WC/DC	-0.009	0.48	0.99	1.09
22	54796	330	0.3393	1.249E-08	PE/PVC/WC/DC	0.355	0.48	0.99	1.09
23	54992	336	0.0683	-1.826E-10	PE/PVC/WC/DC	-0.026	0.48	0.99	1.09
24	55010	338	0.3315	2.992E-10	PE/PVC/WC/DC	0.009	0.48	0.99	1.09
25	55520	336	0.0995	3.894E-09	PE/PVC/WC/DC	0.378	0.48	0.99	1.09
26	56729	337	0.0702	2.960E-09	PE/PVC/WC/DC	0.407	0.48	0.99	1.09
27	58918	336	0.2301	4.127E-09	PE/PVC/WC/DC	0.173	0.48	0.99	1.09
28	59499	330	0.1034	3.277E-09	PE/PVC/WC/DC	0.306	0.48	0.99	1.09
29	60506	336	0.2711	1.013E-08	PE/PVC/WC/DC	0.360	0.48	0.99	1.09
30	60512	342	0.0858	1.591E-09	PE/PVC/WC/DC	0.179	0.48	0.99	1.09
31	60744	336	0.0488	3.205E-09	PE/PVC/WC/DC	0.634	0.48	0.99	1.09
32	61135	336	0.0819	3.842E-09	PE/PVC/WC/DC	0.453	0.48	0.99	1.09
33	61245	336	0.0663	2.284E-09	PE/PVC/WC/DC	0.332	0.48	0.99	1.09
34	61385	336	0.1989	1.129E-08	PE/PVC/WC/DC	0.548	0.48	0.99	1.09
35	61388	335	0.1619	2.670E-09	PE/PVC/WC/DC	0.159	0.48	0.99	1.09
36	61797	336	0.2828	6.008E-09	PE/PVC/WC/DC	0.205	0.48	0.99	1.09
37	61884	336	0.0936	5.282E-09	PE/PVC/WC/DC	0.545	0.48	0.99	1.09
38	62709	300	0.1463	5.593E-10	PE/PVC/WC/DC	0.037	0.48	0.99	1.09
39	63074	336	0.0780	3.449E-09	PE/PVC/WC/DC	0.427	0.48	0.99	1.09
40	63469	336	0.1736	5.292E-09	PE/PVC/WC/DC	0.294	0.48	0.99	1.09
41	63768	336	0.0585	2.284E-09	PE/PVC/WC/DC	0.377	0.48	0.99	1.09
42	63772	376	0.1092	4.781E-10	PE/PVC/WC/DC	0.042	0.48	0.99	1.09
43	63966	342	0.2126	2.421E-09	PE/PVC/WC/DC	0.110	0.48	0.99	1.09
44	64549	336	0.1599	3.645E-09	PE/PVC/WC/DC	0.220	0.48	0.99	1.09
45	65057	330	0.7204	8.101E-09	PE/PVC/WC/DC	0.109	0.48	0.99	1.09
46	65476	342	0.0975	3.639E-10	PE/PVC/WC/DC	0.036	0.48	0.99	1.09
47	65484	330	0.3257	1.346E-08	PE/PVC/WC/DC	0.399	0.48	0.99	1.09
48	65560	342	0.0527	5.674E-10	PE/PVC/WC/DC	0.104	0.48	0.99	1.09
49	65643	342	0.0351	9.943E-10	PE/PVC/WC/DC	0.273	0.48	0.99	1.09
50	66329	337	0.1248	4.965E-09	PE/PVC/WC/DC	0.384	0.48	0.99	1.09
51	66543	336	0.4202	1.847E-08	PE/PVC/WC/DC	0.424	0.48	0.99	1.09
52	66855	336	0.1014	3.718E-09	PE/PVC/WC/DC	0.354	0.48	0.99	1.09
53	66867	337	0.1541	2.547E-09	PE/PVC/WC/DC	0.160	0.48	0.99	1.09
54	68067	330	0.3491	2.415E-08	PE/PVC/WC/DC	0.668	0.48	0.99	1.09
55	68286	335	0.3276	5.251E-09	PE/PVC/WC/DC	0.155	0.48	0.99	1.09
56	68608	337	0.0858	2.007E-09	PE/PVC/WC/DC	0.226	0.48	0.99	1.09
57	68655	336	0.5440	1.089E-08	PE/PVC/WC/DC	0.193	0.48	0.99	1.09
58	69104	330	0.1775	7.932E-09	PE/PVC/WC/DC	0.431	0.48	0.99	1.09
59	69376	330	0.7555	1.429E-08	PE/PVC/WC/DC	0.183	0.48	0.99	1.09
60	69907	376	0.1034	1.324E-09	PE/PVC/WC/DC	0.124	0.48	0.99	1.09
61	70850	337	0.0780	1.764E-09	PE/PVC/WC/DC	0.218	0.48	0.99	1.09
62	70895	330	0.1599	8.164E-09	PE/PVC/WC/DC	0.493	0.48	0.99	1.09

Table D-2. (continued).

	Drum no.	IDC	Watts	Hydrogen gas generation rate (moles/sec)	MDP matrix	Hydrogen G_{eff} (molecules/ 100 eV)	UCL_{95} for mean G-value	95th Percentile G-value	UTL_{95}
63	71852	336	0.3588	3.174E-08	PE/PVC/WC/DC	0.853	0.48	0.99	1.09
64	72380	330	0.5928	2.706E-08	PE/PVC/WC/DC	0.440	0.48	0.99	1.09
65	72559	336	0.2126	8.120E-09	PE/PVC/WC/DC	0.369	0.48	0.99	1.09
66	73268	330	0.1823	8.629E-09	PE/PVC/WC/DC	0.457	0.48	0.99	1.09
67	74974	336	0.0936	8.390E-09	PE/PVC/WC/DC	0.865	0.48	0.99	1.09

Appendix E

Postirradiation Examination

POSTIRRADIATION EXAMINATION

Postirradiation examinations were conducted on two test cylinders, TC A04 ($^{239}PuO_2$ and dry cellulosics) and TC A16 ($^{239}PuO_2$ and PE). The purpose of these examinations was twofold: (a) to obtain a sample of material for microscopic examination to assess the nature of adherence of the particles to the surface; and (b) to document the gross effects of the test materials' prolonged exposure to an alpha source. Results of microscopic examination are not yet available, but will be included in a future revision of this document. Figures E-1 through E-3 illustrate the contents of TC A16 at the time of loading (Figure E-1), after it was removed from the test cylinder (Figure E-2), and after the PE was unfolded (Figure E-3). There was no apparent degradation of the PE during the course of the experiment. The PE tie was removed, and the PE was carefully unfolded. A substantial fraction of the PuO_2 was observed in a fold that had been at the bottom of the test cylinder. The PE's inner surface had a mottled appearance, with small patches of PuO_2 (approximately 1 cm x 1 cm) adhering to the surface. When viewed at an oblique angle, the PE appeared to be waffled or dimpled in these patches of adhered PuO_2; however, there was no evidence of holes or discoloration. The material seemed to retain its elasticity and was not noticeably embrittled.

Figures E-4 through E-6 illustrate the contents of TC A04 at the time of loading (Figure E-4),at the time of removal from the test cylinder (Figure E-5); and after the dry cellulosics (cheesecloth and paper) was unfolded (Figure E-6). The tie that held the package together was clipped with a pair of scissors, and the paper was carefully unfolded. The cheesecloth within the paper wrapping was folded back to expose the region where PuO_2 was in contact with paper and cheesecloth. It appeared that a substantial fraction of the PuO_2 had settled into the fold that had been at the bottom of the test cylinder. The paper was considerably discolored (yellows and browns) and degraded where it was in contact with the PuO_2; and was quite brittle and cracked easily. The cheesecloth was discolored (yellows and browns) and degraded, with many loose fibers plainly evident.

Figure E-1. Contents of TC A16 (~2.3 grams of $^{239}PuO_2$ and PE) at the time of loading.

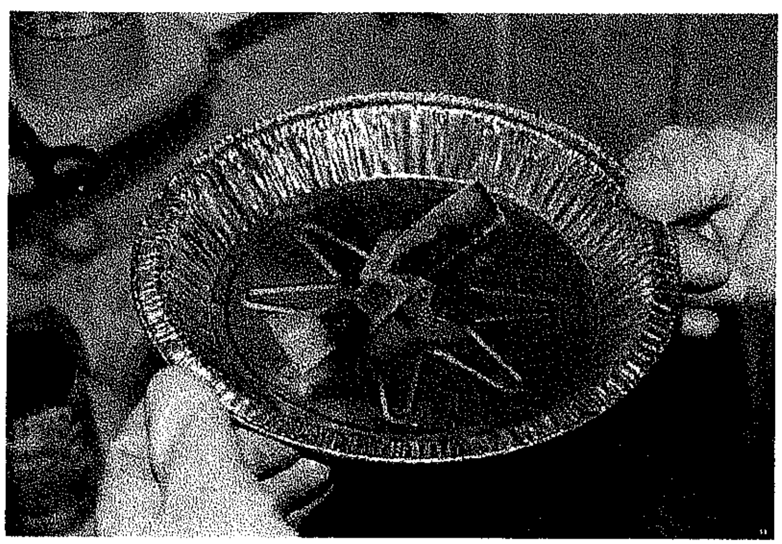

Figure E-2. The waste matrix when it was removed from TC A16.

Figure E-3. Contents of TC A16 after removal.

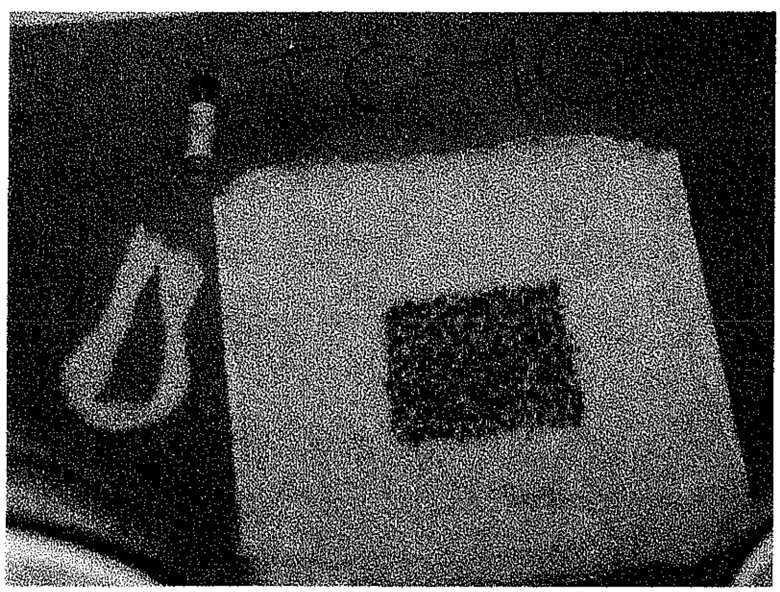

Figure E-4. Contents of TC A04 (~2.3 grams of $^{239}PuO_2$ and dry cellulosics) at the time of loading.

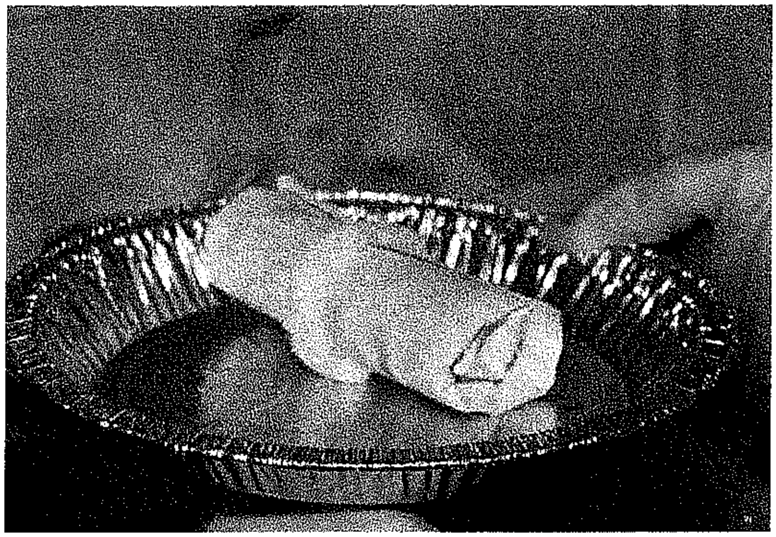

Figure E-5. Waste matrix when it was removed from TC A04.

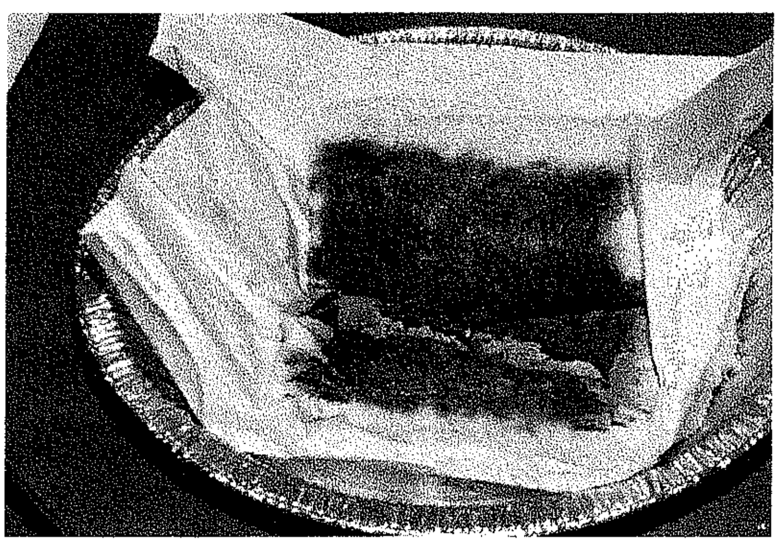

Figure E-6. Contents of TC A04 after removal.