TRUPACT-III Transport Package

A Presentation to the
US Nuclear Regulatory Commission

Docket 71-9305

November 16, 2005

PACTEC

Agenda

- *Meeting Objectives*
- *Engineering Test Results*
- *Certification Test Plan – overview & discussion*
- *Program Schedule*
- *Summary Discussion*

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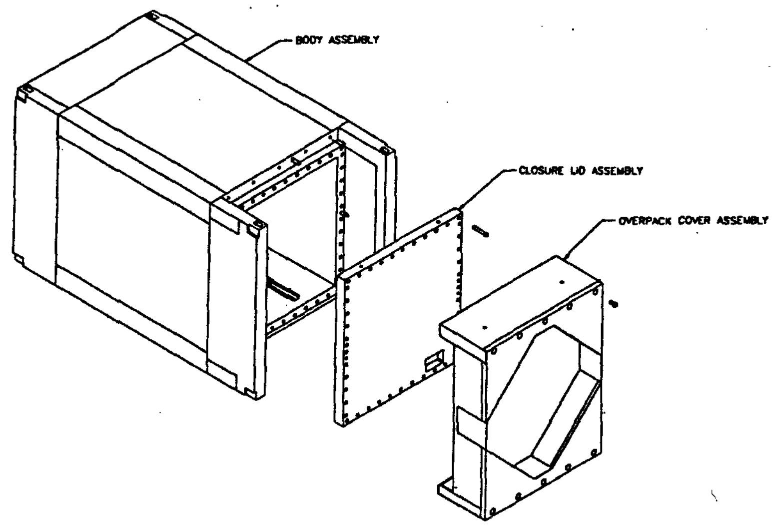
Meeting Objectives

- Review the results from the engineering test
- Review the Certification Test Plan
- Receive NRC staff views and comments
- Discuss program schedule

TRUPACT-III Design

- TRUPACT-III redesigned since March 2004 SAR submittal
  - Primarily a reduction in length, change from wood to foam, & increase in flange stiffness
- New design features discussed during NRC meeting in April 2005
- No significant changes made since then
- Vital statistics:
  - 4.3 m long, 2.5 m wide, and 2.65 m tall (external)
  - Gross weight 25,000 kg

TRUPACT-III Design



TRUPACT-III Design

Withheld per 10 CFR 2.390

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> NRC #8, November 16, 2005

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TRUPACT-III Payloads

- Contents: Contact-Handled Transuranic waste materials similar to TRUPACT-II
- Primary payload: SLB-2 box (DOT 7A Type A container which essentially fills the payload cavity)
- Contents limits:
  - 80 Watts total
  - Payload weight 5,125 kg [11,300 lb], including roller floor, pallet, and dunnage

Engineering Test

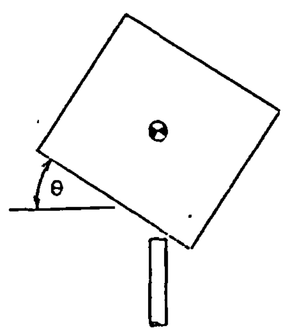
- Objectives of engineering test:
  - (I) Ensure package integrity in 9 m flat side free drop
  - (II) Determine worst-case puncture orientation angle
  - (III) Determine effectiveness of puncture-resistant plates used in both end overpacks
- Testing performed on previously tested half-scale unit
  - Test unit weight made equal to current design weight
  - Prior damage had minimal effect on results
  - End puncture-resistant structure refurbished

Engineering Test

- *Part (I): 9 m flat side free drop*
  - *Planned for full scale certification test series due to maximum lateral impact*
  - *Engineering test not prototypic, but representative*
- *Results:*
  - *No signs of deformation of CSA walls*
  - *Capable of hard vacuum between lid seals*
  - *Lid load-bearing areas showed minimal bearing yield*
  - *Closure bolts retained torque*

Engineering Test

- *Part (II): Determination of worst-case puncture orientation angle*
- *Angles tested: θ = 19°, 25°, 30°, 35°*



(19° results adopted from 2003 cert test on package end)

Engineering Test

- Basis of evaluation: depth of dent in CSA outer sheet
- Results:

Angle θ	CSA Dent Depth	Comment
19	1.1" + cut	Damage similar to 25°
25	1.1"	Damage similar to 19°
30	0.6"	Intermediate damage
35	negligible	Least damaging

- Conclusion: Worst case angle between 20° - 25°

NRC 86, November 18 2005

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Engineering Test

- Part (III): Effectiveness of redesigned puncture-resistant plates on ends
  - 50% thicker puncture-resistant plates used on ends (15 mm compared to 10 mm)
- Result: no cutting or shearing of puncture-resistant plate

NRC 86, November 18, 2005

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Engineering Test

- ***Test conclusions:***
  - ***9 m flat side drop can be sustained without excessive lid lateral movement, bearing surface yielding, loss of bolt preload torque, or loss of leaktight capability***
  - ***Most damaging puncture orientation on package side is 20° - 25°***
  - ***Increased puncture-resistant plate thickness on ends is effective in protecting the lid from excessive deformation or thermally-relevant damage***
- ***Findings will be confirmed in certification testing***

Certification Test Plan

- ***Objectives***
  - ***To demonstrate that, after a worst-case sequence of free drop and puncture events, the package is leak tight***
  - ***To demonstrate that no deformations will be incurred that would lead to failure of the elastomeric containment seals, or allow the CSA to exceed 600 °F in the subsequent HAC fire***

Certification Test Plan

- Single, full-scale, prototypic CTU
- Demonstration basis: leaktight containment per ANSI N14.5 after full series of free drops and puncture drops
- Free Drops Instrumented with accelerometers
- High-speed filming of free drops planned
- Prior half scale results utilized as guide

Certification Test Plan

- Thermal evaluation by analysis
  - Thermal analysis of damaged package must show acceptable thermal margin
- Structural evaluations:
  - NCT free drop, and HAC free drop & puncture, by test
    - Total of five free drops and four punctures
  - All other NCT and HAC load cases by analysis

Certification Test Plan

- *Initial conditions*
  - *Internal design pressure*
  - *For high-impact drops, temperature will be cold (-20 °F)*
  - *For maximum crush deformation drops, temperature will be ambient, with analytical correction to max. temperature*
  - *Puncture tests will be at ambient*

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Certification Test Plan

- *CTU configuration*
  - *Full-scale, prototypic package*
  - *Generally of nominal construction*
    - *Steel thickness and strength will be as-received*
  - *To the extent possible:*
    - *Foam strength which governs impact will be nominal-to-max*
    - *Foam strength which governs deformation will be nominal-to-min*

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Certification Test Plan

- ***CTU configuration, cont.***
  - ***CTU will feature special containment seal test ports***
    - *Allows leak testing without removal of overpack cover*
  - ***Containment O-ring compression will be reduced:***
    - *The maximum CTU compression will be less than the minimum production unit compression at -20 °F*
  - ***Test payload will be loose metal objects, such as steel or aluminum round bars***

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Certification Test Plan

- ***Free drops and punctures result from a selection process, guided by prior test results***
- ***One NCT, 1-ft free drop***
- ***Four 30-ft free drops***
  - ***Two focus on impact***
  - ***Two focus on deformation***
- ***Four puncture drops***
  - ***Two focus on puncture-resistant panels***
  - ***Two focus on damage relevant to HAC fire***

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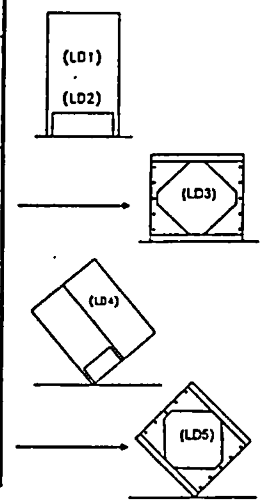
Certification Test Plan

Free Drop Test	Purpose
Vertical, Lid Down (cold); NCT & HAC	Closure and containment seal
Flat Side (cold)	Closure and containment seal, general structural integrity
CG over Lid Corner (ambient)	Max thermally-relevant damage (1)
Side-Edge (ambient)	Max thermally-relevant damage (2)



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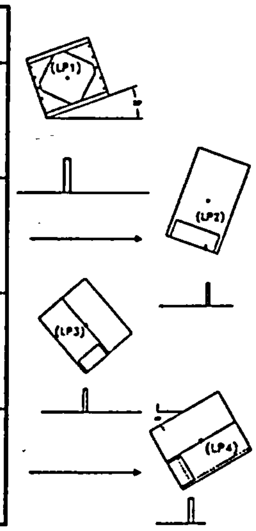
Certification Test Plan

Puncture Test	Purpose
On Flat Side Damage	Test puncture-resistant design (Side)
On Overpack Cover	Test puncture-resistant design (Closure lid end)
On CG over Lid Corner Damage	Max thermally-relevant damage accumulation (1)
On Side-Edge Damage	Max thermally-relevant damage accumulation (2)



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Certification Test Plan

- *Near-vertical free drop will not be performed*
  - *The impact magnitude drops off rapidly with angle, therefore near-vertical impacts will be relatively low*
  - *The near-vertical orientation does not represent a significant reduction in lid support compared to vertical*
  - *Overpack cover cannot be pried off by impact on one edge*
- *Slapdown free drop will not be performed*
  - *Crush deformation bounded by CG over corner drop*
  - *Secondary impact (primarily lateral to package axis) bounded by flat side drop*

Certification Test Plan

- *CG over corner free drop damage will be conservatively combined with end drop damage*
  - *Calculations indicate conservatism will not be excessive*
  - *Combined damage bounds CG over corner drop damage at NCT hot temperature*
- *Side-edge free drop damage at ambient temperature analytically adjusted to NCT hot temperature*
- *First three punctures through package CG*
- *Last puncture aims near, but not through, CG*

Certification Test Plan

- Data collection
  - Temperature of crushable media
  - Accelerations (free drops)
  - High speed film
- Measurements (pre- and post-test)
  - Helium leak tests
  - Crush distance, puncture damage
  - Cavity dimensions
  - Photographs

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Certification Test Plan

- Acceptance Criteria
  - Leaktight per ANSI 14.5
  - Deformations bounded by thermal analysis assumptions
- Discussion

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Program Schedule

- Long-lead plate material delivered
- CTU fabrication start – November 2005
- Certification testing at Sandia National Laboratory – July 2006
- Submittal of revised application to NRC – October 2006
- Planning on approximately 5 months to first round RAIs

TRUPACT-III

- Summary Discussion

TRUPACT-III Payload

Safe Transport of Boxed TRU Waste

Washington TRU Solutions LLC
11/16/05

Background

- Presentation addresses a proposed compliance methodology for flammability requirements
- Approximately 25% of transuranic (TRU) waste is packaged in large boxes - typically 4'x4'x7'
- Use of currently approved TRU waste methodologies for demonstrating compliance with 10 CFR 71.43(d) necessitate repackaging nearly all of the boxed waste
- Repackaging transuranic waste (particularly ^{238}Pu) entails significant risk for worker exposure

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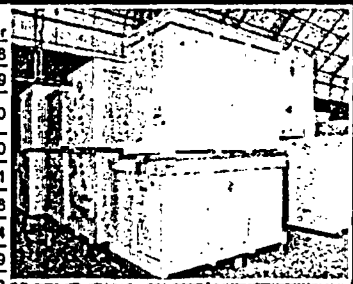
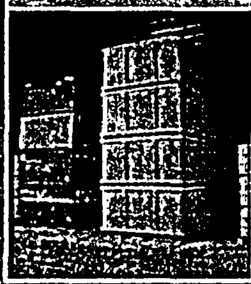
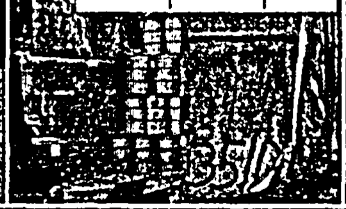
Background (cont.)

Site	Vol (m^3)	Number
Hanford	7955	668
INL	35,103	11,019
Knolls/NFS	51	20
LANL	6,576	890
LLNL	166	31
NTS	270	58
SNL	13	4
SRS	5245	349
WV	777	112
Total	**56,156**	**13,151**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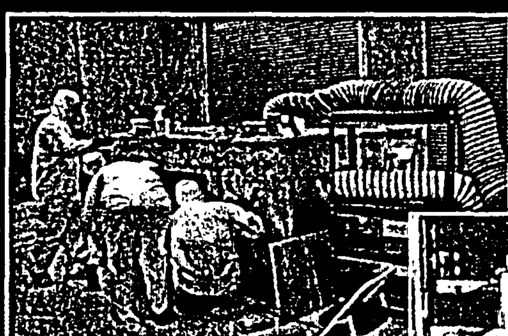
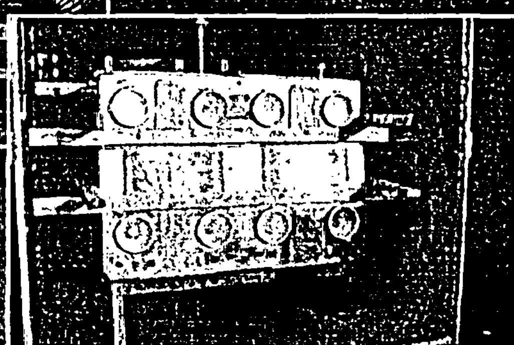
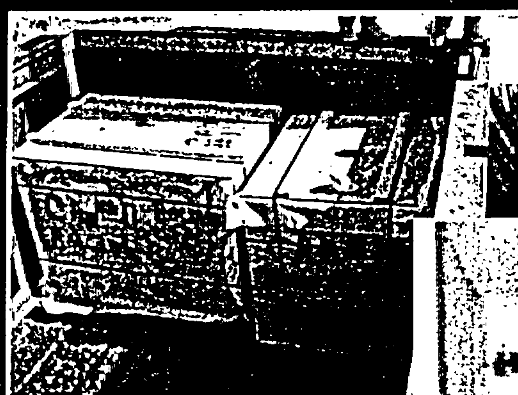


Repackaging large boxes and size reduction presents special problems (typically too big to fit in a glovebox)

Many large boxes contain contaminated equipment which is not vented



Background (cont.)



Retrievably stored plywood boxes

RTR of large box showing a piece of machining equipment housed in a glovebox enclosure

Objective

- Establish a compliance methodology for TRUPACT-III flammability requirements that ensures no loss of containment under normal conditions of transport and hypothetical accident conditions
- Minimize the number of large boxes that require repackaging

Note: Some boxes may not meet the proposed requirements and, therefore, will be repackaged.

Approach

- Demonstrate safety by a combination of analysis and test
- Application for revised gas generation methodology will be based on results of analysis and test
- Application will establish basis for flammable gas limits, requirements, and methods of compliance
- Adequate margin of safety will be shown by testing a more conservative condition than would naturally occur
- Approach is consistent with NRC guidance and/or approval for other packages

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Proposed Methodology

- Establish a total flammable gas source term from all potential unvented layers of confinement (ULC)
- Determine through physical testing the contribution to total pressure exerted on the TRUPACT-III containment vessel (CV) by the flammable gas source term in a deflagration event inside ULC
- Utilize an evacuation and backfill process with inert gas in vented layers of confinement (VLC) to initially remove and render nonflammable any gases produced or released during transport in VLC

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Proposed Payload Controls (cont.)

- MNOP in TRUPACT-III CV
  - Generation of gas from radiolysis controlled by limiting decay heat as a function of waste material type and shipping duration
  - Potential release of gaseous propellant and contents from aerosol cans controlled by limiting the number of aerosol cans in the payload (18 oz. can ≅ 32 L of gas)
- Evacuation and backfill with inert gas
  - Initial presence of flammable gas in all regions other than ULC reduced through a controlled process and then replaced with inert gas to establish an oxygen deficient atmosphere that eliminates potential for flammability/deflagration in VLC

Proposed Test Plan

- Deflagrate 16.5 mol of H_2 at stoichiometric conditions in a surrogate unvented layer of confinement (SULC) inside an SLB2 and mock TRUPACT-III containment vessel (Mock CV)
  - SULC designed with engineered lid release to contain initial stoichiometric ratio of H_2/air at 6.3 psig; designed to release lid at 10 psig when the SULC lid closure bolts fail
  - Rigid dunnage designed to minimize void space
  - Mock CV designed to measure pressure increase in annular void space

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Proposed Test Plan (cont.)

- Three tests proposed: one with SLB2 filters installed, one with SLB2 filter ports plugged, and one with SLB2 filters removed
  - Designed to determine whether filter release/failure is significant contributor and/or necessary mitigating factor on pressure in Mock CV
  - If "filtered" test results in largest Mock CV pressure reading, then new filters would be designed with pressure rating exceeding the "plugged" SLB2 pressure reading unless the Mock CV pressure pulse in the "removed" test is acceptably low
- Test articles: 1-Mock CV, 3-SLB2s, 3-SULCs, and 1-Rigid Dunnage

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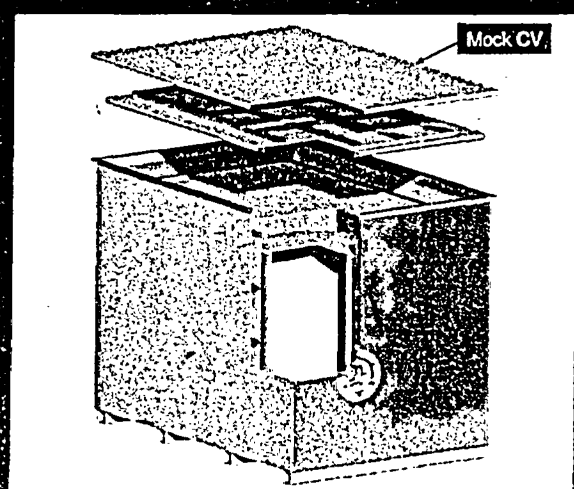
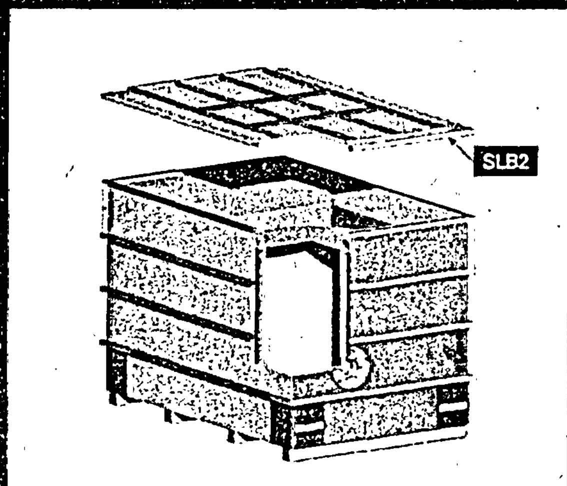
Proposed Test Plan (cont.)



Proposed Test Plan (cont.)



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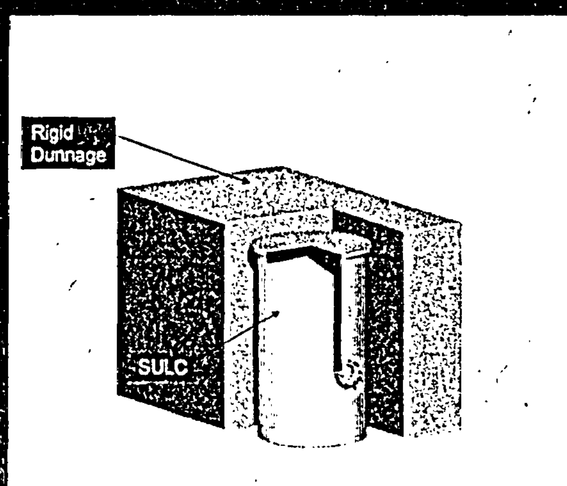
Proposed Test Plan (cont.)



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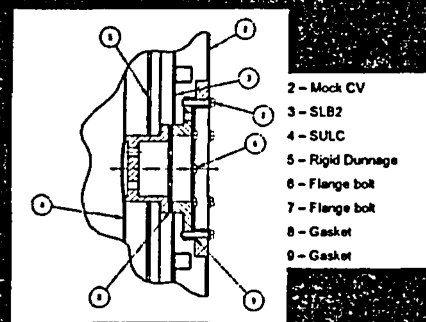
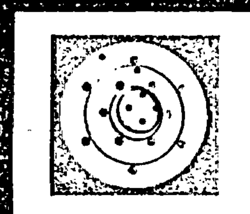
Proposed Test Plan (cont.)

- Instrumentation
  - 4 ports in SULC
    - Piezoelectric pressure transducer
    - Static pressure gauge
    - Hydrogen fill tube
    - Electric match
  - 1 port in SLB2
    - Piezoelectric pressure transducer
  - 6 ports in Mock CV
    - Piezoelectric pressure transducers (1 in each side to determine average pressure increase)





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Bounding Test Conditions

- Deflagration conditions
  - H_2 is proposed as the test flammable gas because of high laminar flame velocity, high flame temperature, and efficient air/fuel ratio that minimizes void volume
  - H_2 is proposed to be consolidated to a single SULC at a stoichiometric concentration (≅ 30%) and pressurized to 6.3 psig to enhance the resulting deflagration pressures by starting at an elevated pressure, producing the largest deflagration pressure factor increase, and minimizing the void volume available to absorb the pressure increase
  - Use of rigid dunnage, sized to limit void space in SLB2 to 25% of the volume in the SLB2 surrounding the SULC, enhances pressures

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Bounding Test Conditions (cont.)

- Predicted deflagration pressures
  - Deflagration pressure increase factors as a function of air/fuel ratio predicted with CHEETAH thermodynamics code under the assumption of constant volume adiabatic conditions
  - Simple void volume scaling analysis neglects further heat transfer, provides an upper bound on predicted test pressures, and predicts interplay between pressures and void volumes in SULC, SLB2, and Mock CV
    - P0 = initial gage pressure in SULC
    - P1, V1 = gage pressure and void volume in SULC
    - P2, V2 = gage pressure and void volume in SLB2
    - P3, V3 = gage pressure and void volume in Mock CV

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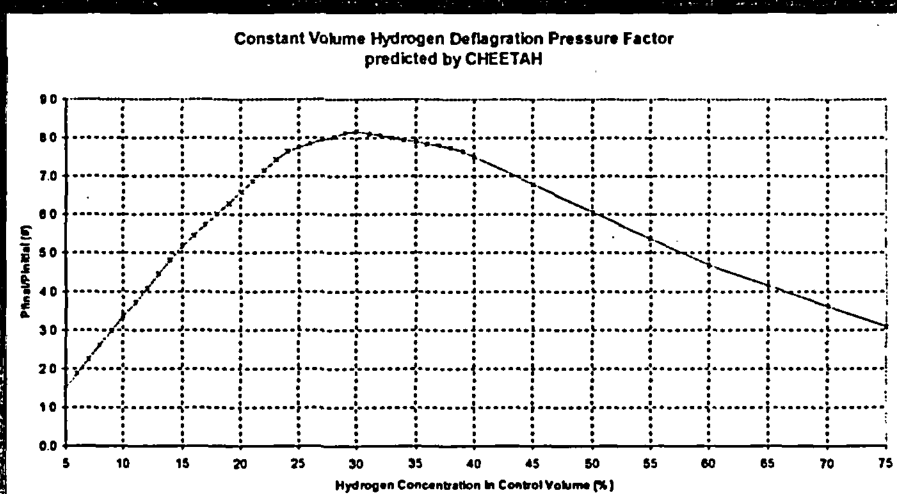
Bounding Test Conditions (cont.)



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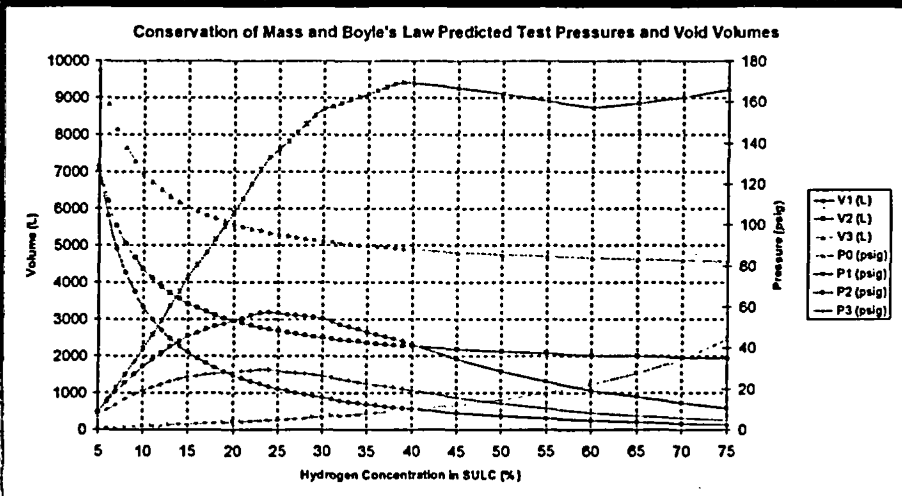
Bounding Test Conditions (cont.)



Bounding Test Conditions (cont.)

- Summary of test conservatisms
  - All flammable gas is consolidated into a single 6.3 psig pressurized SULC, which minimizes the void volume available in the system to absorb the deflagration pressures and increases the resulting total deflagration pressures initiating from the SULC
  - H_2 is utilized as the bounding flammable gas at stoichiometric conditions
  - An engineered lid release on the SULC minimizes the energy absorbed while releasing the gases to the SLB2
  - Rigid dunnage is utilized to minimize void space and represent the nominally compliant payload, which enhances the attack of deflagration pressures on the SLB2

Summary

- Flammable gas in unvented layers of confinement restricted to 16.5 mol H_2 equivalent (potential deflagration pressure increase determined by test)
- Flammable gas in vented layers of confinement rendered nonflammable by evacuation and backfill with inert gas
- MNOP met by accounting for sources of gas generation/release in all layers of confinement (i.e., radiolysis and aerosol cans), bounding pressure increase due to potential deflagration in unvented layers of confinement, and pressure increase due to water evaporation and thermal expansion of gases
- Ensures that the TRUPACT-III maintains containment and allows safe transport

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Proposed Methodology (cont.)

- Establish payload controls on size, quantity, and pressure capacity (or lack thereof) of ULC to ensure the flammable gas source term limit is not exceeded
- Establish payload controls to ensure the package maintains containment by not exceeding the maximum normal operating pressure (MNOP)
- MNOP contributors
  - Pressure due to gas generation from radiolysis over the shipping duration
  - Pressure due to bounding deflagration event in ULC
  - Pressure due to potential gas release from aerosol cans
  - Pressure due to evaporation of water and thermal expansion of the gases at steady-state operating conditions

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Proposed Payload Controls

- Flammable gas source term in ULC
  - Limited to the equivalent of 5% hydrogen <u>averaged</u> over the internal volume of the Standard Large Box 2 (SLB2) payload container
    - (5% H_2)*(7413 L) = 371 L of H_2
    - (371 L of H_2)/(22.4 L/mol) = 16.5 mol of H_2 at STP
  - Controlled by limiting the size, number, and pressure capacity of ULC under the assumption that all contain H_2 at a stoichiometric ratio with air at the defined pressure capacity of ULC
    - Pressure capacity (likely < 2 psi) limited by
      - Porosity or leakage based on process knowledge
      - Inherent structural/mechanical limitations
      - Lack of visible distention determined through real-time radiography (RTR)

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