TRUPACT-II SAR Addendum for ARROW-PAK

Status of Application
As of 5/25/06

5/25/06 Presentation to the US Nuclear Regulatory Commission

Top Level Status

- Response to RAI #1 on TRUPACT-II SAR Addendum for ARROW-PAK Submitted Feb 17, 2006
- NRC Initial Feedback on RAI #1 Response Provided via Telecon on April 13, 2006 Identified Need for:
  - Elimination of administrative control on ambient temperature
  - Additional data and/or tests to address brittle fracture
  - Deflagration tests at reduced and/or elevated temperatures with increased initial internal pressure
  - Improved coverage of bases for free drop test orientations and initial conditions (pressures and temperatures); may require additional testing
- Second Round Written RAIs Pending & Will Follow:
  - Data gathering and material testing
  - Meeting with NRC to discuss planned path forward

Current Key Activities

- Charpy and K_{Ic} testing at various temperatures for various grades of HDPE
  - TR480 not the best choice if no administrative controls on temperature
- Investigations into suitable NDE methods vs. critical flaw size; what is possible and practical
- Analyses of free drop response with and w/o internal pressure
- Evaluation of pros/cons of increasing ARROW-PAK wall thickness
- Based on results of above and other considerations, a set of supplemental deflagration and/or free drop tests at various initial conditions/orientations will be developed and presented to NRC as primary basis for RAI response

Enclosure 2

TRUPACT-III Payload Initiative

Planned Methodology for Establishing Flammable Gas Limits

5/25/06 Presentation to the US Nuclear Regulatory Commission

1

Previous Methodology Review

- TRUPACT-III Flammable Gas Methodology proposed to USNRC in November 2005
  - Approach was to evacuate/backfill with inert gas all vented layers of confinement and limit the hydrogen source term in unvented layers to 5% (on average) of the SLB2 internal volume
    - Hydrogen source term limit of 16.5 mol maintained by accounting for gas in unvented layers, assuming a stoichiometric mix, and establishing the max pressure and volume of each unvented layer
    - Aerosol can contribution to the source term addressed by assuming all flammable contents and accounting for the size and number of cans at a max pressure capacity
  - Deflagration testing was proposed to establish the pressure contribution to the TRUPACT-III containment vessel resulting from a stoichiometic deflagration of 16.5 mol of H_2 in a surrogate unvented layer of confinement
  - Pressure capacity of unvented layers proposed to be established and limited due to a) porosity or leakage based on process knowledge, b) inherent structural/mechanical limitations, c) lack of visible distention determined through real-time radiography (RTR)

2

November Meeting Issues

- Issue Summary
  - Discussions regarding 16.5 mol H_2 limit indicated that 5% on average concentrations were of no particular benefit if the innermost layer was not maintained less than 5% (i.e., exemption required)
  - Discussions regarding unvented layers indicated that a comprehensive way to establish the bounding pressure capacity of sealed containers was needed
  - Discussions regarding the evacuation/backfill process indicated that oxygen generation in vented layers needed to be comprehensively addressed
- Path Forward
  - The flammable gas methodology has been revised to incorporate feedback and address the issues raised in November
  - Revised methodology (presented today) is currently being implemented to support October 2006 TRUPACT-III SAR submittal

Flammable Gas Methodology

- TRUPACT-III Dual-Path Approach
  - Path 1
    - Less than or equal to 5% hydrogen in the innermost layer of confinement (same as TRUPACT-II)
    - Primarily for newly generated waste (e.g., waste that is packaged to meet the requirements)
  - Path 2
    - Applies a "no consequence" methodology to ensure that any significant chemical reaction in the payload results in pressures which are below the maximum normal operating pressure (MNOP) of the containment vessel
    - Primarily for previously generated waste containing sealed containers, unpunctured aerosol cans, and/or waste than cannot otherwise meet the Path 1 requirements

Flammable Gas Methodology (cont.)

- Path 1 Logic
  - Same methodology for requirements and methods of compliance as TRUPACT-II
- Path 2 Logic
  - Utilize evacuation/backfill of TRUPACT-III and contents to eliminate flammability potential in vented layers and the TRUPACT-III containment vessel void volume
    - Evacuation process to initiate a controlled removal of flammable gas and air/oxygen in vented layers down to a level below the lower flammability limit(s)
    - Backfill to provide inert atmosphere

5

Flammable Gas Methodology (cont.)

- Path 2 Logic (cont.)
  - Predetemine the total percent contribution to MNOP that all sealed containers and/or aerosol cans would make to the total pressure in the TRUPACT-III
    - Sealed container – contribution based on a stoichiometric deflagration at a bounding initial pressure limit (i.e., hydrostatic burst pressure)
    - Aerosol can – contribution based on expanded volume of pressurized gas
  - Calculate decay heat limits for total gas generation based on the remaining percentage of MNOP available over the shipping duration
    - Presence of compressed air/oxygen precluded and generation of oxygen limited to maintain nonflammable conditions in vented layers of confinement

6

Flammable Gas Methodology (cont.)

- Path 2 Analysis Requirements
  - Analysis to determine the required evacuation and associated backfill with inert gas process requirements to render vented layers nonflammable
  - Analysis to correlate sealed container size/initial pressure to a percent contribution to MNOP in the TRUPACT-III containment vessel (i.e., adiabatic deflagration and void volume scaling)
  - Analysis (previously performed) to show that an aerosol can flammable contents deflagration is bounded by hydrogen
  - Analysis to establish methodology to calculate pressure-based decay heat limits to meet MNOP requirements

Flammable Gas Methodology (cont.)

- Path 2 Testing Requirements
  - Testing of SLB2 with sealed container having a stoichiometric H_2/Air source in a mock TRUPACT-III to confirm and demonstrate as bounding the adiabatic deflagration and void volume scaling calculations
    - Test will utilize a source term and surrogate unvented layer of confinement with volume and initial pressure to theoretically achieve MNOP in TRUPACT-III containment vessel (i.e., 25 psig)

Flammable Gas Methodology (cont.)

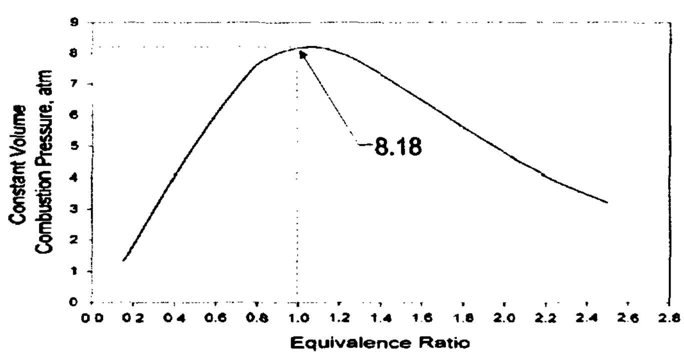
- Path 2 Testing Requirements (cont.)
  - Hydrostatic burst testing of selected sealed container configurations expected in the TRUPACT-III inventory to establish maximum pressure capacity (e.g., 5-gal plastic paint bucket, 5-gal plastic carboy, 5-gal crimped lid steel can, 30-gal steel drum, 55-gal steel drum)
    - Selected sealed containers based on AK collected from sites
    - Plan is to have ability to add sealed containers outside of the amendment process via an NRC approved test plan (in the SAR application)

9

Percent Contribution to MNOP

- Adiabatic Deflagration

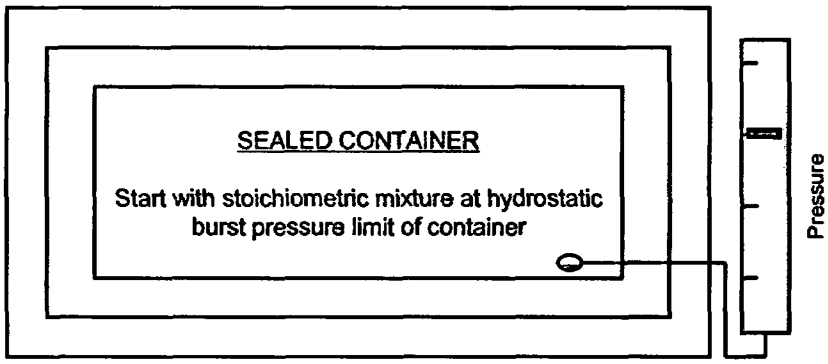
Cheetah Computed
Hydrogen Deflagration Pressure



10

Percent Contribution to MNOP (cont.)

- Void Volume Scaling
  - Adiabatic process with no heat loss to surroundings
  - Stoichiometric hydrogen/air mixture in sealed container
  - 25% void (outside of sealed container and inside SLB2)



11

Percent Contribution to MNOP (cont.)

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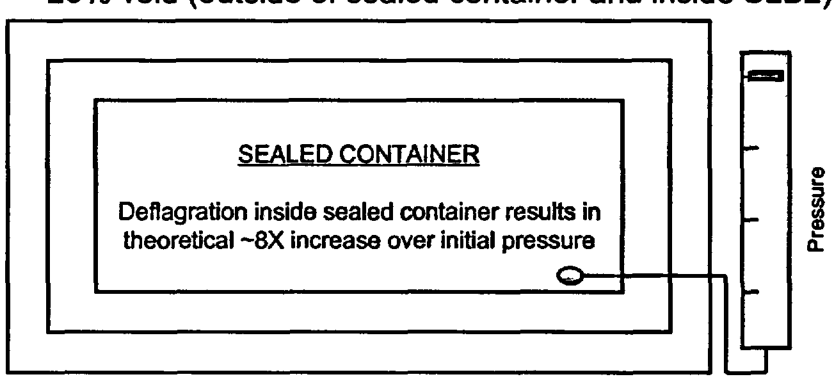

12

Percent Contribution to MNOP (cont.)

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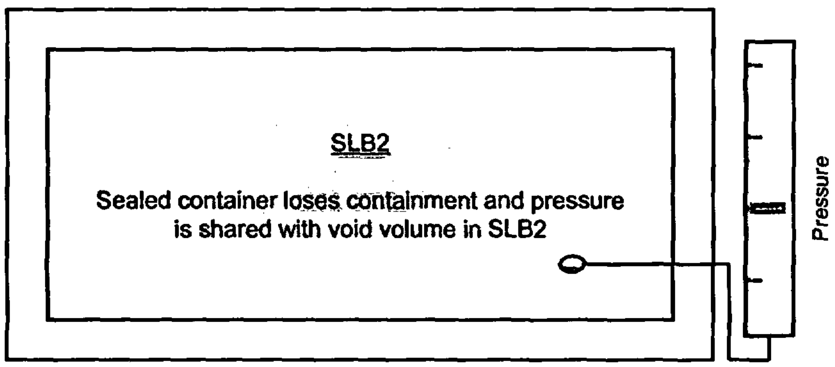

13

Percent Contribution to MNOP (cont.)

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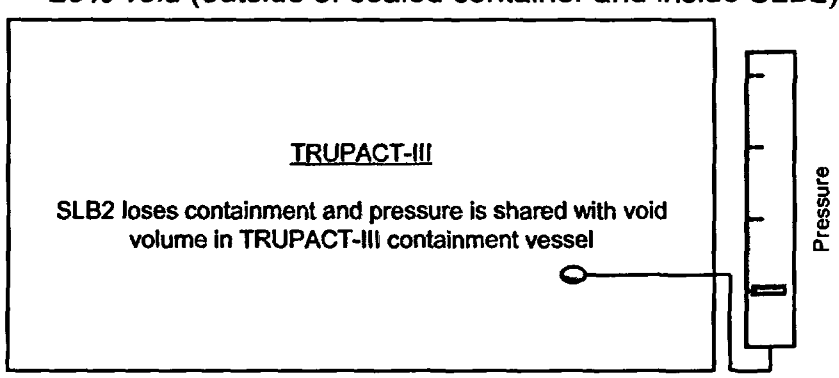

14

Percent Contribution to MNOP (cont.)

SEALED CONTAINER PRESSURE LIMIT (PSI)									
	SEALED CONTAINER SIZE (GAL)								
%MNOP	1/4	1/2	3/4	1	5	10	30	55	85
1	168.10	77.60	47.44	32.36					
2	349.10	168.10	107.80	77.62	5.23				
3	530.00	258.60	168.10	122.90	14.30	0.73			
4	711.00	349.10	228.50	168.10	23.37	5.27			
5	892.00	439.60	288.80	213.40	32.43	9.81			
6	1073.00	530.10	349.10	258.70	41.50	14.36			
7	1254.00	620.60	409.50	303.90	50.57	18.90			
8	1435.00	711.10	469.80	349.20	59.64	23.44			
9	1616.00	801.60	530.10	394.40	68.70	27.99	0.84		
10	1797.00	892.10	590.50	439.70	77.77	32.53	2.37		
12	2159.00	1073.00	711.20	530.20	95.90	41.62	5.43		
14	2521.00	1254.00	831.80	620.70	114.00	50.70	8.48		
16	2883.00	1435.00	952.50	711.20	132.20	59.79	11.53	0.57	
18	3245.00	1616.00	1073.00	801.80	150.30	68.88	14.59	2.25	
20	3607.00	1797.00	1194.00	892.30	168.40	77.96	17.64	3.94	
25	4512.00	2250.00	1496.00	1119.00	213.80	100.70	25.28	8.14	0.89
30	5416.00	2702.00	1797.00	1345.00	259.10	123.40	32.92	12.35	3.65
35	6321.00	3155.00	2099.00	1571.00	304.50	146.10	40.55	16.56	6.40
40	7226.00	3607.00	2401.00	1797.00	349.80	168.80	48.19	20.77	9.16
45	8131.00	4060.00	2702.00	2024.00	395.10	191.50	55.83	24.98	11.92
50	9036.00	4512.00	3004.00	2250.00	440.50	214.30	63.46	29.19	14.68
55	9941.00	4965.00	3306.00	2476.00	485.80	237.00	71.10	33.40	17.43
60	10850.00	5417.00	3607.00	2703.00	531.10	259.70	78.74	37.61	20.19
65	11750.00	5870.00	3909.00	2929.00	576.50	282.40	86.37	41.82	22.95
70	12660.00	6322.00	4211.00	3155.00	621.80	305.10	94.01	46.03	25.71
75	13560.00	6775.00	4513.00	3382.00	667.10	327.80	101.60	50.24	28.47
80	14470.00	7227.00	4814.00	3608.00	712.50	350.60	109.30	54.45	31.22
85	15370.00	7679.00	5116.00	3834.00	757.80	373.30	116.90	58.66	33.98
90	16280.00	8132.00	5418.00	4060.00	803.20	396.00	124.60	62.87	36.74
95	17180.00	8584.00	5719.00	4287.00	848.50	418.70	132.20	67.08	39.50
100	18080.00	9037.00	6021.00	4513.00	893.80	441.40	139.80	71.29	42.26

15

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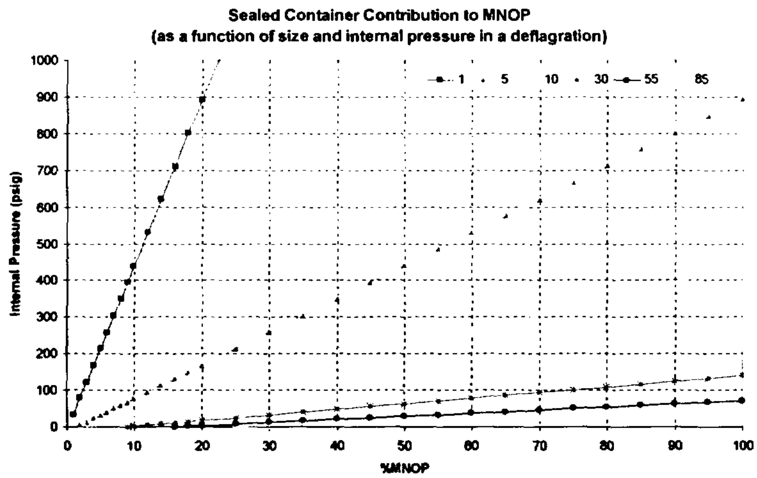
95					848.50	418.70	132.20	67.08	39.50
100					893.80	441.40	139.80	71.29	42.26

Ignore presence of small sealed containers (initial pressures required to impact MNOP are not credible)

16

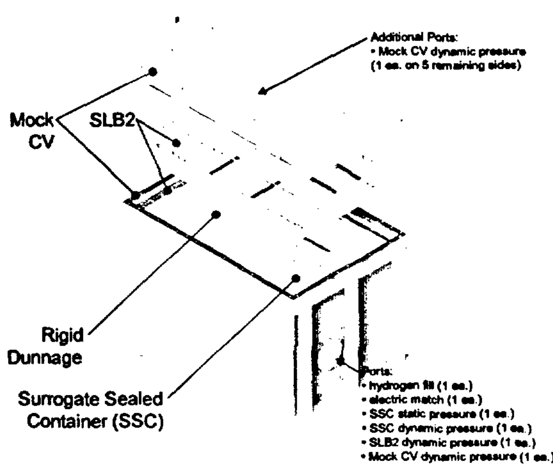
Percent Contribution to MNOP (cont.)



17

Deflagration Test Plan

- Three Tests at Ambient Conditions
  - SLB2 filters installed
    - Baseline response
  - SLB2 filter ports plugged
    - Focused energy on SLB2 seals
  - SLB2 filter ports open
    - Maximum gas release to Mock CV



18

Deflagration Test Plan (cont.)

- Test articles and initial conditions designed/sized to "theoretically" generate MNOP pressures in Mock CV
  - SSC
    - 33.5" ID x 53" IH carbon steel vessel with o-ring seal and closure bolts with a locally reduced cross-section designed to release lid at 10 psig internal pressure
    - 766 liters internal volume filled with stoichiometric hydrogen/air to 6.174 psig
  - SLB2
    - Prototypic construction with 7394 liters internal volume
  - Rigid Dunnage
    - Foam filled carbon steel L-shaped rigid structure
    - 4950 liters external volume designed to fill 75% of void space surrounding SSC in SLB2
  - Mock CV
    - Structurally reinforced carbon steel structure with 10019 liters internal volume (equivalent to TRUPACT-III containment vessel less pallets, roller floor, air bags, ...)

19

Hydrostatic Burst Test Plan

- Establish the pressure capacity of sealed containers
  - Size, construction, material, closure type are all variables that affect pressure capacity of sealed containers
  - Approach is to pressurize with water to determine point at which water leaks from the container and/or structural failure occurs
  - Testing is planned for initial inventory of containers that have been identified in site surveys of boxed waste
  - Following NRC approval, the test plan will be applied, as needed, to additional types/sizes of sealed containers; request will be to approve test procedure rather than explicit inventory of sealed containers
- 5 test articles for each sealed container size to be tested to establish the burst pressure at ambient conditions

20

Summary

- Flammability of vented layers precluded by applying the evacuation/backfill process, prohibiting compressed air/oxygen containers, and by limiting oxygen generation to less than that allowed by the lower flammability limit(s)
- Flammability of unvented layers assumed as stoichometric deflagration with defined analytical contribution to MNOP which is validated as conservative by test
- MNOP maintained by limiting decay heat for total gas generation over the shipping duration to that percentage of MNOP not assumed taken up by the sum of potential sealed container deflagrations and total gas release from aerosol cans

Questions?