U.S. DEPARTMENT OF ENERGY | OFFICE OF ENVIRONMENTAL MANAGEMENT

West Valley Melter Package
NRC Special Authorization
Second Pre-Application Briefing

Presenters:

SRNL: Jeff England, Charles McKeel, Ed Ketusky

CHBWV: Todd Pieczynski

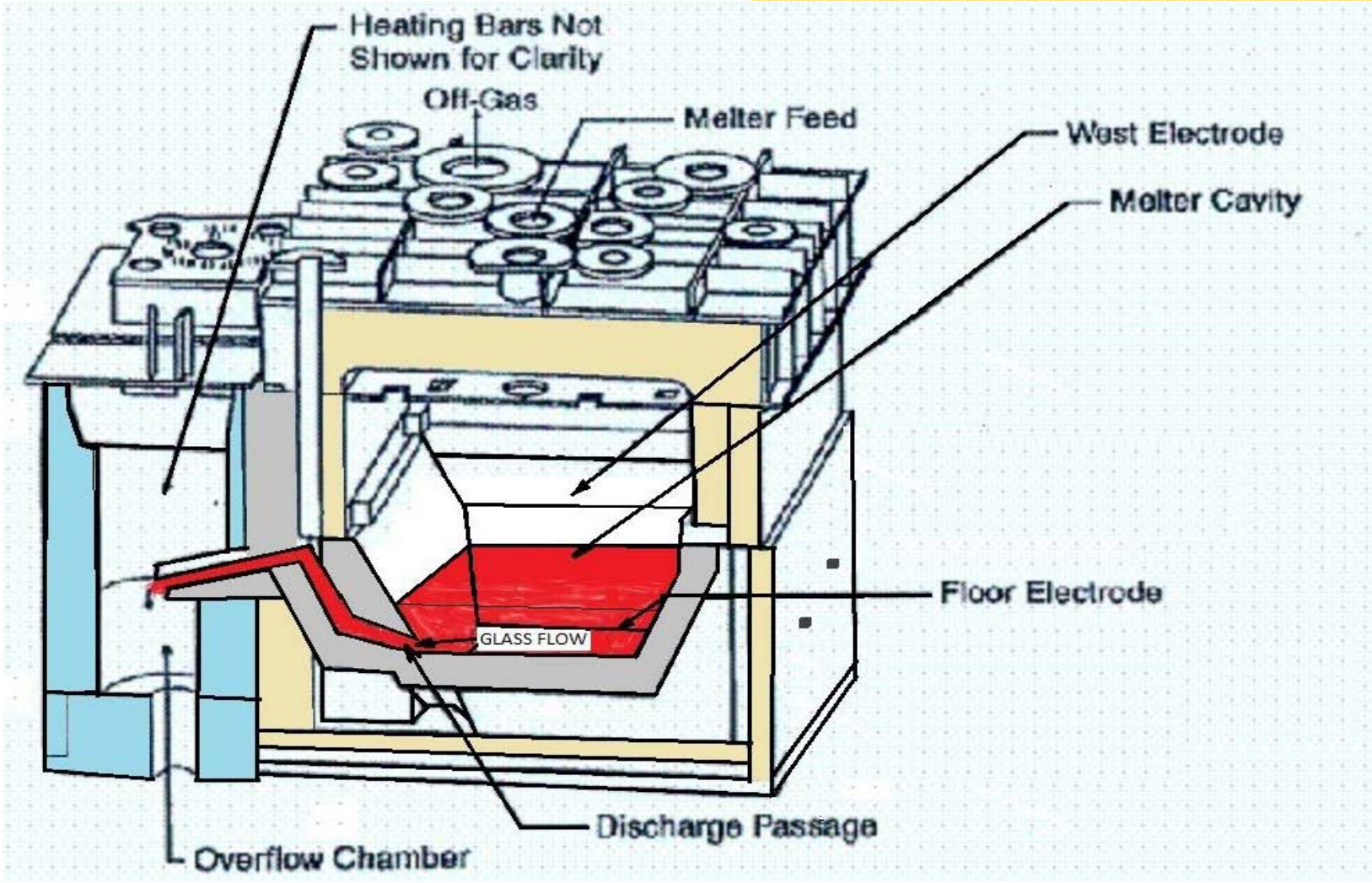
Ameriphysics: Chris Brandjes

August 19, 2014

Content Description

- The West Valley Melter (Melter) is comprised of a stainless steel outer housing with an exterior structural steel frame
- The interior of the Melter is lined with refractory materials
- The maximum envelope dimensions of the Melter is 10'-9¾" wide x 11'-10" long x 10'-5 ½" high
- The Melter weight is 107,500 pounds
- The Melter was built to ASTM standards and procured under the West Valley NQA-1 program

West Valley Melter Configuration



PREDECISIONAL DRAFT

Rev. 0, 08/14/2014

Content Radiological Description

- **The Melter contains 3,554 curies (decay corrected to September 2, 2014), including the surface contaminants**
- **The external contaminated Melter surfaces were coated with three layers of Bartlett's PBS™ contamination fixative**
  - Surface contaminants were fixed on the equipment surface
  - A fraction of the radioactive surface content is assumed to have leached in the LDCC external to the Melter
- **The internal contamination associated with the Melter is contained within a borosilicate glass**
  - Radioactive content characterization was derived using analytical data from glass samples from specific sources associated with the heel and spout. Quantification of the radioactivity within the Melter refractory was completed using an average of analytical slurry samples obtained throughout Melter processing
  - A fraction of the radioactive glass content is assumed to have leached into the LDCC contained within the Melter

Content Characterization

Activity Breakdown by Source Term					
Source Term	**Total Act (Ci)**	**Fissile Mass (g)**	**A2s**	**Decay Heat (W)**	**% of Total Activity**
Exterior Contamination (decay corrected)	1.436E+01	6.569E-01	2.136E+00	4.054E-02	0.404%
Melter Spout (decay corrected)	1.793E+03	1.899E+01	8.244E+01	4.551E+00	50.445%
Refractory (decay corrected)	6.300E+02	3.268E+01	6.713E+01	1.768E+00	17.725%
Melter Heel (decay corrected)	1.117E+03	2.923E+01	6.315E+01	2.834E+00	31.426%
Totals	**3.554E+03**	**8.156E+01**	**2.149E+02**	**9.194E+00**	100.000%

Activity Associated to Primary Isotopes						
	Exterior Surface	**Spout**	**Refractory**	**Heel**	**Totals**	
	Act (Ci)	Act (Ci)	Act (Ci)	Act (Ci)	Act (Ci)	% of Total Act
Cs-137	5.062E+00	8.566E+02	2.132E+02	5.419E+02	1.617E+03	45.487%
Ba-137m	4.778E+00	8.086E+02	2.012E+02	5.116E+02	1.526E+03	42.938%
Sr-90	2.213E+00	6.332E+01	1.068E+02	3.120E+01	2.035E+02	5.726%
Y-90	2.213E+00	6.333E+01	1.068E+02	3.121E+01	2.036E+02	5.727%
Total Activity of Primary Isotopes						99.878%
Remaining Activity						0.122%

PREDECISIONAL DRAFT

Rev. 0, 08/14/2014

Content Characterization

MELTER SOURCE TERM

The radioactivity associated to the Melter is contained within four separate Source Terms

- Heel
  - Contained within the lower body of the Melter
  - Consists of the remaining vitrified glass from processing of flushing materials from the Melter Feed Hold Tank and Concentrator Feed Make-Up Tank
  - Consists of 300 kg of vitrified glass
  - Characterized using glass shard samples taken from evacuated canister material
  - Radiological Characterization Summary:
    - Total Activity 1.117E+03 Ci
    - Fissile Mass 2.923E+01 grams
    - A_2 Contribution 6.315E+01 A_2s
    - Percent of Total Activity 31.426%

Content Characterization

MELTER SOURCE TERM (Continued)

- Spout
  - Consists of vitrified glass material from Batch 75, Canister 266 that clogged the West Discharge Port during vitrification processing
  - Consists of 99 kg of vitrified glass
  - Characterized using shard samples of Canister 266 waste for Cs-137 and Sr-90 and scaling in remaining isotopes using Heel isotopic distribution
  - Radiological Characterization Summary:
    - Total Activity 1.793E+03 Ci
    - Fissile Mass 1.899E+01 grams
    - A_2 Contribution 8.244E+01 A_2s
    - Percent of Total Activity 50.445%

Content Characterization

MELTER SOURCE TERM (Continued)

- Refractory
  - Contained within the body of the Melter surrounding the Melter cavity
  - Consists of vitrified glass contained within the cracks, crevices and interstitial spacing between and within the pieces of refractory brick
  - Conservative estimate of 1% of the total volume of refractory brick was used as the volume of vitrified glass
  - Total volume of vitrified glass contained within the refractory brick is 0.927 ft^3 (68.3 kg)
  - Characterized using the average geometric mean concentrations for all of the samples taken from Batch 6 through 77 and applied to the mass of vitrified glass
  - Radiological Characterization Summary:
    - Total Activity 6.300E+02 Ci
    - Fissile Mass 3.268E+01 grams
    - A_2 Contribution 6.713E+01 A_2s
    - Percent of Total Activity 17.725%

Content Characterization

MELTER SOURCE TERM (Continued)

- Melter Exterior Contamination
  - Consists of the removable activity associated to the exterior surface of the melter
  - Characterized using smear data samples
    - Applied highest reported result to entire surface are of the Melter
    - Applied a 10% Wiping Efficiency
  - Total Surface Area of Melter is 80,950 in^2
  - Activity concentration associated to exterior Melter is 27.50 uCi/cm^2
  - Radiological Characterization Summary:
    - Total Activity 1.436E+01 Ci
    - Fissile Mass 6.569E-01 grams
    - A_2 Contribution 2.136E+00 A_2s
    - Percent of Total Activity 0.404%

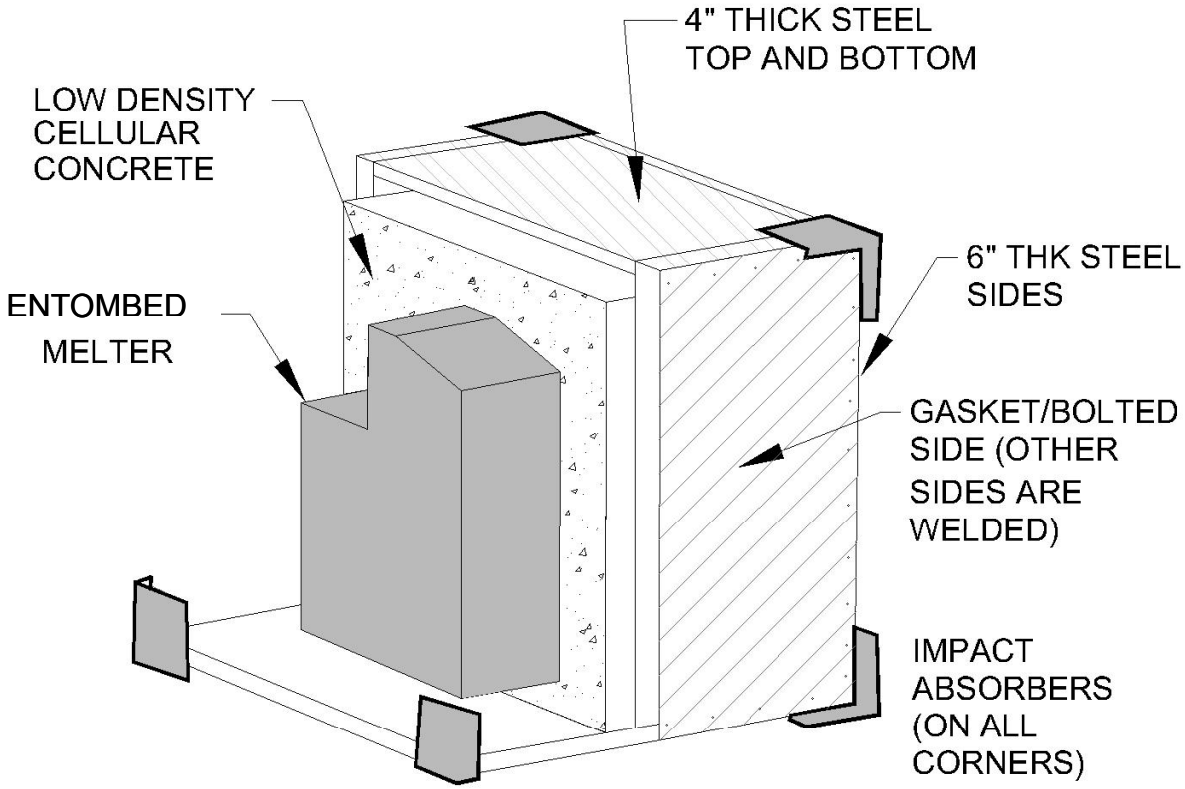
West Valley Melter Package Description

- The West Valley Melter Package (WVMP) is a rectangular shaped package made from SA-516, Grade 70 carbon steel
- The package is 15'-9" long x 12'-6" wide x 12'-6" high
- It has a side cover recessed into the package with 32 1½" diameter bolts
- It was sealed with a neoprene rubber gasket
- It will be reinforced with an impact limiter over the bolted side cover (adding approximately 10" to the length of the package)

Package Materials of Construction and Criteria

- **ASTM SA-516 Grade 70 Carbon Steel for the Package top, bottom, sides, end cover and temporary attachments**
- **ASTM A36 Carbon Steel for the shock absorbers**
- **Package side cover bolts are ASTM A193-B7**
- **American Welding Society (AWS) D1.1**
  - e.g., Weld electrodes per Structural Welding Code – Steel
- **American Institute of Steel Construction (AISC) for shipment of radioactive material under 49CFR173**
- **The impact limiter will be 10 CFR 71 compliant**

Packaging Configuration (Cutaway Section)



MELTER DOT PACKAGE CONFIGURATION

PREDECISIONAL DRAFT

Not-to-scale

Rev. 0, 08/14/2014

Packaging Weight and Design Criteria

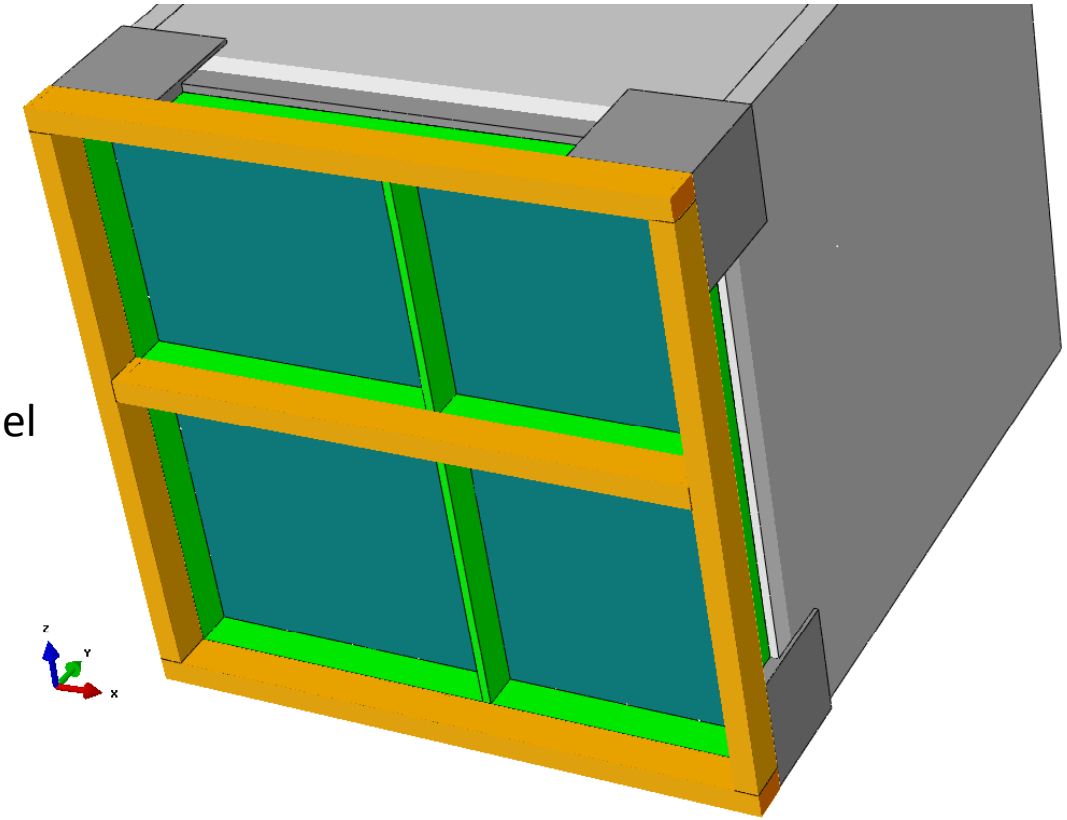
- **The weight of the empty package is approximately 212,000 lbs.**
- **Content weight is 107,500 lbs.**
- **The impact limiter will meet 10 CFR 71 criteria and will weigh approximately 7,000 lbs.**
- **The total weight of the WVMP, including the radioactive contents, low-density cellular concrete (LDCC) and the package, is approximately 389,000 lbs.**

OFFICE OF ENVIRONMENTAL MANAGEMENT

West Valley Melter Package

Impact Limiter for Hypothetical Accident Condition (HAC)

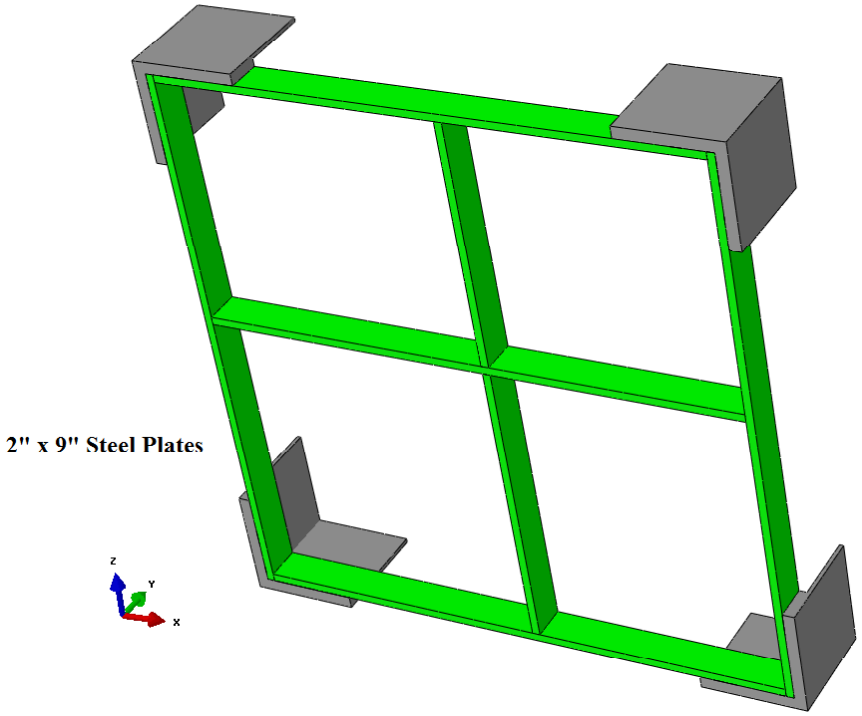
2”x9” plates
6”x10” Tube Steel
Foam Fill
2” dia Pins

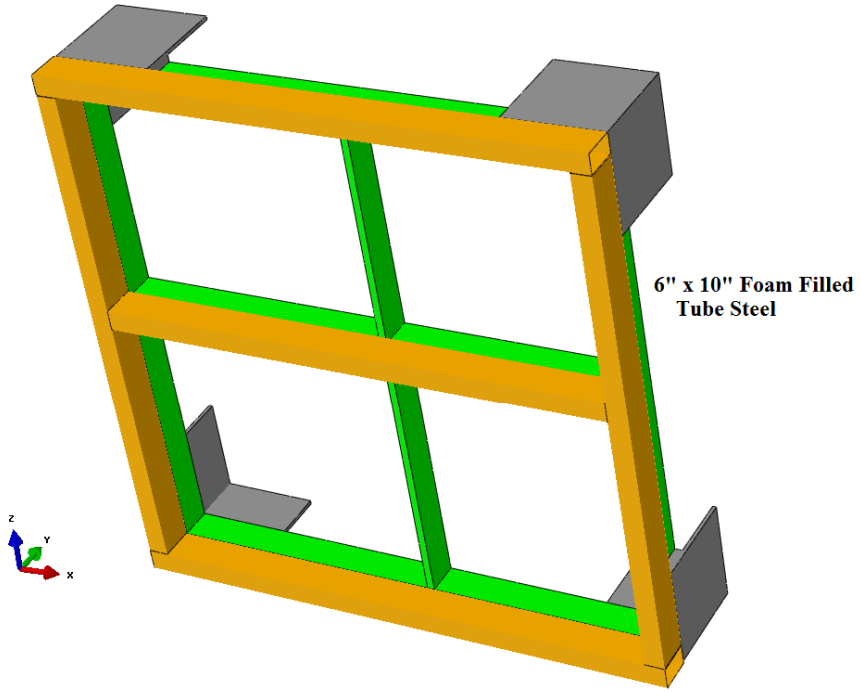


PREDECISIONAL DRAFT

Reinforcement of Impact Limiters

Impact Limiter



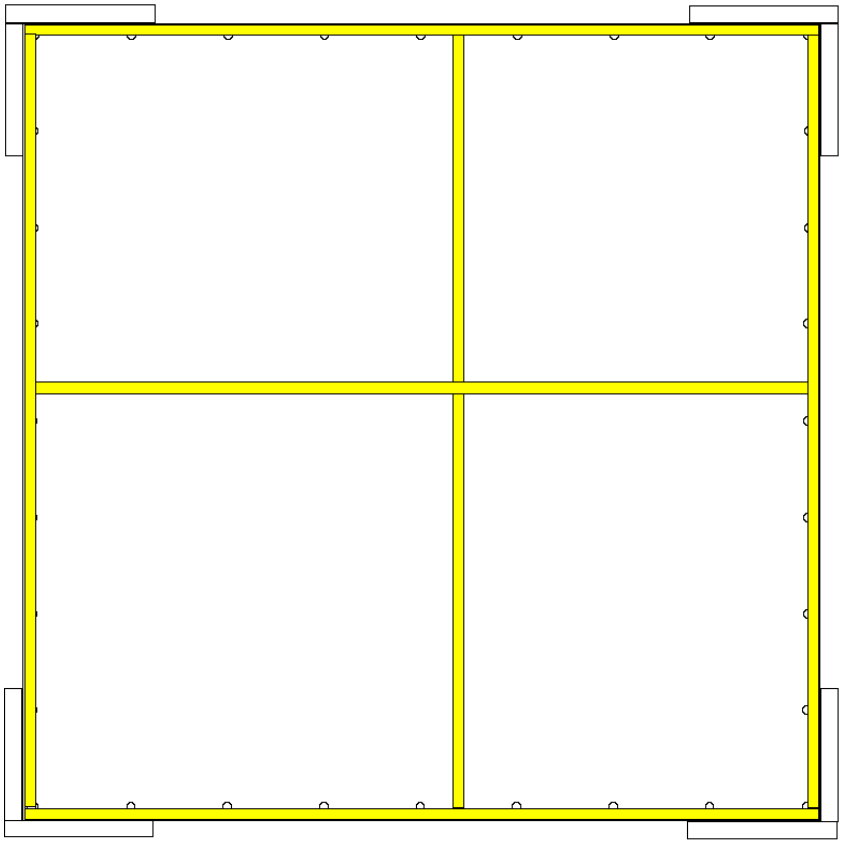


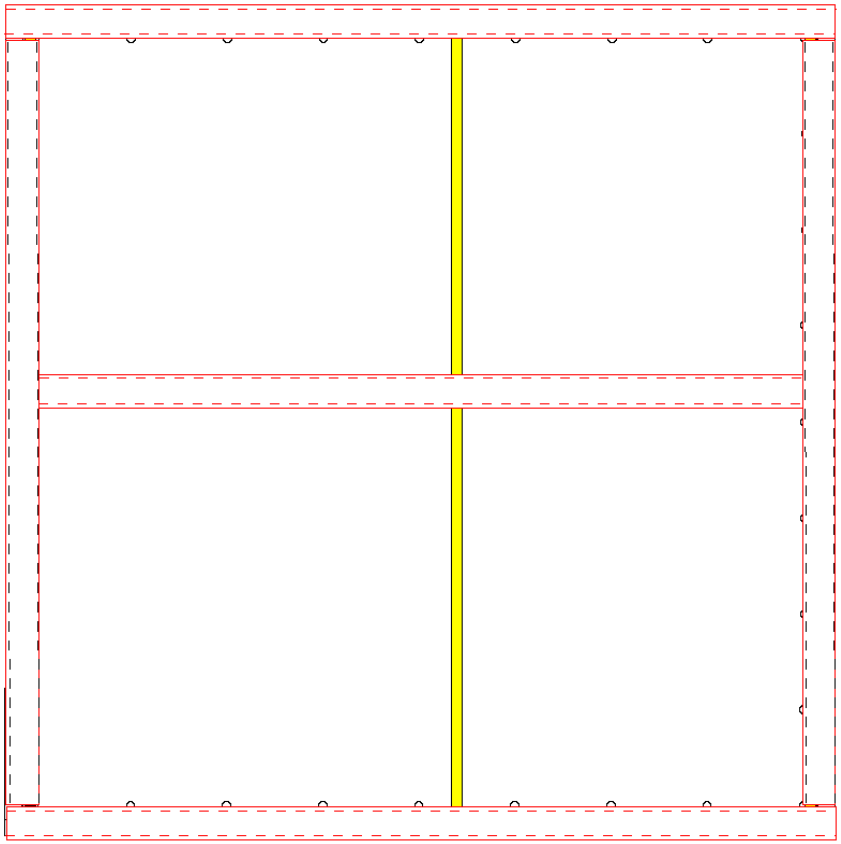
PREDECISIONAL DRAFT

Rev. 0, 08/14/2014

Reinforcement of Impact Limiters

Impact Limiter



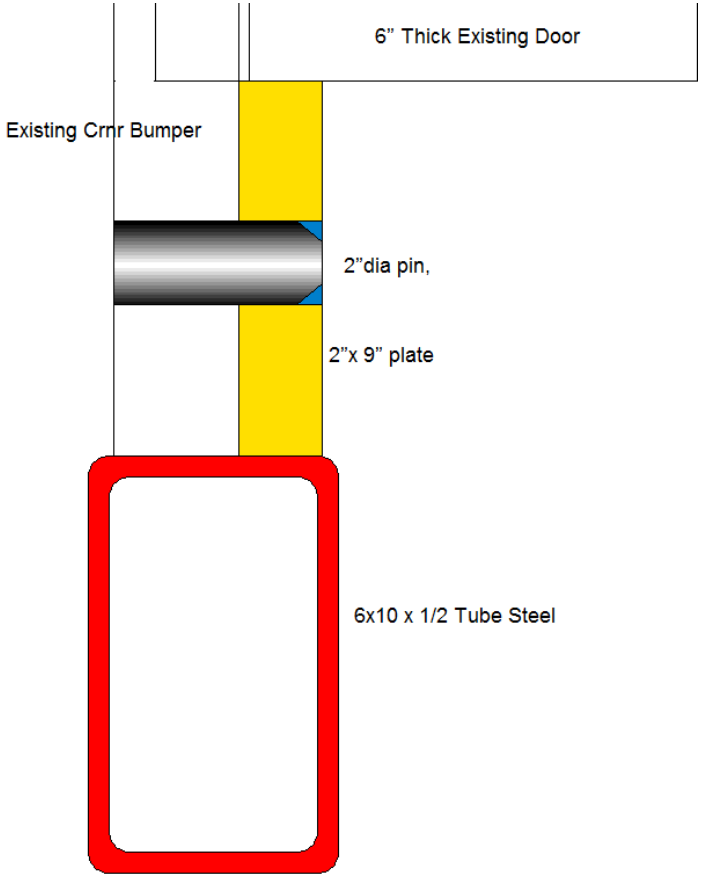


PREDECISIONAL DRAFT

Rev. 0, 08/14/2014

Reinforcement of Impact Limiters

Impact Limiter



PREDECISIONAL DRAFT

Rev. 0, 08/14/2014

Ongoing Structural Analyses

- **NCT/HAC Drop Analyses Orientations**
  - Door Side Down (Maximize Content Inertial Effect)
  - CG over Corner (Maximize Fish-Mouth Opening at Door)
  - CG over any Edge (Combined Effect of Above two)
  - Back Side Down Drops (no Added Impact Limiter)

Ongoing Structural Analyses

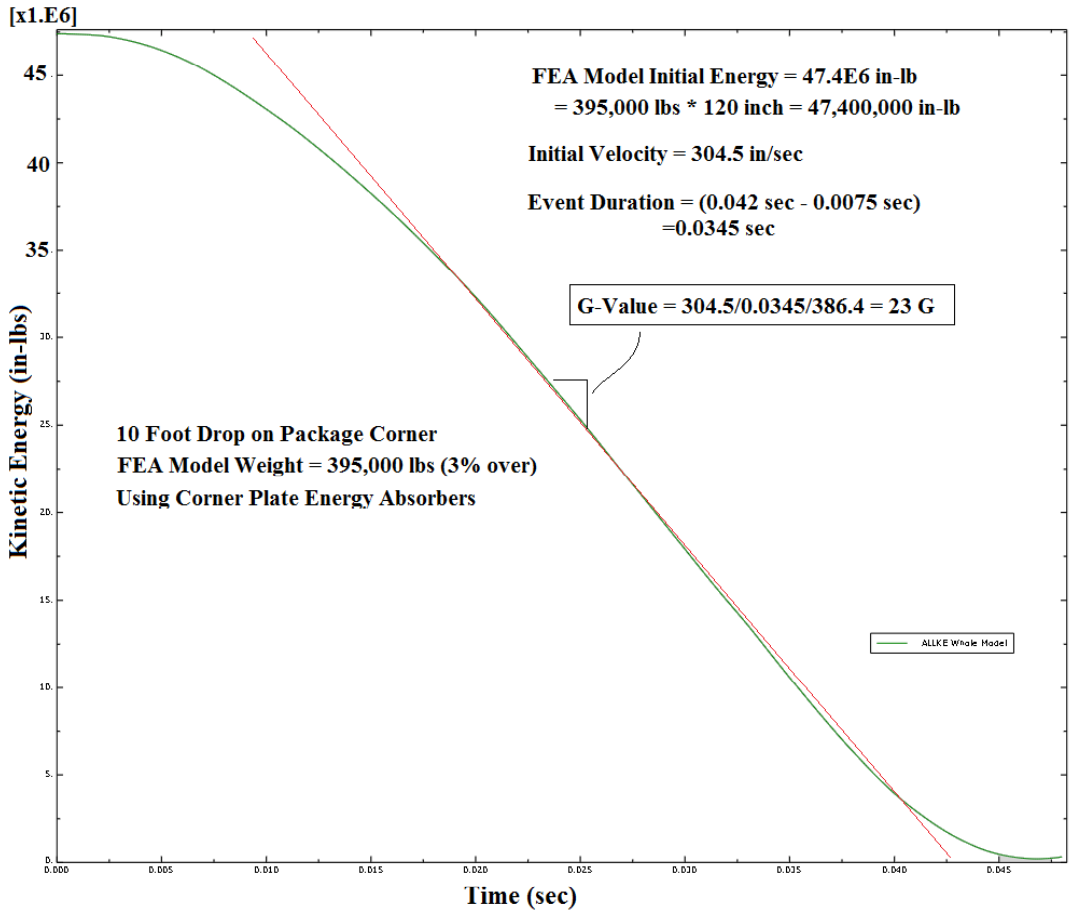
- **Existing Data for Glass Performance in Drops**
  - Battelle Northwest Laboratory (BNWL) Drop Tests of Bare Canisters
    - 10 foot, 30 foot, 68 foot and 213 foot drops
    - BNWL-1903 UC-70
  - Tests were performed to establish impact behavior and production of airborne particles
  - Glass mixture for test was 75% frit, 25% calcine
  - No canister breach at 30 foot drops
  - Some canisters breached at 68 ft and 213 ft, “very little, if any, glass escaped”
  - G-values were 1,000G to 3,600G for 30 foot drops
    - Glass Breakage Fraction was 0.029
  - 30 foot drop analysis shows Melter with ~50G and stress is less than yield

Ongoing Structural Assessment

- **10 Foot Corner Drop Confirmatory FEA**
  - SRNL Evaluation shows 23G
  - Indicates Full Utilization of Absorber Occurs Prior to Absorbing Energy Demand of the 10' Drop
    - Due to 382,000 lbs. Model Weight
    - Causes Spike in Bolt Demands In latter stage of impact
    - Additional Drop Height Invokes Disproportionately Higher Demands in bolts
  - Bolts Do Not Break, but at tensile strain limit (ignores Thread Failure)
    - Thread Failure Still In Question, cannot credit full bolt tensile strains, since shear failure in non-ductile

Ongoing Confirmatory Structural Assessment

- **10 Foot Corner Drop Confirmatory FEA**



Kinetic Energy History During Impact

Energy Plot matches the 2004 analysis, once weight diff is accounted.

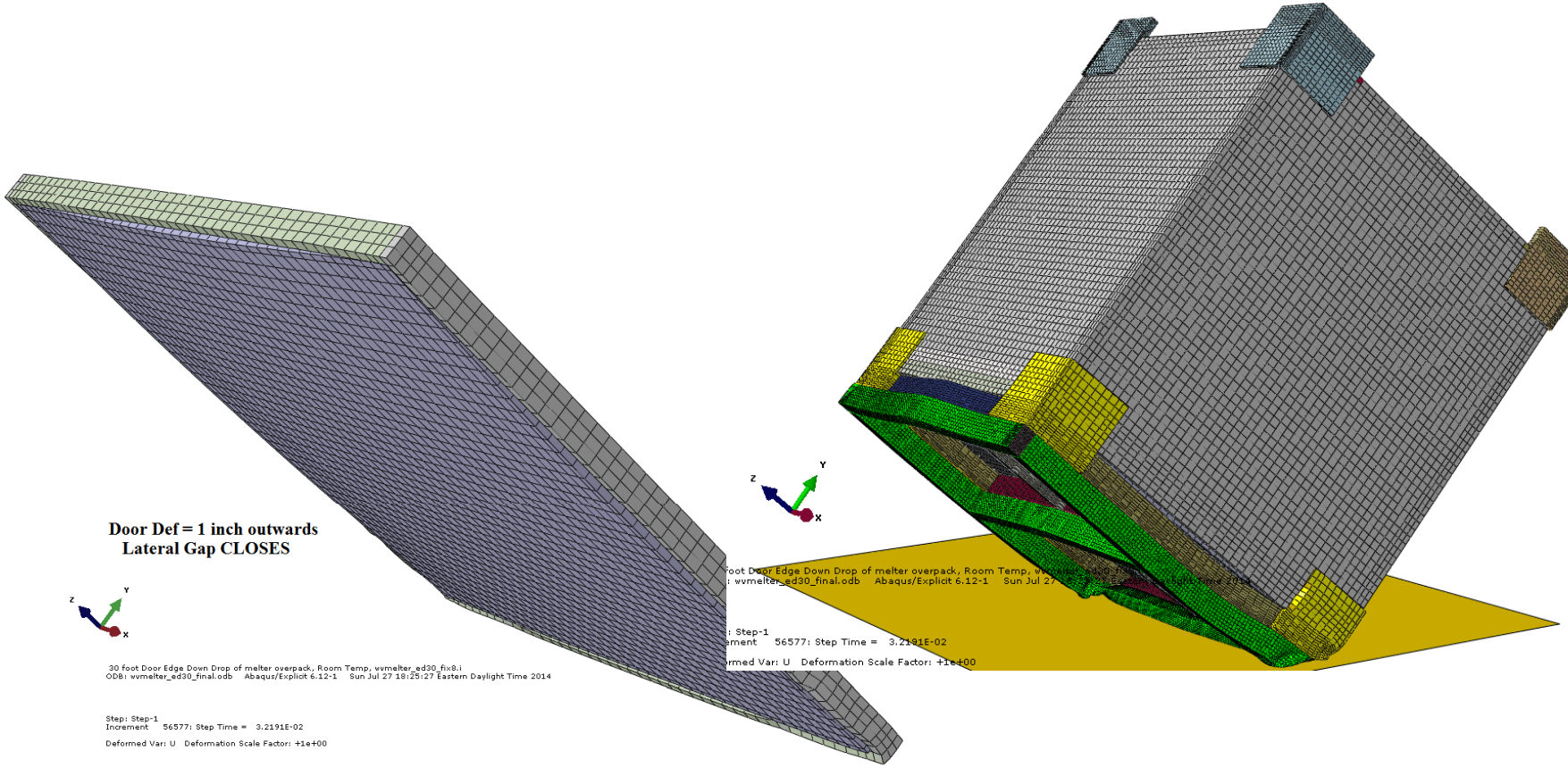
PREDECISIONAL DRAFT

Rev. 0, 08/14/2014

Ongoing Confirmatory Structural Assessment

- **30 Foot Drop, CG Over Door Side Edge**
  - Impact = 68G Load
    - 0.035 sec total Duration, High G based on 0.02 sec
  - Concrete Stress Nominally < 1000 psi, by Localized Regions above compression stress limits, ~10% damaged
  - About 75% of Bolts Fail in Tension (Content Inertial Loads, Deformed Absorber)
  - Door Deflection, < 1 inch. Door Lateral Gaps Tighten at Impact Points, Unchanged elsewhere

Ongoing Confirmatory Structural Assessment

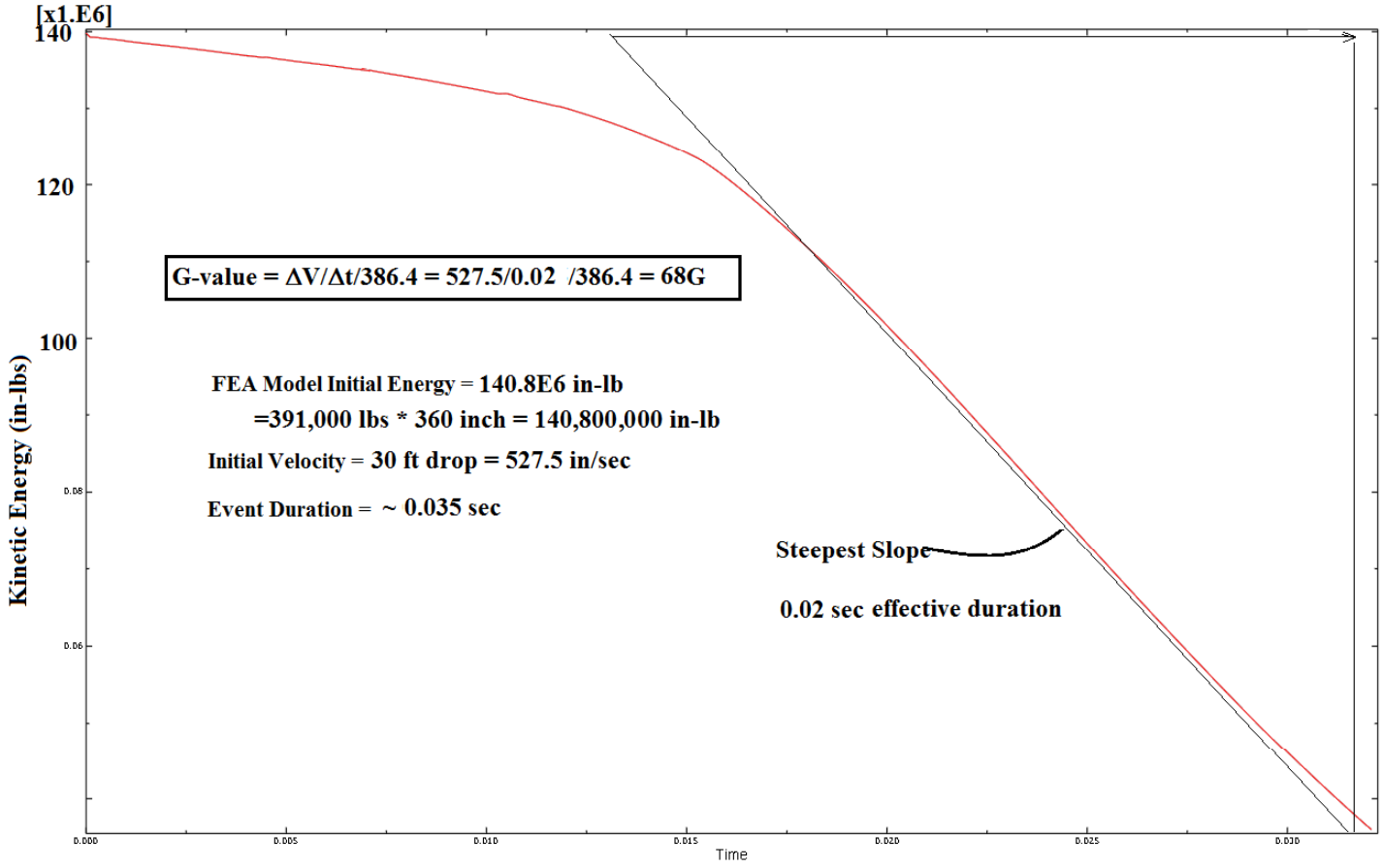


- **30 Foot Drop, CG Over Bottom Edge, Deformed Shape**

PREDECISIONAL DRAFT

Rev. 0, 08/14/2014

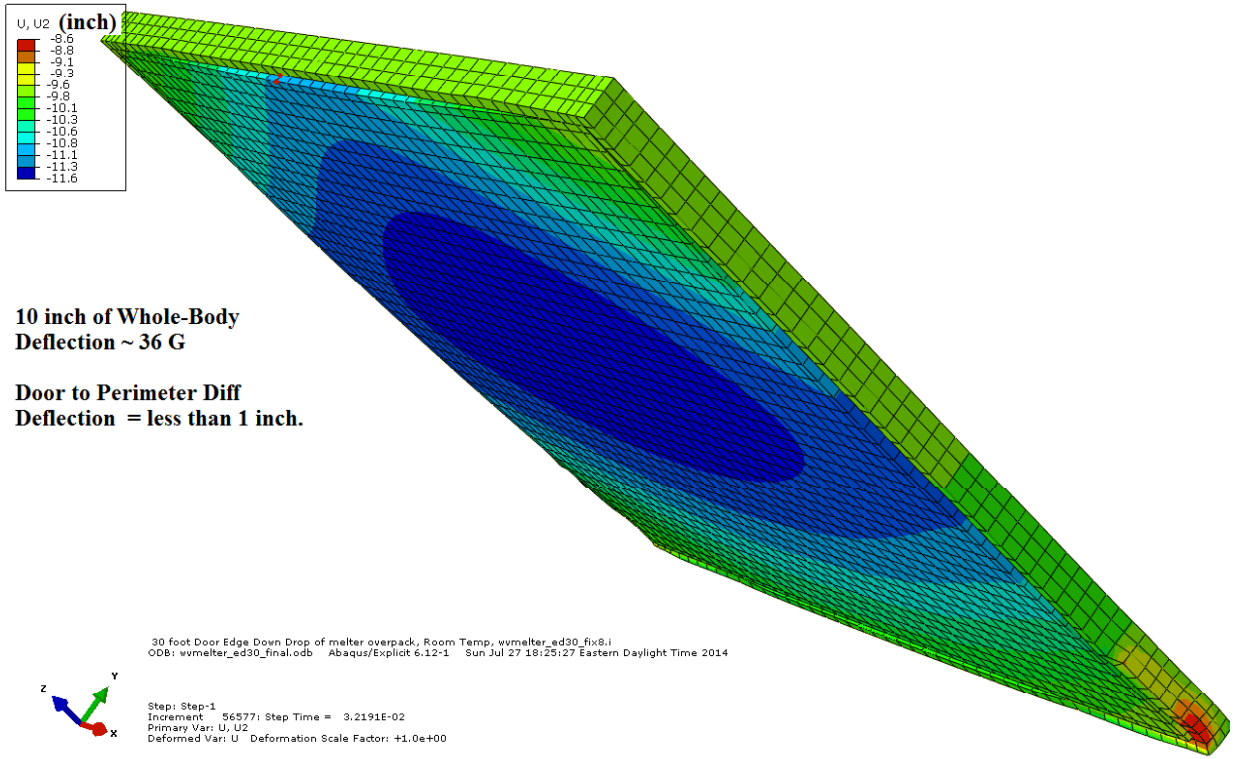
Ongoing Confirmatory Structural Assessment



- **30 Foot Drop, CG Over Bottom Edge, Kinetic Energy History**

Ongoing Confirmatory Structural Assessment

- **30 Foot Drop, CG Over Edge, Door Deflections**
  - 10 inch at Perimeter, ~36G
  - Additional 1.5 inch at Door Center
  - Door Gap Change ~1 inch

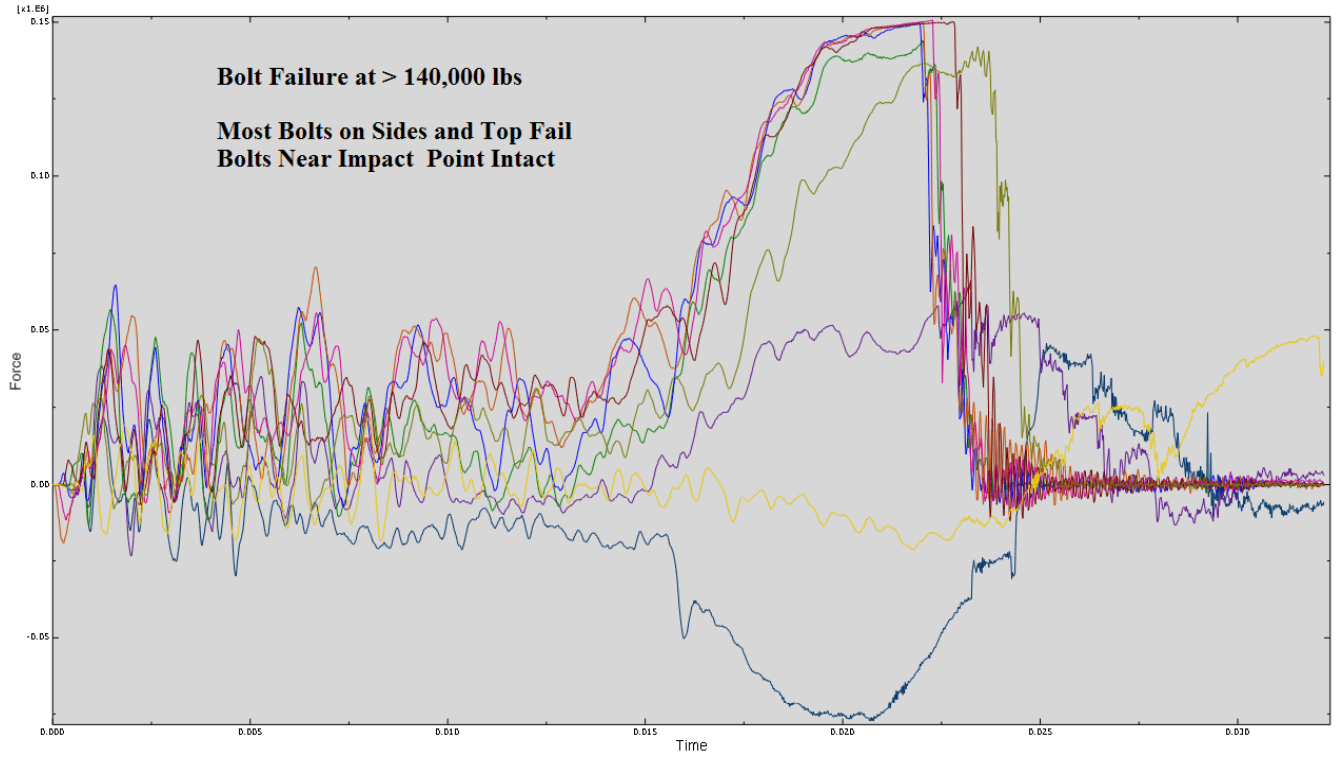


PREDECISIONAL DRAFT

Rev. 0, 08/14/2014

Ongoing Confirmatory Structural Assessment

- **30 Foot Drop, CG Over Edge, Bolt Loads**
  - Most Bolts Still Fail
  - Failure Due to Inertial Loads from Contents

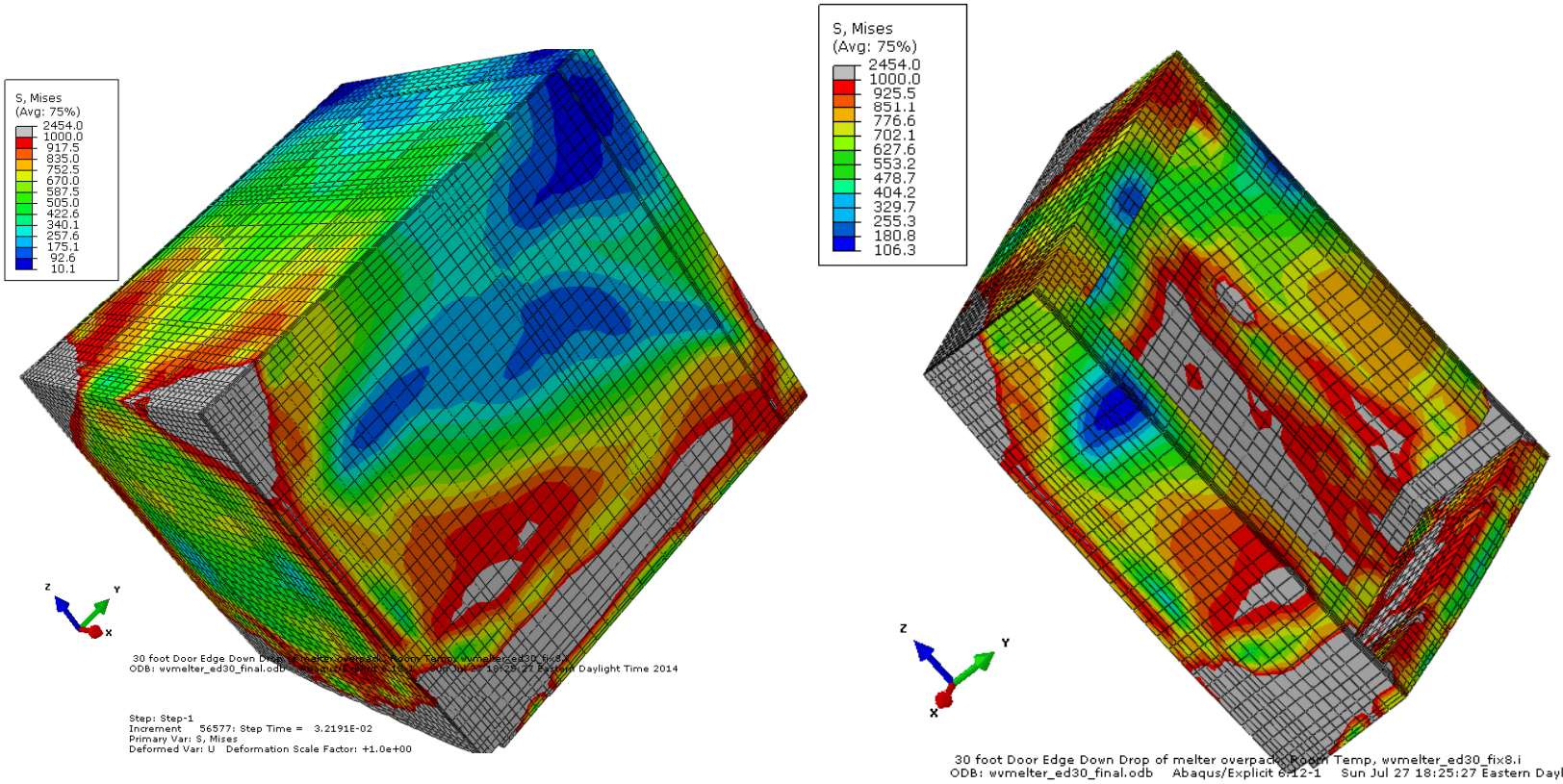


PREDECISIONAL DRAFT

Rev. 0, 08/14/2014

Ongoing Confirmatory Structural Assessment

- **30 Foot Drop, CG Over Edge, LDCC**
  - Localized LDCC Crush
  - 10% by Volume above 1000 psi Threshold in Impact Zone



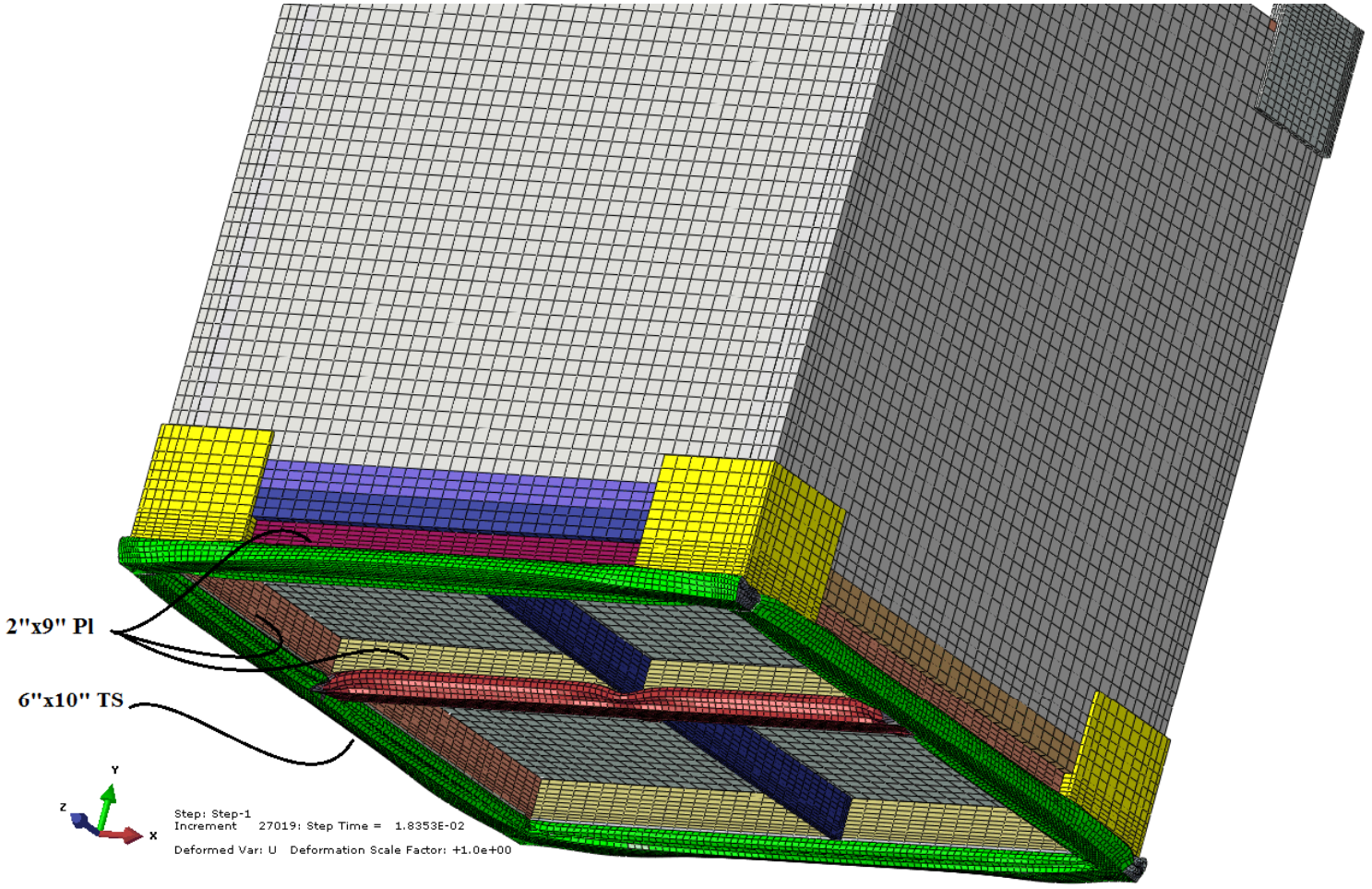
PREDECISIONAL DRAFT

Rev. 0, 08/14/2014

Ongoing Confirmatory Structural Assessment

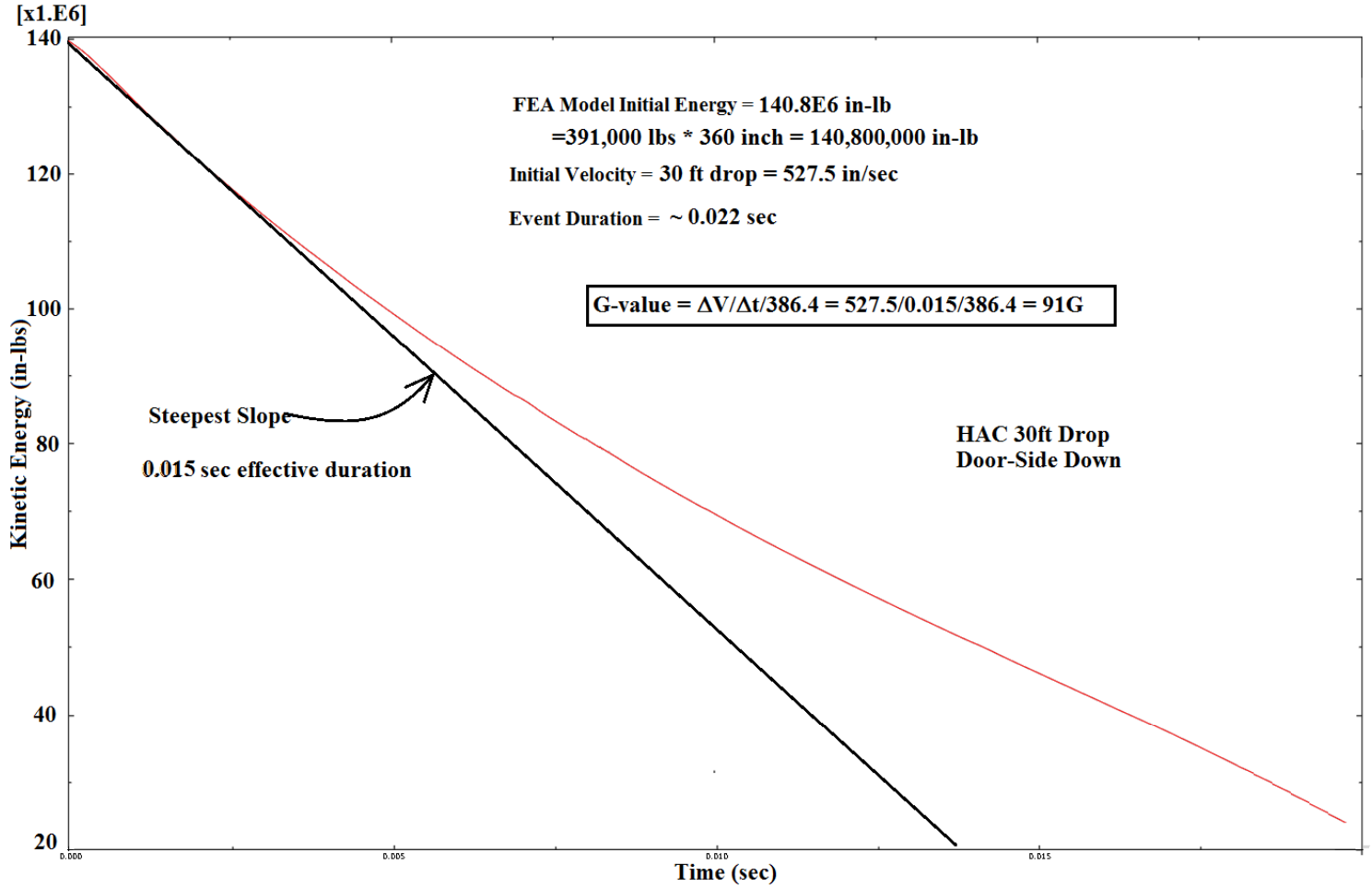
- **30 Foot Drop, Door Side Down**
  - Impact = 91G Load
    - 0.022 sec total impact duration, High G based on 0.015 sec
  - Concrete Stress Nominally at 850 psi (107,500 lbs*91G/surf area)
    - FEA shows sparse locations above 1000 psi (less than 5%)
  - Added Hardware Acts to Compress Door Into Container
    - No indicated bolt failures, no tension of many bolts
  - Side Door Bending < 1 inch (Center to Edge)
  - Total Crush of Absorbers = 6.6 inch (~50G)
    - ~70% compression of tube steel
  - Melter Stress/Deflection Insignificant
    - Less than 1/10 inch differential, mostly on bottom
    - Stress < Yield

Ongoing Confirmatory Structural Assessment



- **30 Foot Drop, Door Side Down, Deformed Shape**

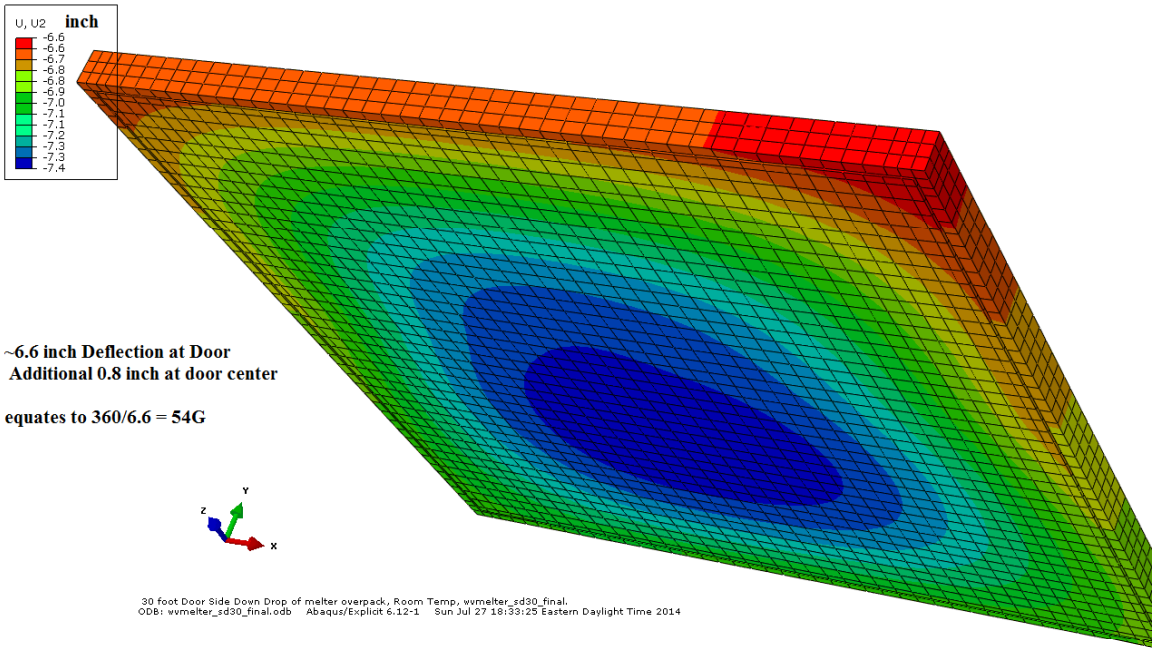
Ongoing Confirmatory Structural Assessment



- **30 Foot Drop, Door Side Down, Kinetic Energy History**

Ongoing Confirmatory Structural Assessment

- **30 Foot Drop, Door Side Down, Deflections**
  - 6.6 inch at Perimeter, ~54G
  - Additional 0.8 inch at Door Center
  - Essentially No Change in Door Gap

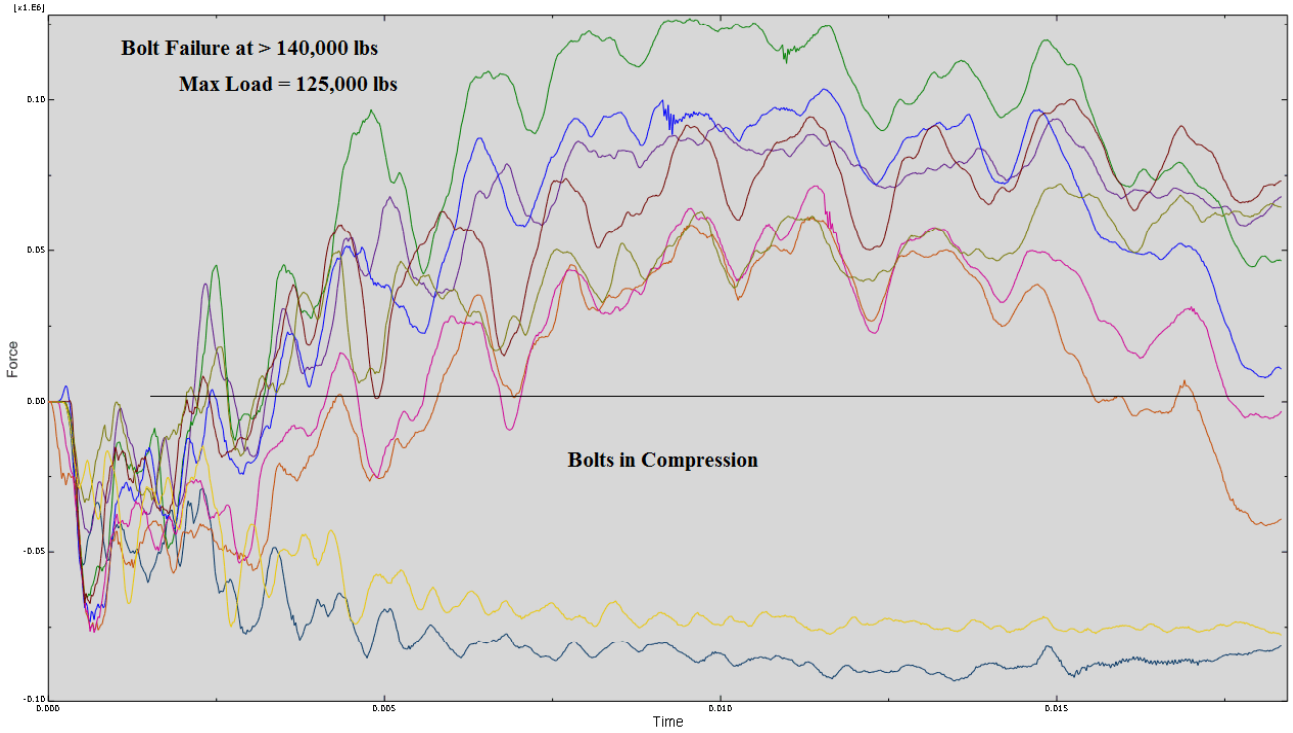


PREDECISIONAL DRAFT

Rev. 0, 08/14/2014

Ongoing Confirmatory Structural Assessment

- **30 Foot Drop, Door Side Down, Bolts Loads**
  - Bolts Remain Intact for Side Drop
  - Some Bolts see No Tension
  - Confirms no Door Gap Change

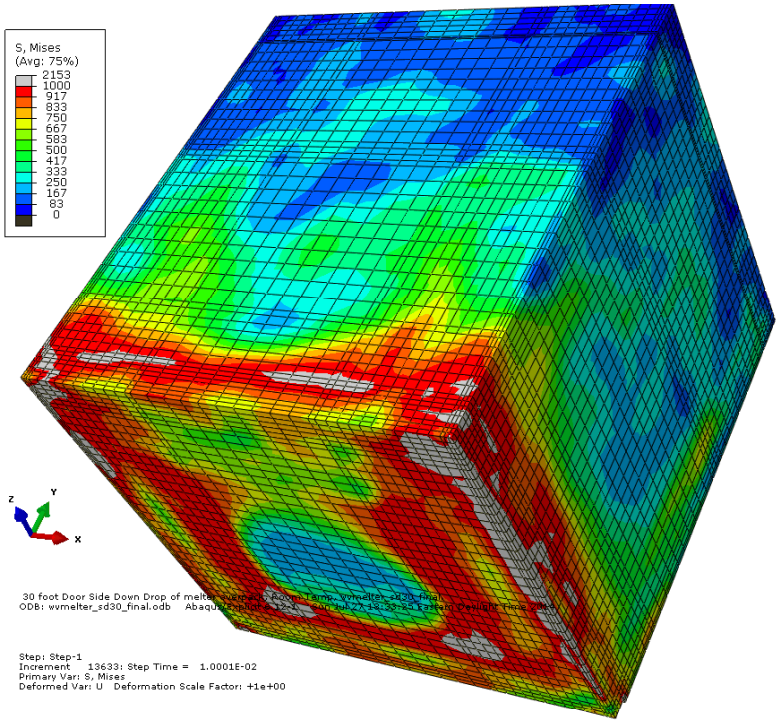


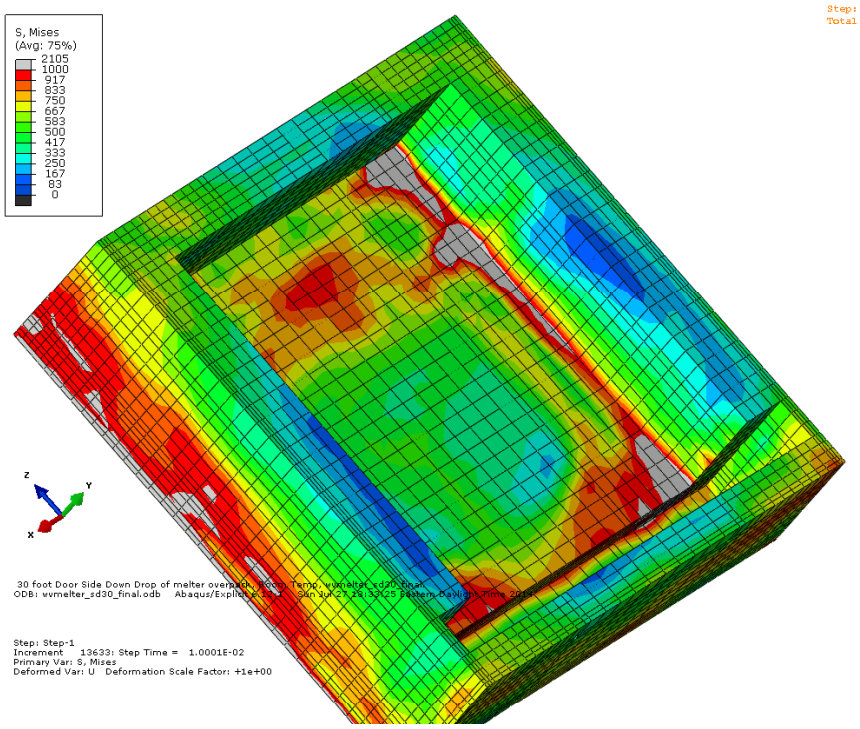
PREDECISIONAL DRAFT

Rev. 0, 08/14/2014

Ongoing Confirmatory Structural Assessment

- **30 Foot Drop, Door Side Down, LDCC**
  - Less than 5% Volume above 1000 psi in Impact Zone
  - FEA Results inline with G-value Based Stress Prediction



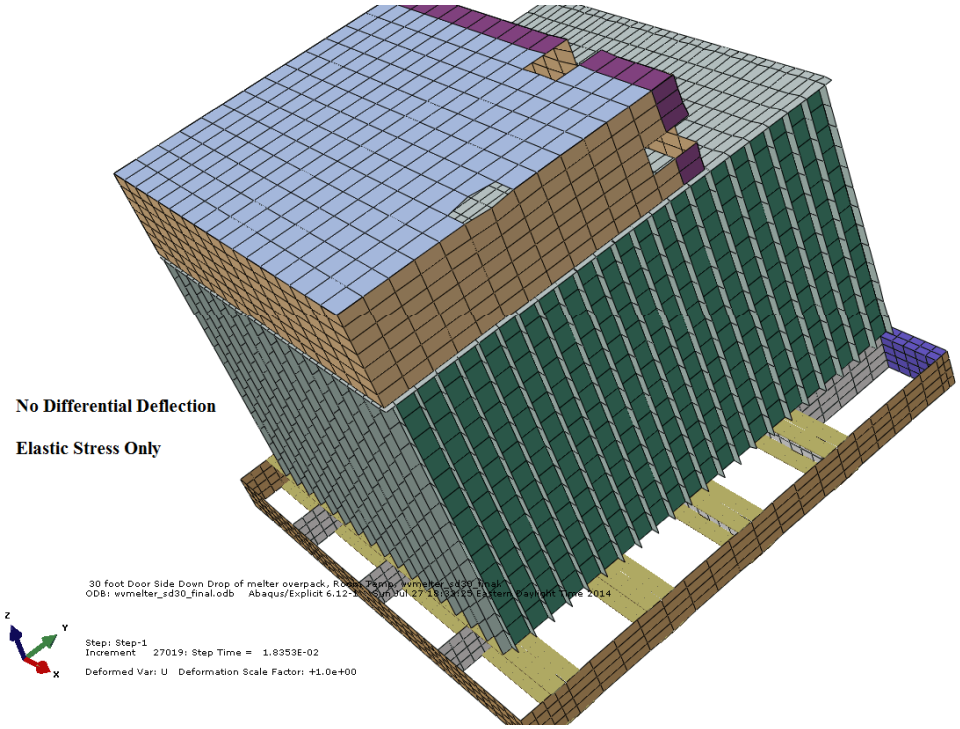


PREDECISIONAL DRAFT

Rev. 0, 08/14/2014

Ongoing Confirmatory Structural Assessment

- **30 Foot Drop, Door Side Down, Contents**
  - Melter Behaves as Rigid Unit
  - Differential Deflection < 1/10 inch, Elastic Only Behavior



PREDECISIONAL DRAFT

Rev. 0, 08/14/2014

Containment

Leak Rate Requirements per 10 CFR 71.51 for Type B packages specifies:

- "Normal Conditions of Transport," no loss or dispersal of radioactive contents as demonstrated to a sensitivity of 1E-06 A_2 per hour
- "Hypothetical Accident Conditions," no escape of other radioactive material exceeding a total amount A_2 in 1 week

Containment

Calculated HAC Releases

A_2s Released from Glass	A_2s
Spout Glass	2.5E-05
Melter Heel Glass	1.9E-05
Refractory Glass	2.0E-05
A_2s Released from LDCC	
LDCC content leached from Bartlett's	2.9E-06
LDCC content leached from Glass	7.9E-07
Nondispersed LDCC (sand)	9.3E-02
TOTAL	9.3E-02

Note: Some radioactive content conservatively double counted

HAC release less than $1A_2$ in one week

Containment

Calculated NCT Releases

A_2s Released from Glass	A_2s
Spout Glass	8.3E-09
Melter Heel Glass	6.3E-09
Refractory Glass	6.7E-09
A_2s Released from LDCC	
LDCC content leached from Bartlett's	2.9E-07
LDCC content leached from Glass	1.6E-07
TOTAL	4.7E-07

Note: Some radioactive content conservatively double counted

NCT release less than 1E-06 A_2 per hour

Containment

STRATEGY:

- LaCrosse Special Authorization used as model for containment
- Containment system is the container made from SA-516, Grade 70 carbon steel in conjunction with LDCC external to melter
- Dispersible content includes glass internal to melter and LDCC both internal and external to melter
  - Glass is a low-dispersible waste form inside the melter
  - Internal to the melter, a fraction of radioactive glass content is assumed to have leached into LDCC
  - Exterior surface contamination was fixed with 3 layers of Bartlett's PBS^{TM} with a fraction assumed to leach into LDCC external to the melter

Containment

RELEASE CALCULATIONS:

Releases calculated based on modified form of the DOE Handbook 3010-94, *Five Factor Formula for Airborne Releases*

Source Term = Material at Risk x Leak Path Factor x Damage Ratio x Respirable Fraction x Airborne Release Fraction

Material at Risk (MAR)

- Glass from Heel, Spout, and Refractory content expressed in terms of A_2s
- LDCC with an assumed 25% of radionuclides leached from glass and Bartlett's PBS™ expressed in terms of A_2s

Leak Path Factor (LPF)

- The LPF, based on handbook criteria, is 0.1 to escape melter, with an additional 0.1 to escape the combined LDCC external to melter and container

  Note: Airborne Release Fractions used for contained LDCC already accounted for in LPF

Containment

RELEASE FACTORS:

Damage Ratio (DR)

- Glass value based on previous testing of mechanical properties (i.e., broken glass fraction for NCT equals 0.01 vs 0.1 at HAC (Ref. BNWL-1903)
- LDCC values based on structural analysis (fraction of LDCC impacted) with additional conservatism applied (HAC external DR = 10%, internal LDCC DR = 1%; NCT external DR = 5%, internal = 1 %)

Respirable Fraction (RF)

- Value = 1: to calculate total A_2s released (i.e., not limited to calculating only inhalation potential)

Containment

RELEASE FACTORS (continued):

Airborne Release Fraction (ARF)

- For the ARF, sub 20 micron inventory value used based on previous testing of mechanical properties
  - NCT fraction of 1E-06 vs. HAC fraction of 3E-04 (Ref. BNWL-1903)
- LDCC values based on testing on contained and uncontained pulverized fly-ash
  - NCT values of 1E-05 contained vs. HAC values of 5E-05 contained and 7.5E-03 uncontained (Ref. IAEA/INIS RN:37121627)

Containment

RELEASE FACTORS (continued):

Non-Release Fraction Differences between NCT and HAC

- Release for NCT includes only dispersible solids (since structural analyses shows negligible impact to WVMP under NCT)
- Modification to source term equation from DOE Handbook 3010-90 for HAC to include the contribution of “released sands” (i.e., other than airborne)