An Evaluation of the Effectiveness of Common Door Blast Shields

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Outline

- Main Objective & Background
- Project Approach
- Experimental Results
- Numerical Benchmarks
- Numerical Results
- Conclusions

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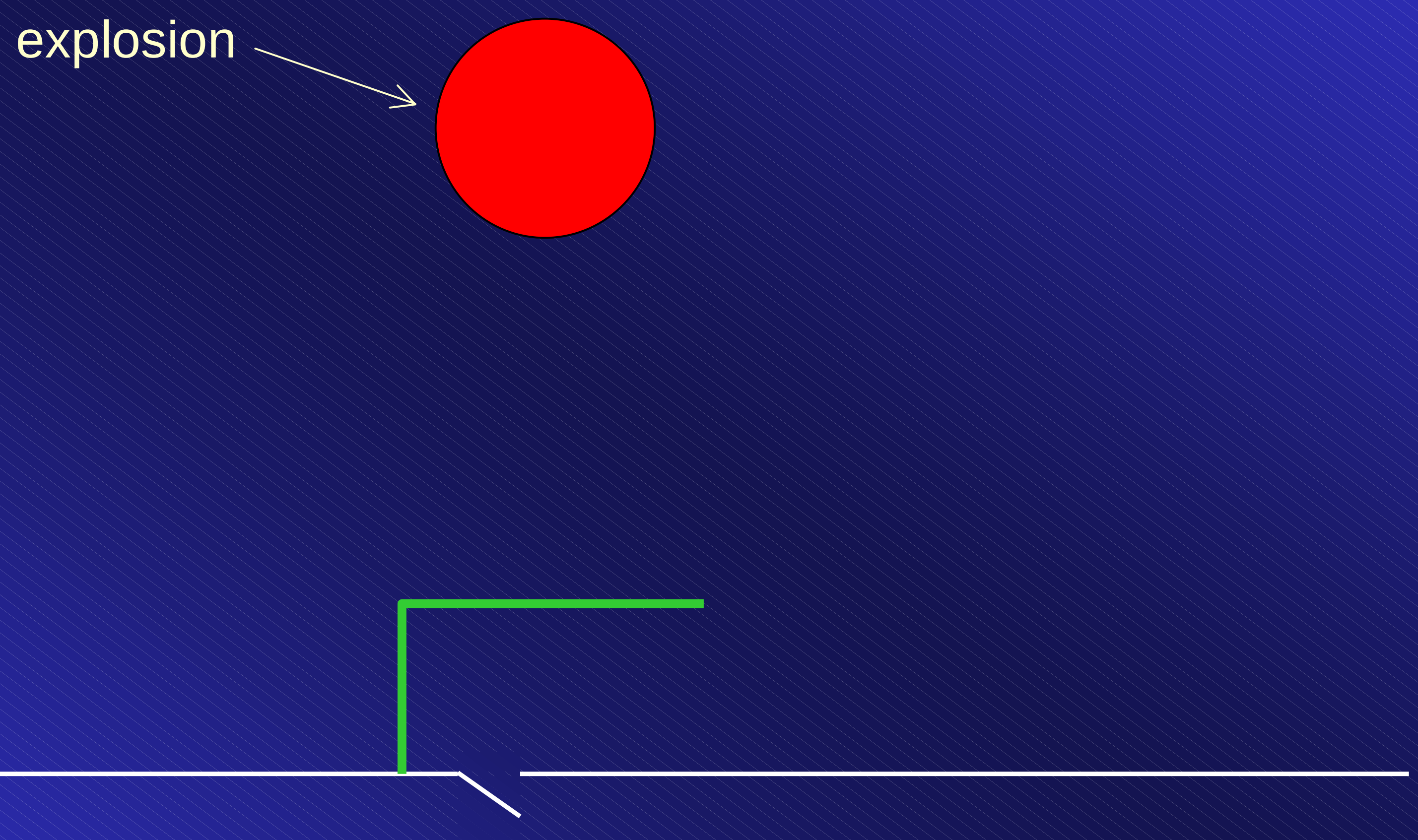
Main Objective and Background

- **Main Objective**
  - ***Evaluate performance of "L-Shaped" door blast shield design (other designs also evaluated)***
- **Background**
  - ***Blast doors can be expensive, pose operational issues (difficultly in opening and closing doors) and require regular maintenance***
  - ***Effective blast shield allows use of conventional doors***
  - ***"L-Shaped" shield design utilized at variety of sites***

Door Blast Shield Arrangement



Project Approach

- Test door blast shield in shock tube
  - *Range of pressures & impulses*
- Benchmark numerical tool (BWTI CFD code) against experimental data
- Utilize BWTI to examine alternative blast loadings

Experimental Task - Overview

- **Conduct small scale model tests in BakerRisk's large shock tube facility**
  - ***Provide benchmark data for computational task***
  - ***Develop understanding of shield performance***
- **Shock tube:**
  - ***Compressed gas driver (3' diameter and up to 21' length)***
  - ***Expands to 8'x8' target over 21' expansion section***
  - ***Open ended 16' extension section***
  - ***Can produce up to 40 psig reflected load***
- **Test rig:**
  - ***Building model, 8'(W) x 3'(H) x 1'(D)***
  - ***Shield model, 18"(W) x 18"(H) x 9"(D), roof plate***

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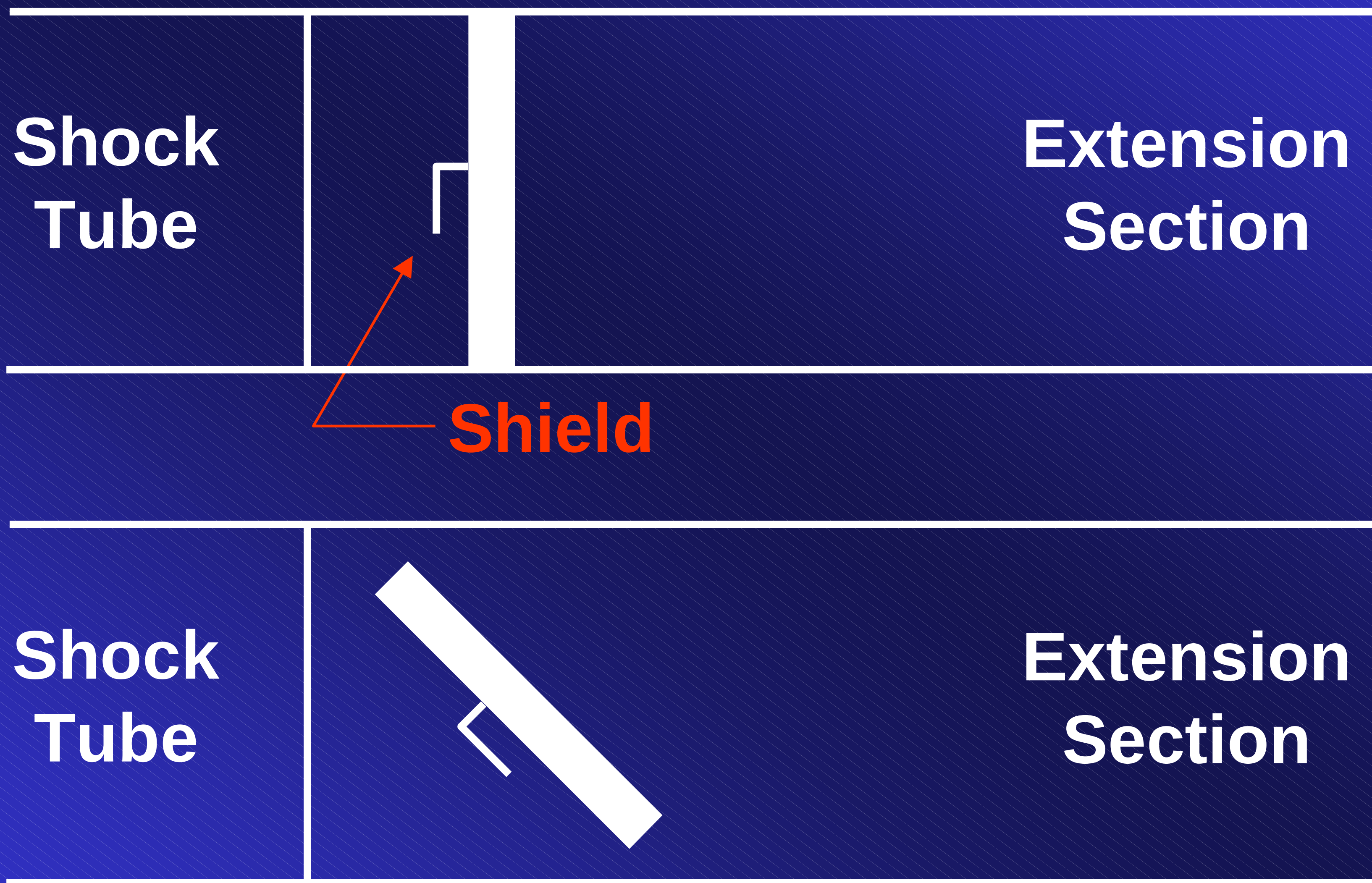
Shock Tube Photograph

Shield Configuration Schematic



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Shock Tube Test Matrix

Door Shield Orientation	Driver Length (feet)	Side-On Pressure (psig)	Baseline Tests Without Building	Baseline Tests With Building	Tests with Door Blast Shield
Normal	5	1	X	X	X
"	"	2	X	X	X
"	"	4	X	X	X
"	20	1	X	X	X
"	"	2	X	X	X
"	"	4	X	X	X
45 degrees	5	1		X	
"	"	2		X	X
"	"	4		X	X

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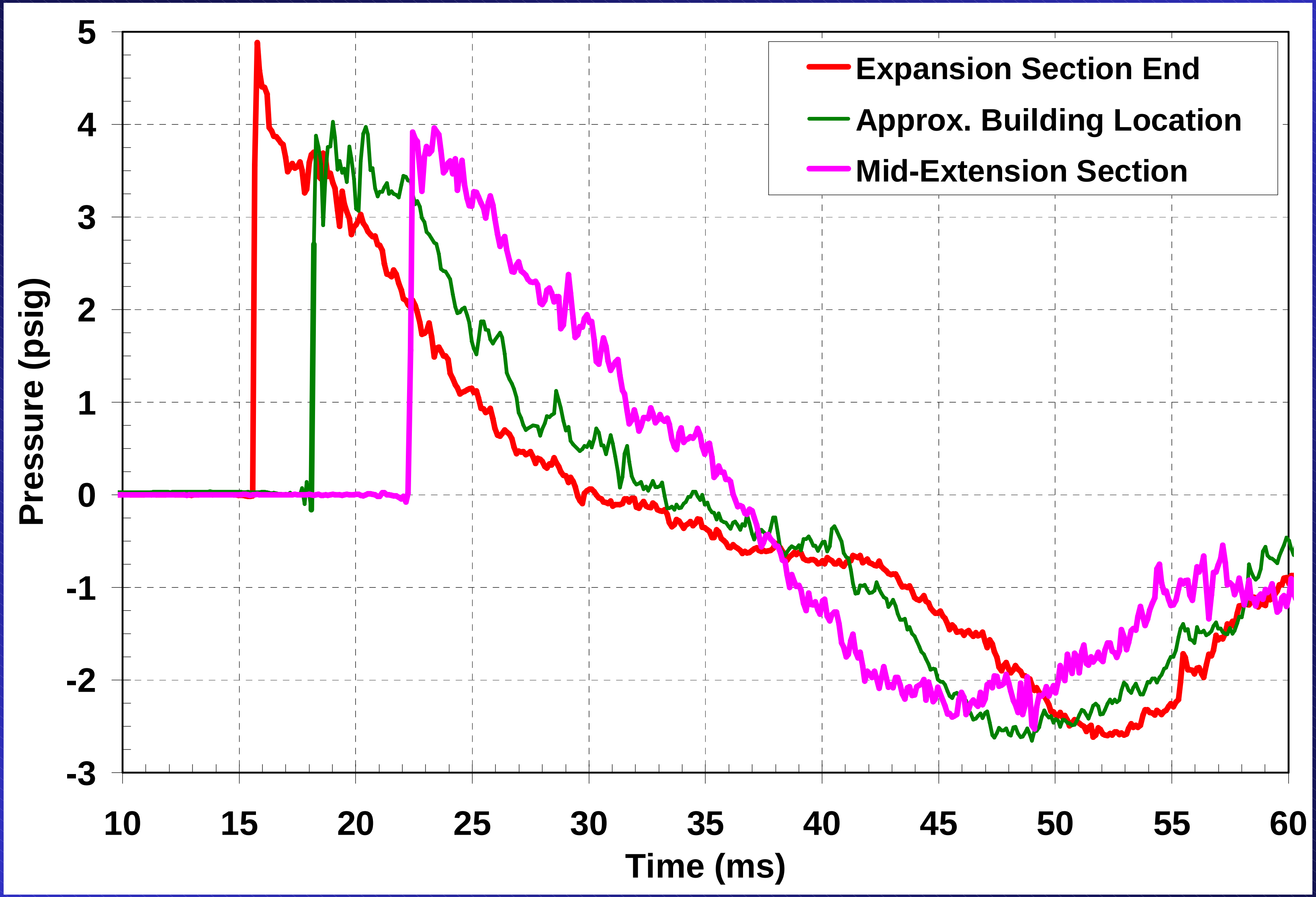
No Building (4 psig, 5 foot driver)



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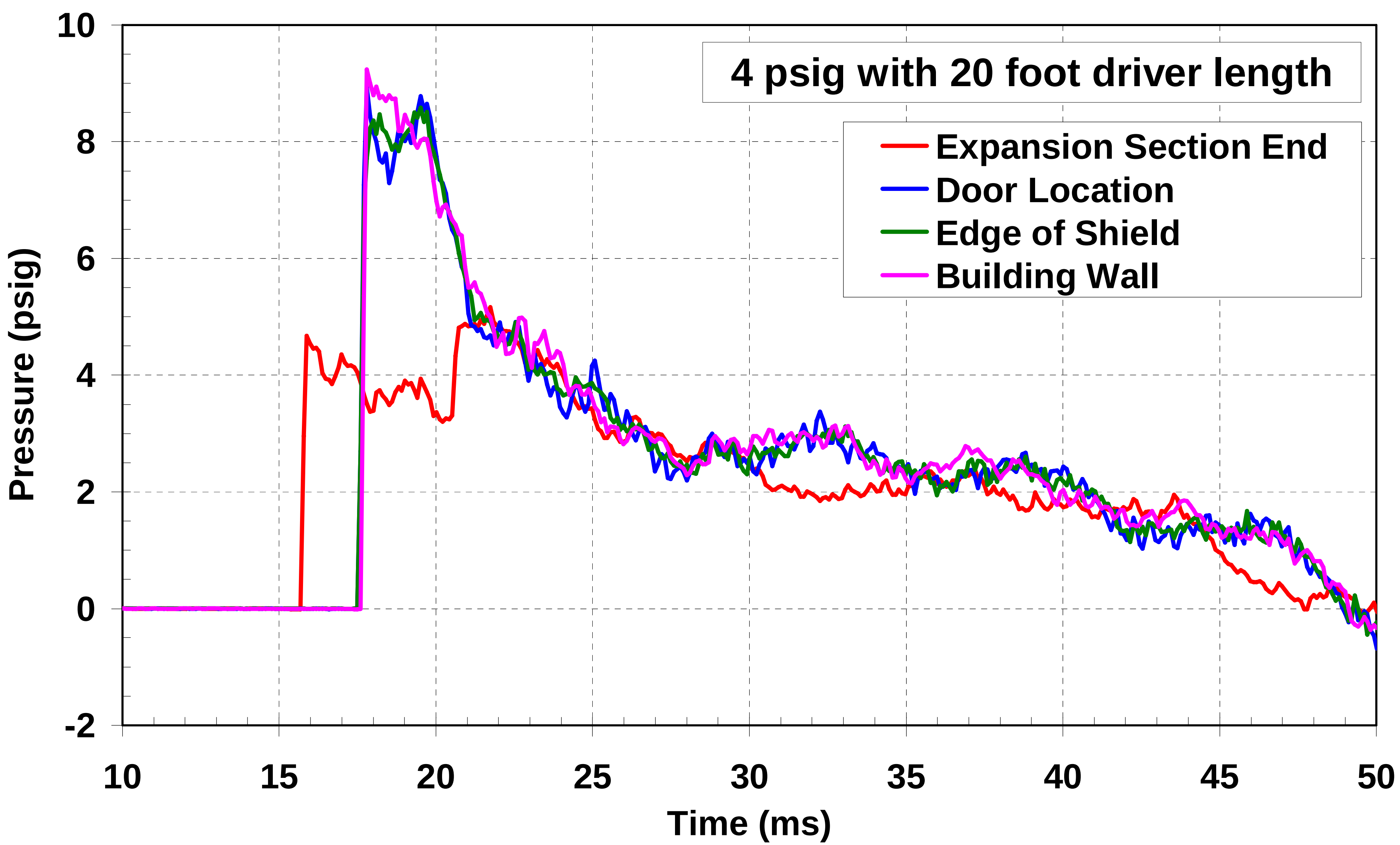
Building Only
(4 psig, 20 foot driver)



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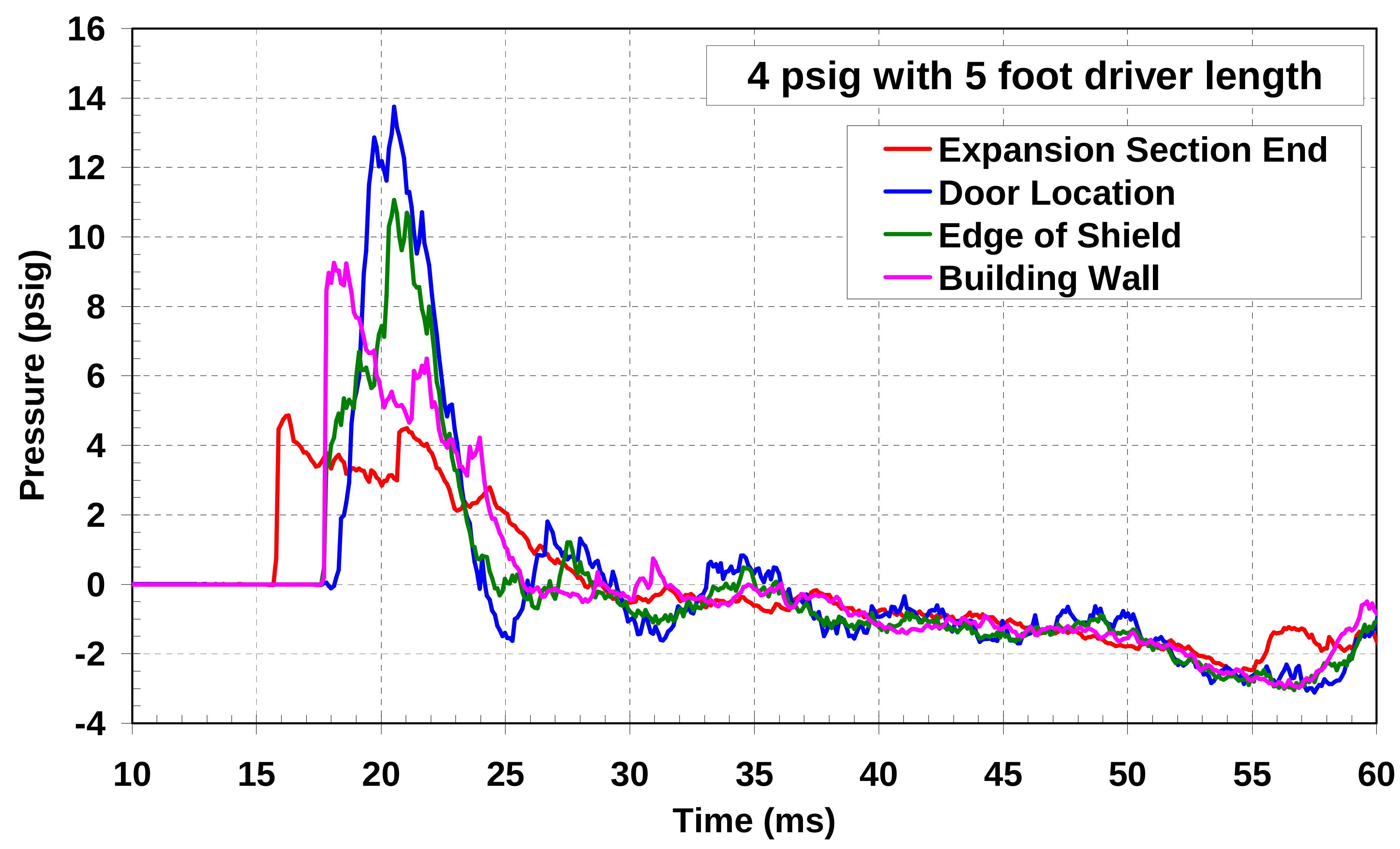
Normal Orientation (4 psig, 5 foot)
(P_s/P_u=1.6, i_s/i_u=1.1)



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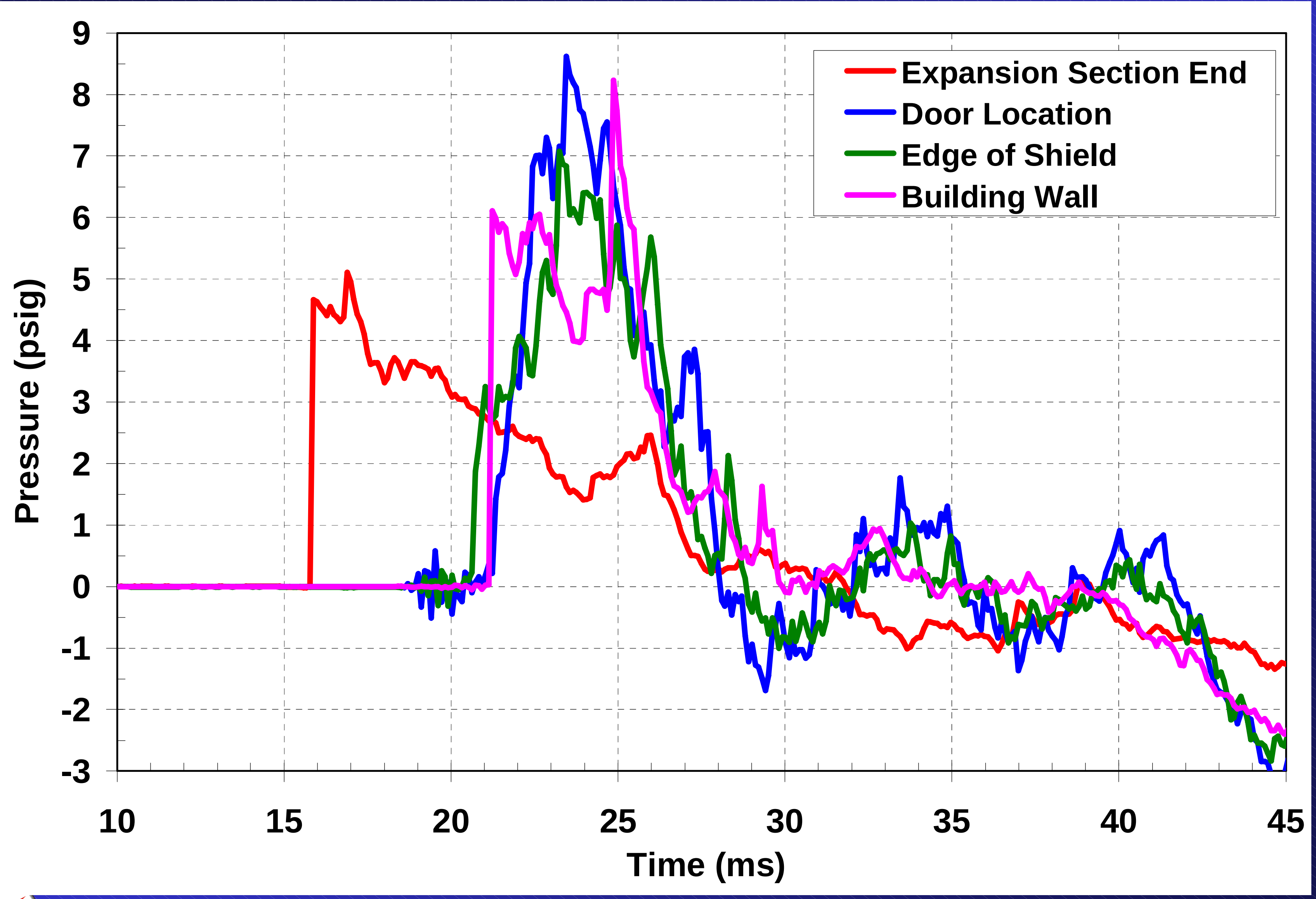
45 degree Orientation (4 psig, 5 foot)
(P_s/P_u=1.2, i_s/i_u=1.0)



Shock Tube Test Results

Door Shield Orientation	Driver Length (feet)	Side-On Pressure (psig)	Pressure Ratio (Shielded / Unshielded)	Impulse Ratio (Shielded / Unshielded)
Normal	5	1	1.6	1.0
"	"	2	1.6	1.2
"	"	4	1.6	1.1
"	20	1	1.3	1.0
"	"	2	1.7	1.1
"	"	4	1.6	1.1
45 degrees	5	1	n/a	n/a
"	"	2	1.3	1.1
"	"	4	1.2	1.0

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Overview of Benchmarks

- **BakerRisk's Blast Wave Target Interaction (BWTI) CFD code employed**
  - ***Generation and propagation of blast & shock waves***
  - ***Interaction of wave with structures***
- **Utilized 2D model**
  - ***Focus of comparison is on initial wave interactions***
- **Benchmark results:**
  - ***L-Shaped, normal, 4 psig, 20 foot driver***
  - ***Pressure traces at several key locations***
  - ***Pressure contour animations***

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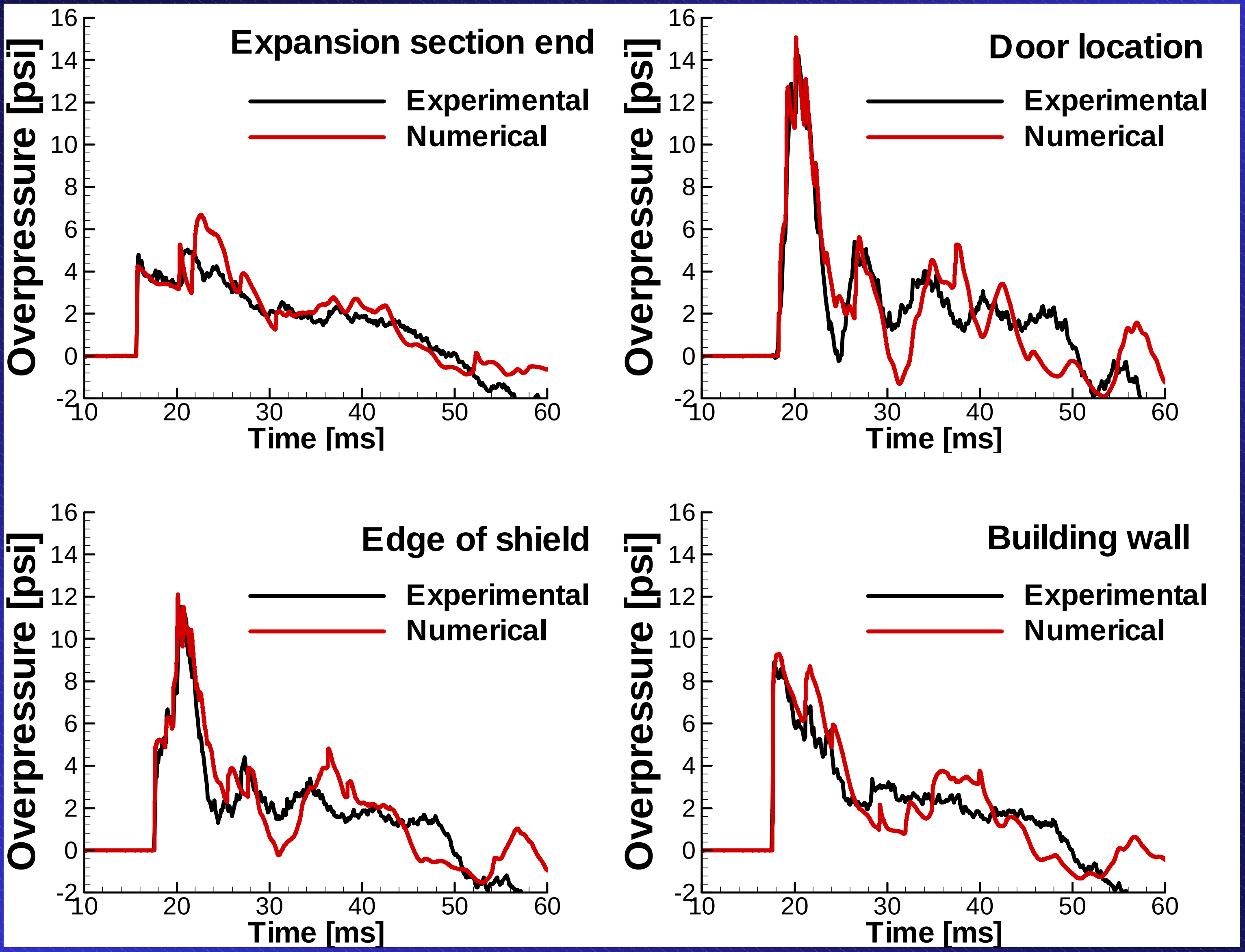
Normal Orientation
(4 psig, 20 foot driver)



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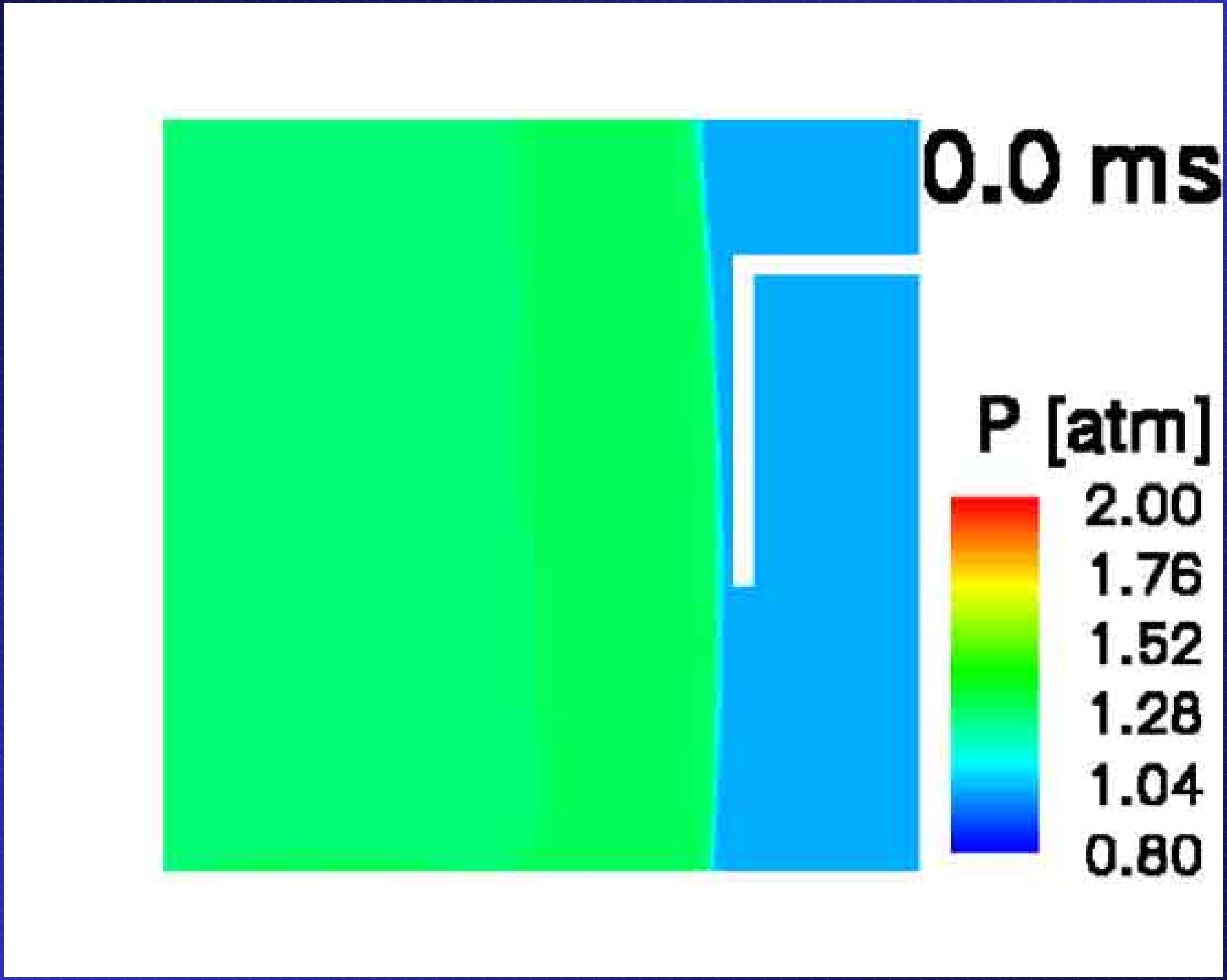
Normal Orientation
(4 psig, 20 foot driver)



Performance with Alternative Blast Loads

- **Benchmark calculations support use of BWTI to evaluate performance at full-scale (4' x 8') with alternative blast loads**
- **Defined "typical" blast loads at 200' standoff**
  - ***VCE (200'x100'x15', M_f=0.4, $3x10^{10}$ in-lb_f)***
    - Reflected load of 1.9 psig & 86 psi-ms (92 ms)
      - Severe damage to conventional door (3'x7' single metal door)
      - Need factor of 2 reduction in <u>pressure</u> to reach minor damage
  - ***BPV (10,000 gallon, 750 psig failure pressure)***
    - Reflected load of 3.5 psig & 43 psi-ms (25 ms)
      - Severe damage to conventional door (3'x7' single metal door)
      - Need factor of 2 reduction in <u>impulse</u> to reach minor damage

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Numerical Model
Door Blast Shield Results

Blast Source	Blast Orientation	Pressure Ratio (Shielded / Unshielded)	Impulse Ratio (Shielded / Unshielded)
BPV	Normal	1.25	1.41
"	45 degrees	0.90	1.40
VCE	Normal	1.24	0.85
"	45 degrees	1.07	0.61

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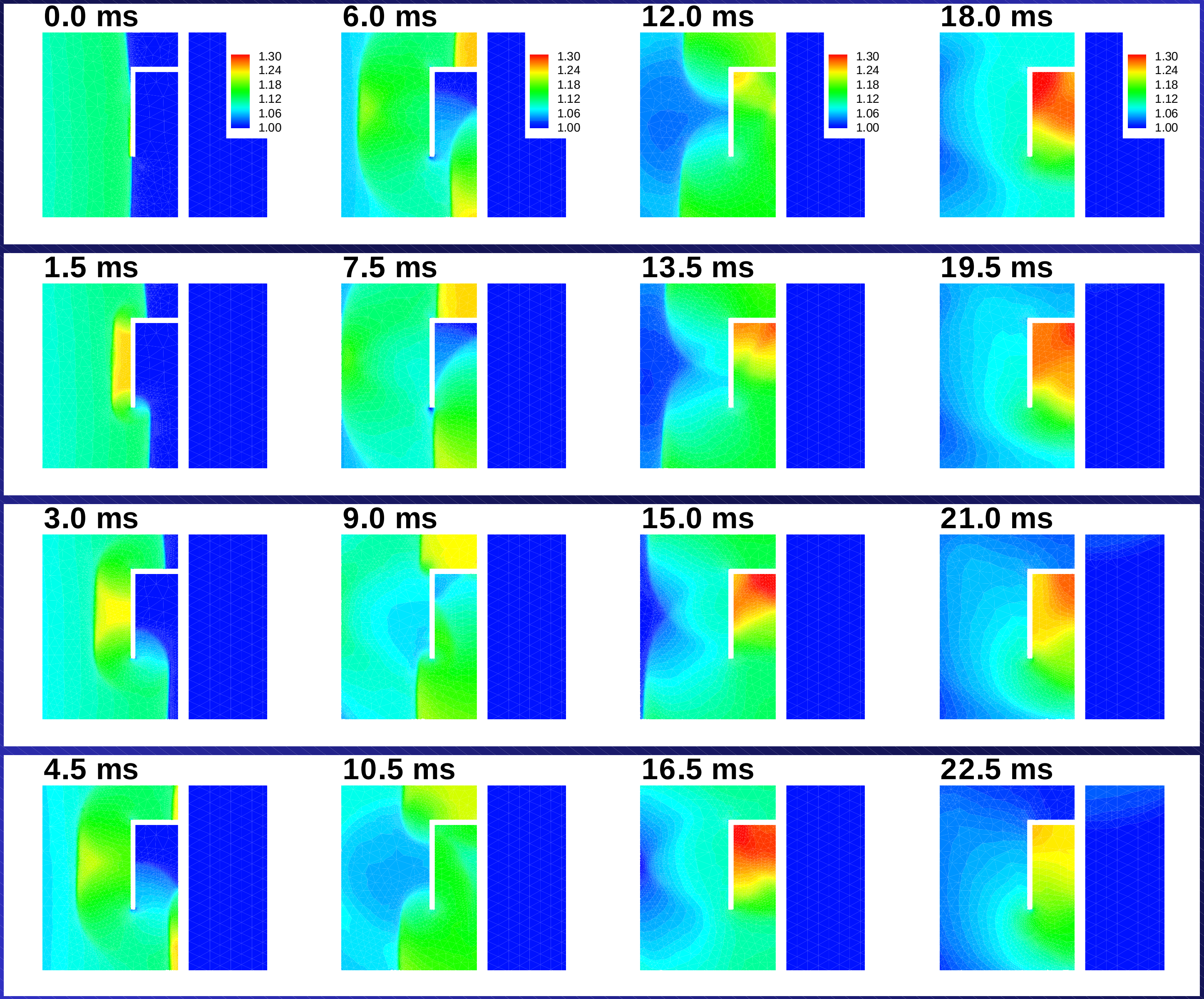
BPV Blast Load
(normal orientation)



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Overall Conclusions

- **"L-Shaped" door blast shield ineffective**
  - ***Little or no benefit***
  - ***Can increase door blast load***
- **Does not indicate removal is best option**
  - ***Still provides measure of protection***
  - ***May need to employ outer door***
  - ***Failure of outer door poses hazard***
- **Alternative shield design may be desirable**
  - ***New construction or upgrade***
  - ***Where outer door cannot be utilized***

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