MODELING A ROBUST CAISSON STRUCTURE TO RESIST EFFECTS FROM BLOW-IN-PLACE OF UNDERWATER UNEXPLODED ORDNANCE

2018 INTERNATIONAL EXPLOSIVES SAFETY SYMPOSIUM & EXPOSITION
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Background

Performers:
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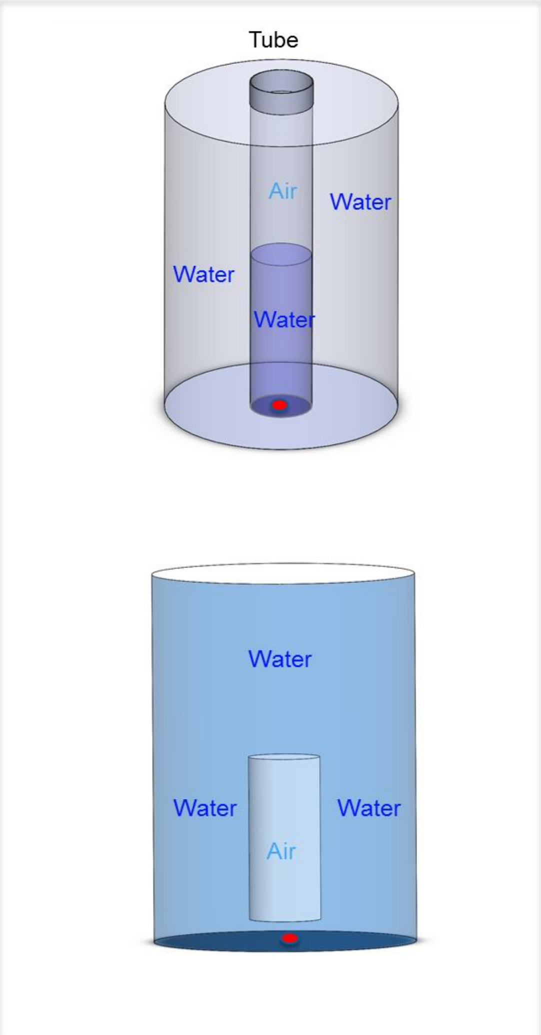
- Robert Conway, NAVFAC EXWC
- Roger Ilamni, NSWC IHEODTD

Technology Focus
- Mitigating blast effects from UNDEX during BIP operations

Research Objectives
(1) demonstrate a reduction in UNDEX blast pressures and acoustics with the use of the shielding concept;
(2) determine a performance requirement that optimizes mitigation efficacy; and
(3) quantify a relation between charge size and shielding performance

Project Progress and Results
- Have a conceptual design that will significantly reduce blast effects

Technology Transition
- Next steps are to field test a caisson structure and validate the model
- Discussion of project results will be presented to the Navy's Munition Response Workgroup and the DoD Underwater Explosion Quantity Distance Working Group.



Problem Statement

- Underwater munitions represent a significant threat to human health and the underwater environment, i.e. marine mammals.
- Technologies are needed to cost-effectively and safely recover munitions in the underwater environment.
- Explosive risk for retrieving fuzed munitions is high.
- Current approach is to Blow-in-Place (BIP) the munition.
- Use of in-situ detonation for assumed fuzed munitions is waning due to blast pressure waves and acoustics that may potentially harm nearby structures and sensitive biota.

Approach

The goal of this project was to develop a robust caisson structure that effectively mitigates blast effects generated by underwater explosions

- Computer simulations using DYSMAS software to evaluate the baseline scenario as well as 4 types of blast mitigations with 9 alternatives.
- The charge weights range from 20 lbs. TNT to 200 lbs. TNT, and the charge location (0m, 12.7m) is at the center of the DYSMAS models, and 12.7m (41.7 ft.) below the water surface, where the water depth is 12.8 m (42 ft.).
- The target parameters include the blast waveform (i.e. the pressure-time history), peak pressure, impulse intensity and energy flux density.

Approach

Fluid-Structure Interaction Software (DYSMAS)

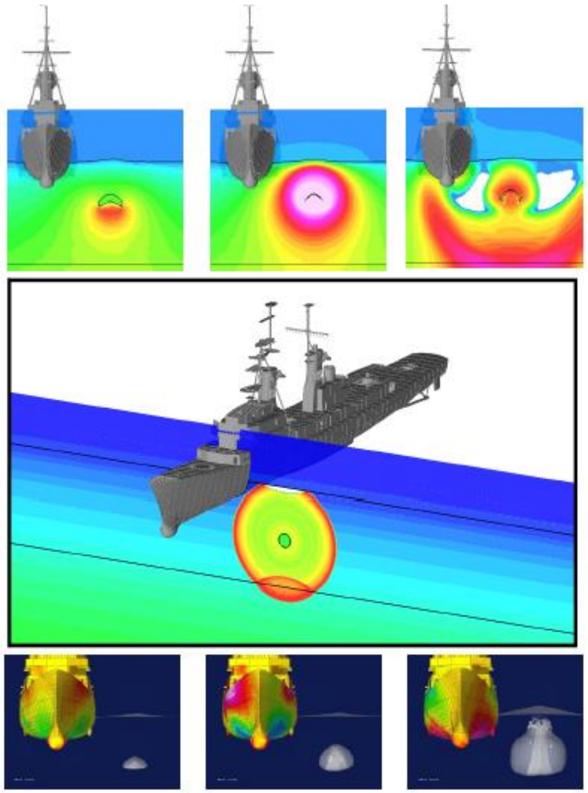
- A fully-coupled, government-owned and developed hydro-code for predicting weapons effects and structural response. It is the most extensively validated code for underwater explosions.

- Developed as a collaboration between the U.S. and Germany since 1995 with more than $50 million direct investment from ONR

- NAVSEA Warfare Centers (*i.e.* NSWC Indian Head) leading *development* role with the technical assistances from Lawrence Livermore National Laboratory, DynaFlow Inc., Advanced Technology & Research, BWB, WTD-71 and IABG.

- Massively parallel computing enabled through the DoD’s High-Performance Computing (HPC) facilities.

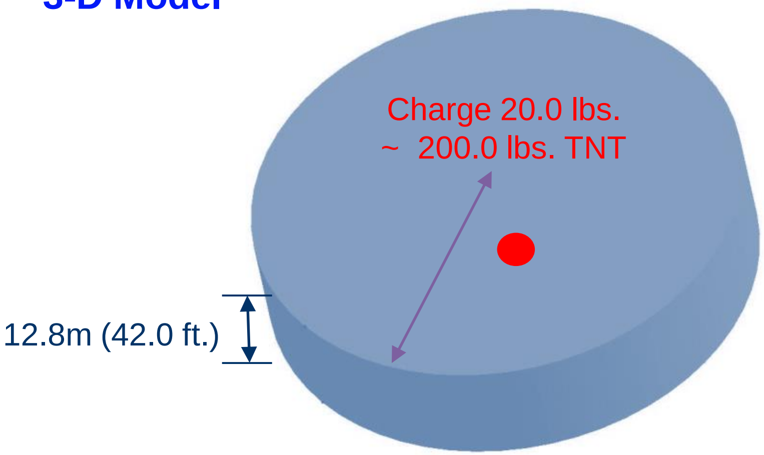
- Export-controlled software (For Official Use Only), maintained by NSWC Indian Head, MD USA.



DYSMAS Version 7.1.00
Manual Dated: 10 June 2015

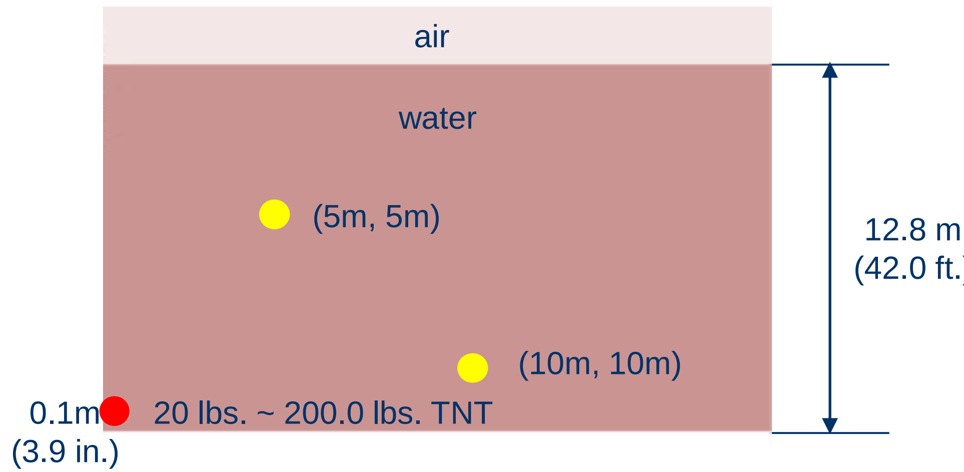
Baseline Scenario (no blast mitigation)

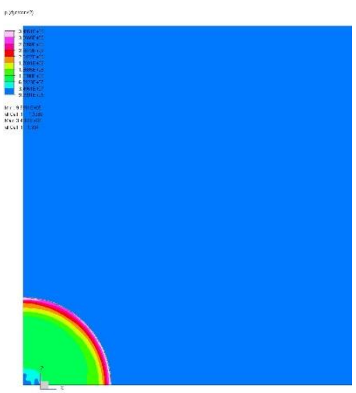
3-D Model



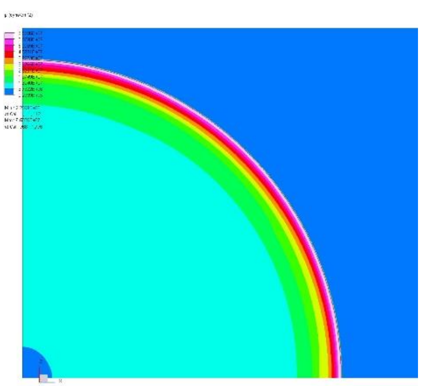
30.48m (100 ft.) ~ 304.8m (1,000 ft.)
in the x direction (horizontally)

2-D Model





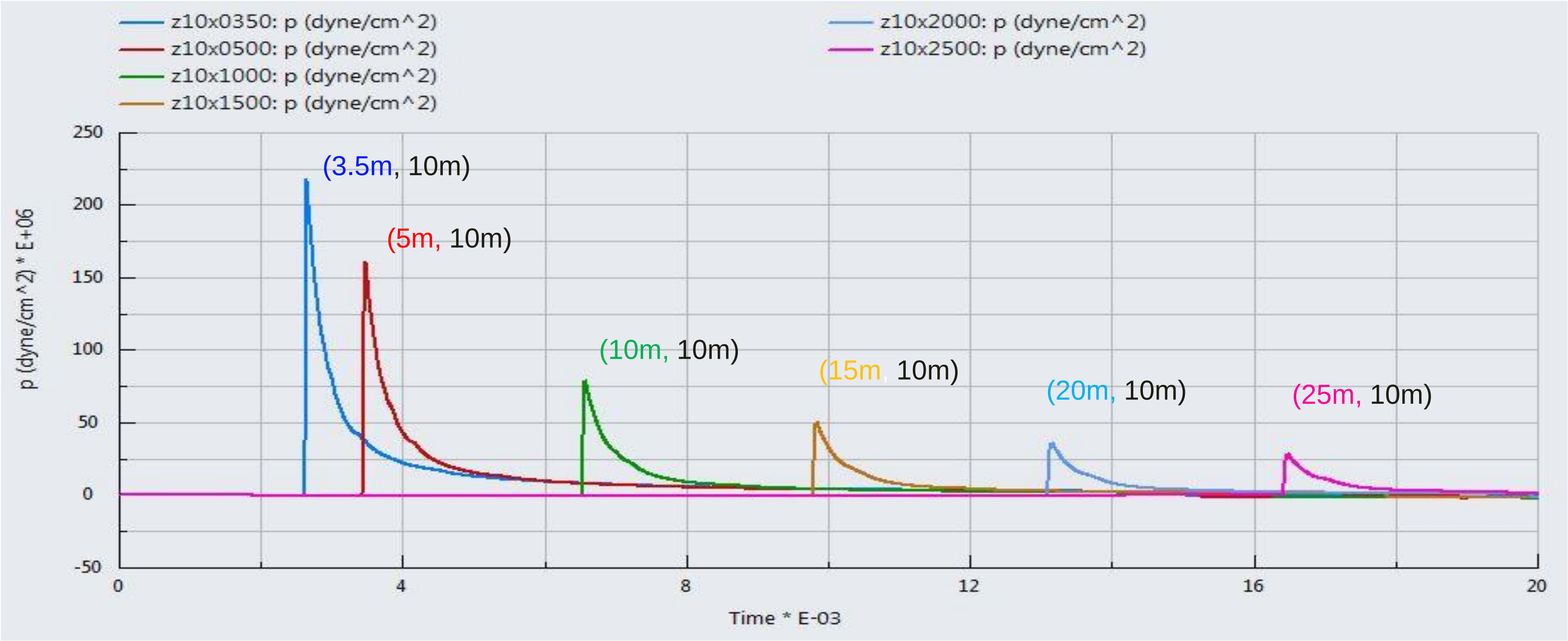
T = 0.002 sec.



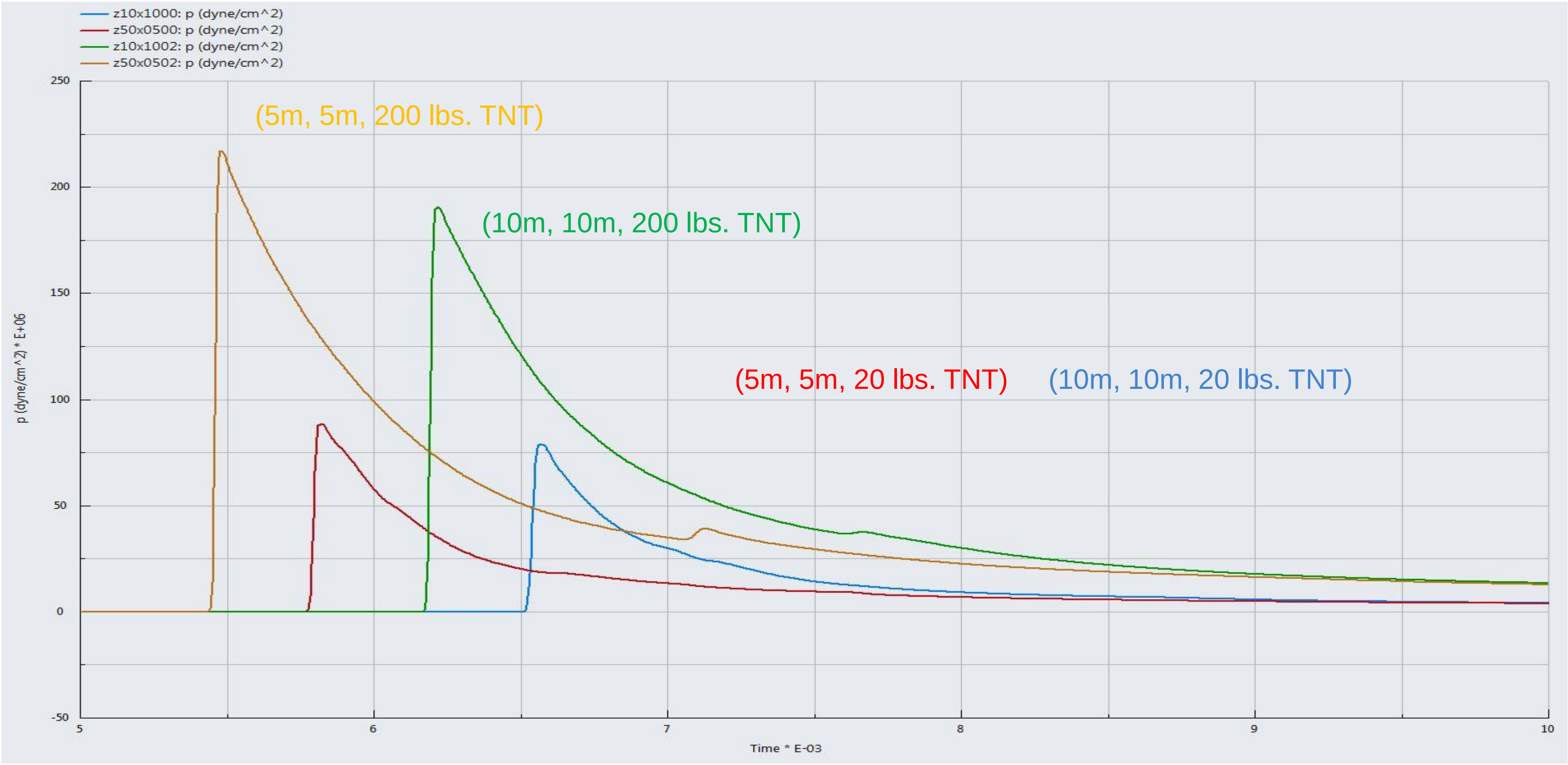
T = 0.008 sec.

T = 0.020 sec.

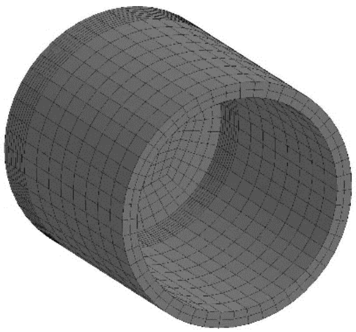
20 lbs. TNT Baseline DYSMAS Results



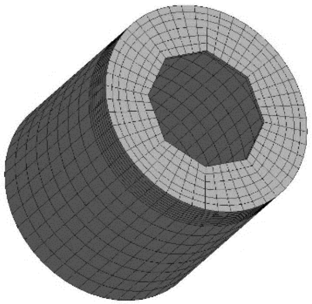
200 lbs. TNT vs. 20 lbs. TNT Baseline DYSMAS Results



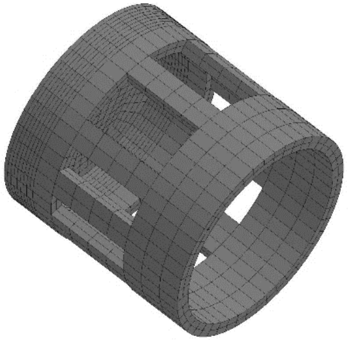
4 Types (9 Alternatives) for Blast Mitigation (8 ft height x 8 ft inner diameter)



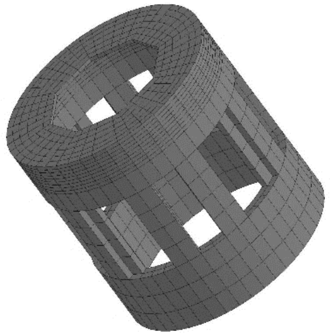
Type I – Single Steel Hull



Top Venting

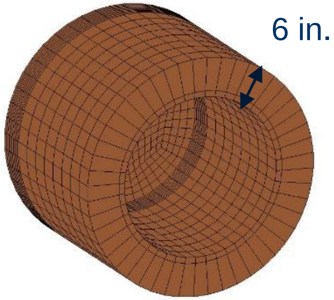


Side Venting

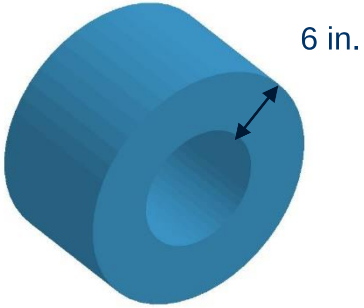


Full Venting

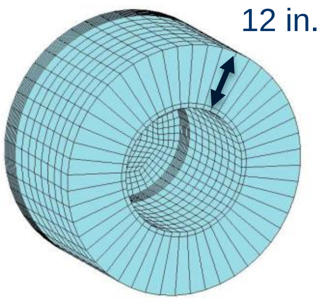
Type II – Double Steel Hull



w/ 6” Sand

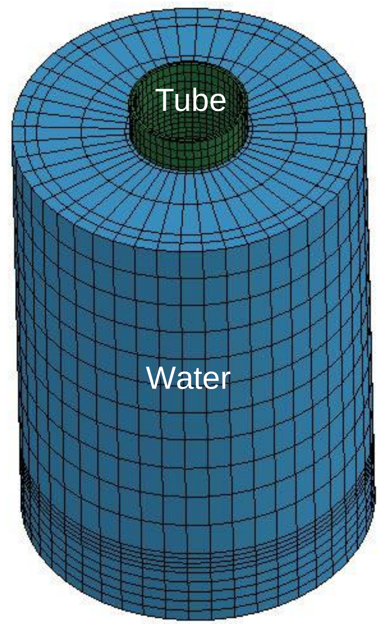


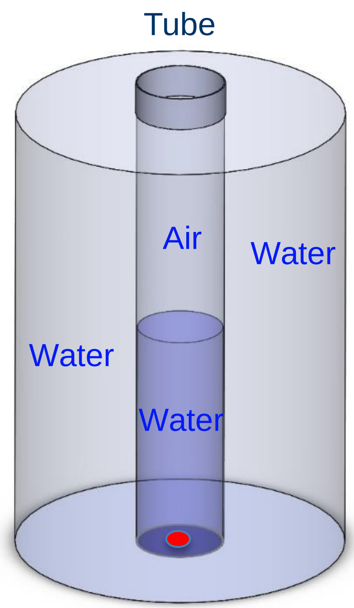
w/ 6” Water

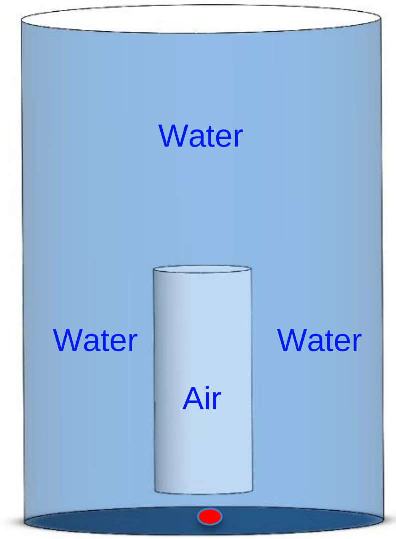


w/ 12” Air

Type III & IV - UNDEX Blast Mitigations (New)



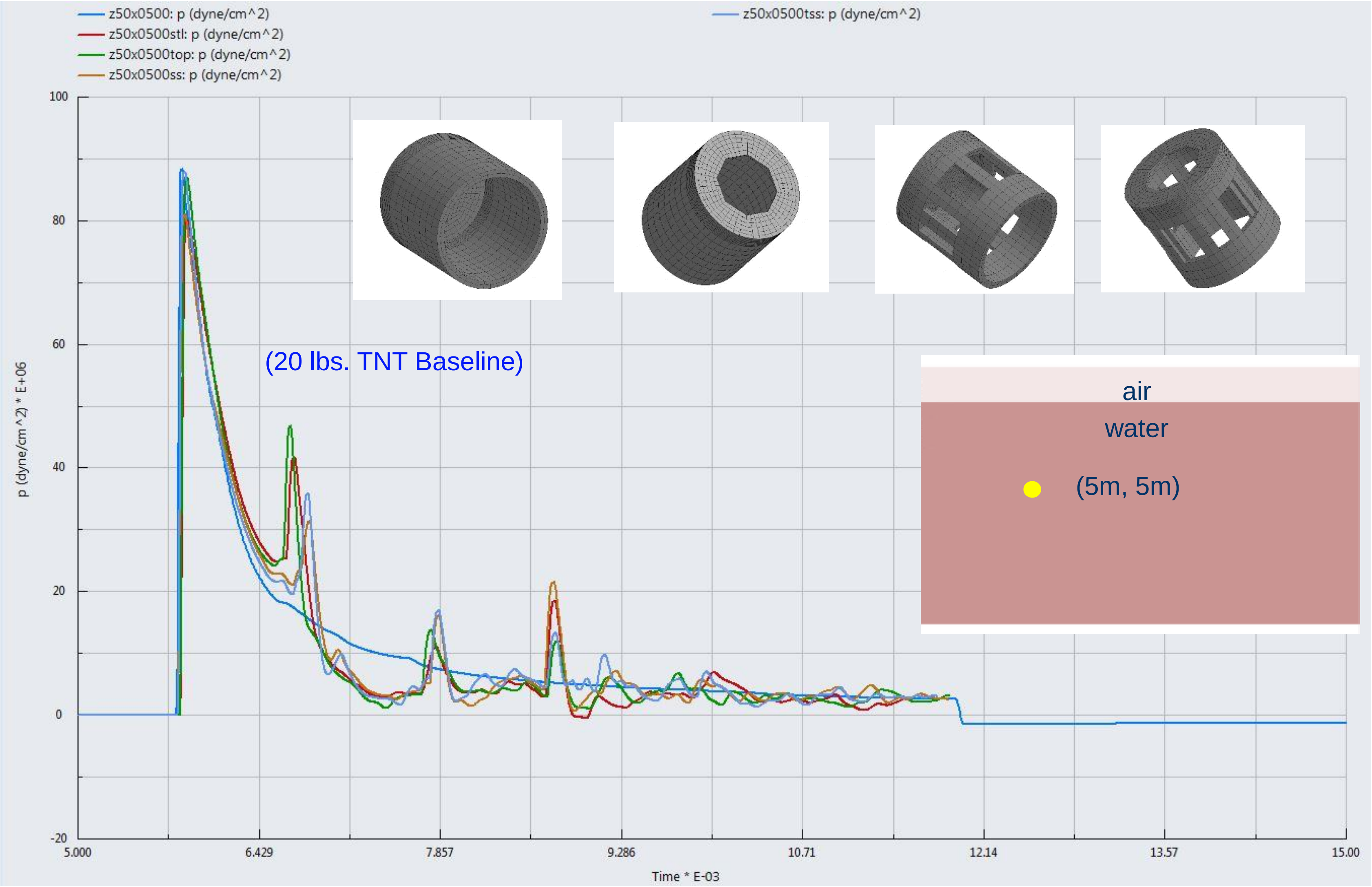




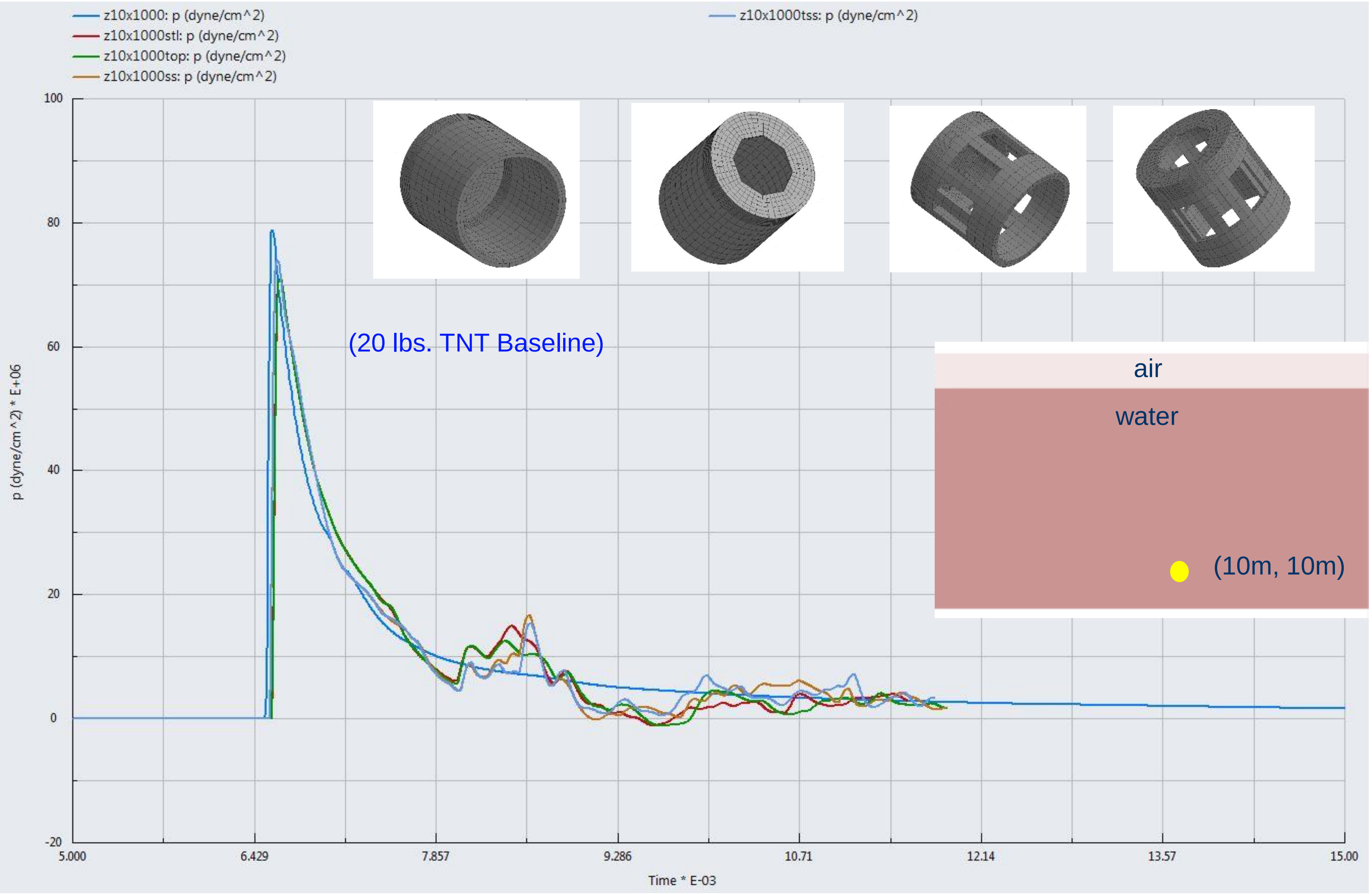
Type III – Shallow Water
(up to 8 ft. inner diameter and 10 ft. deep water)

Type IV – Deep Water

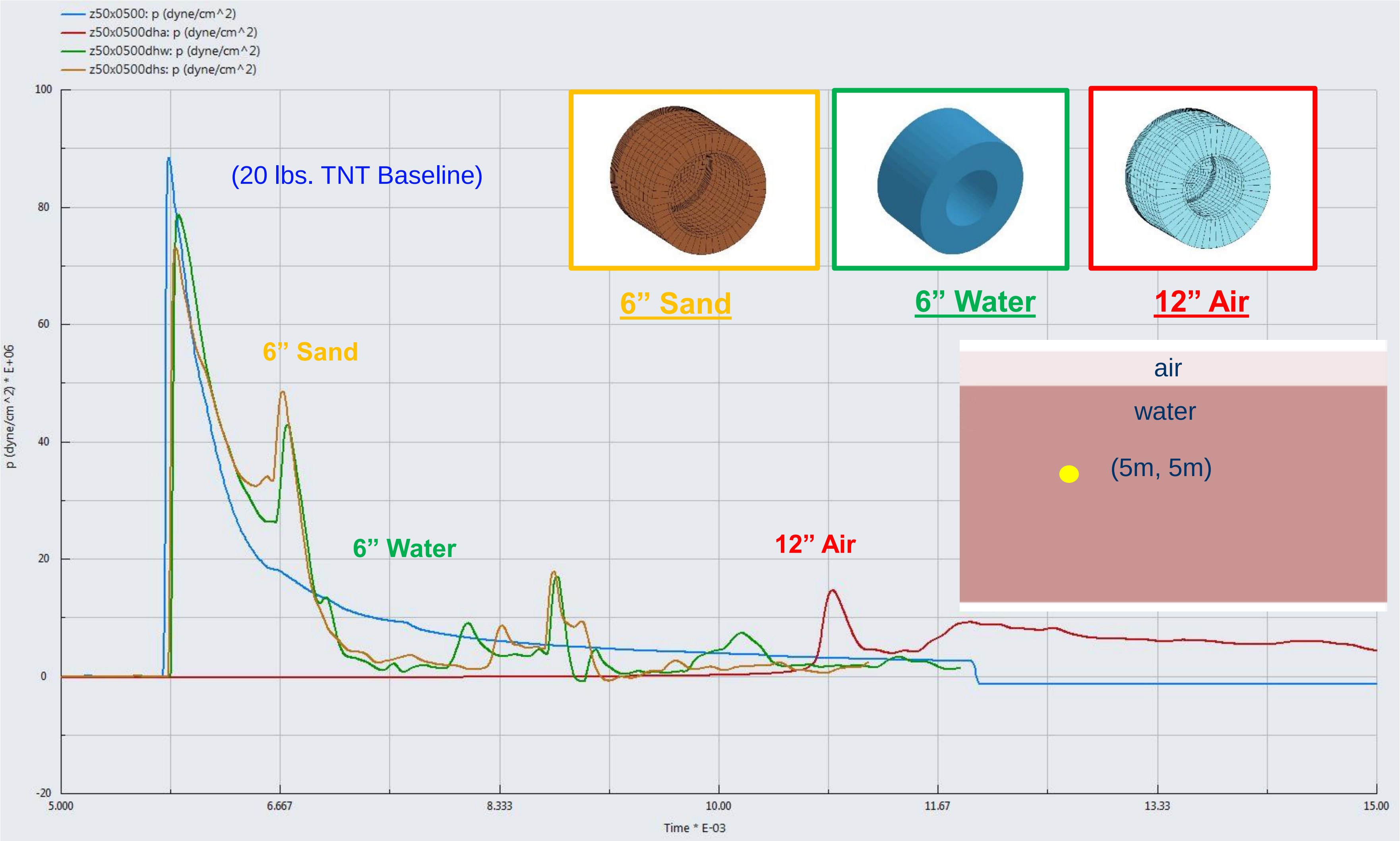
Type I - 20 lbs. TNT DYSMAS Results at (5m, 5m)



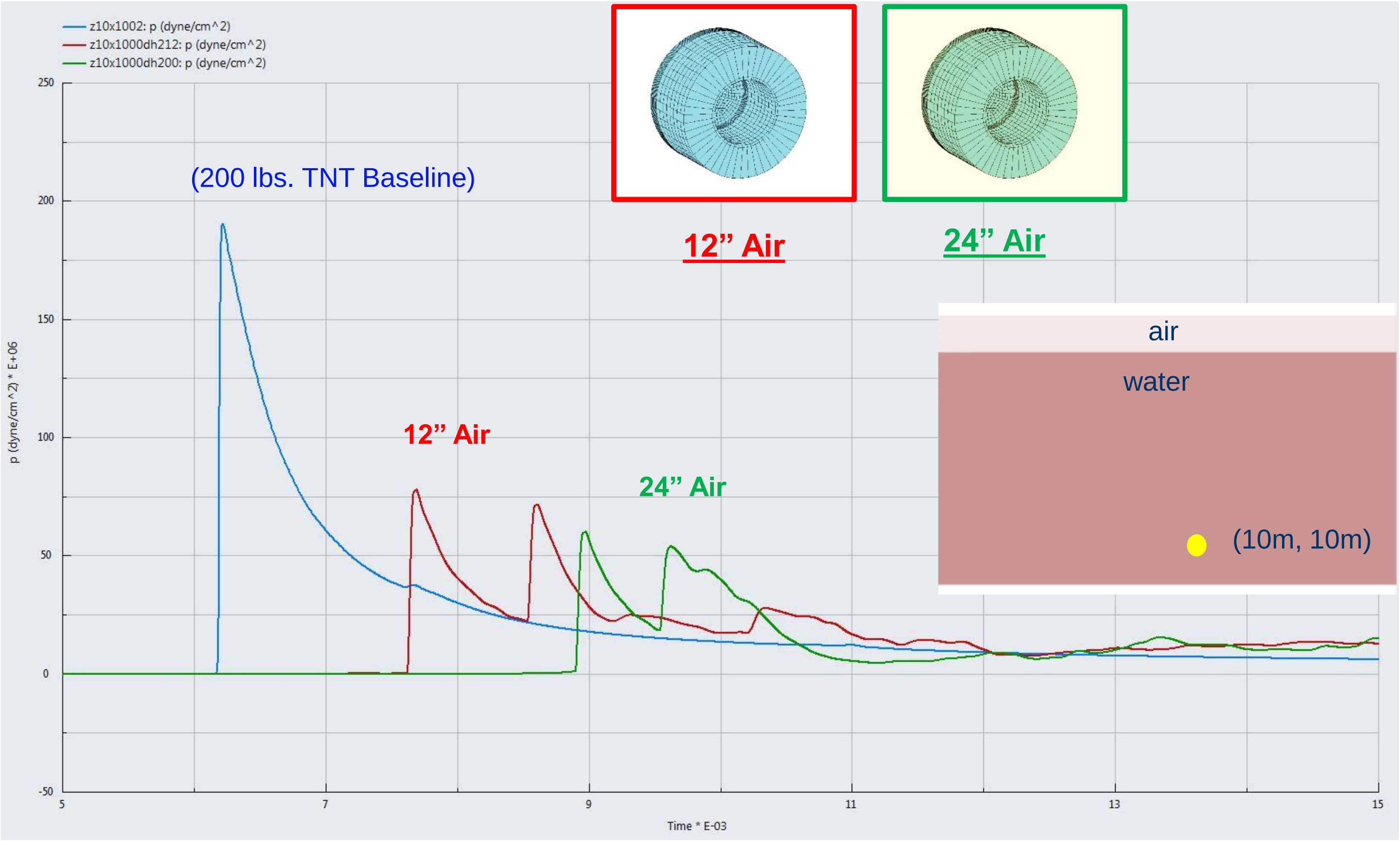
Type I - 20 lbs. TNT DYSMAS Results at (10m, 10m)



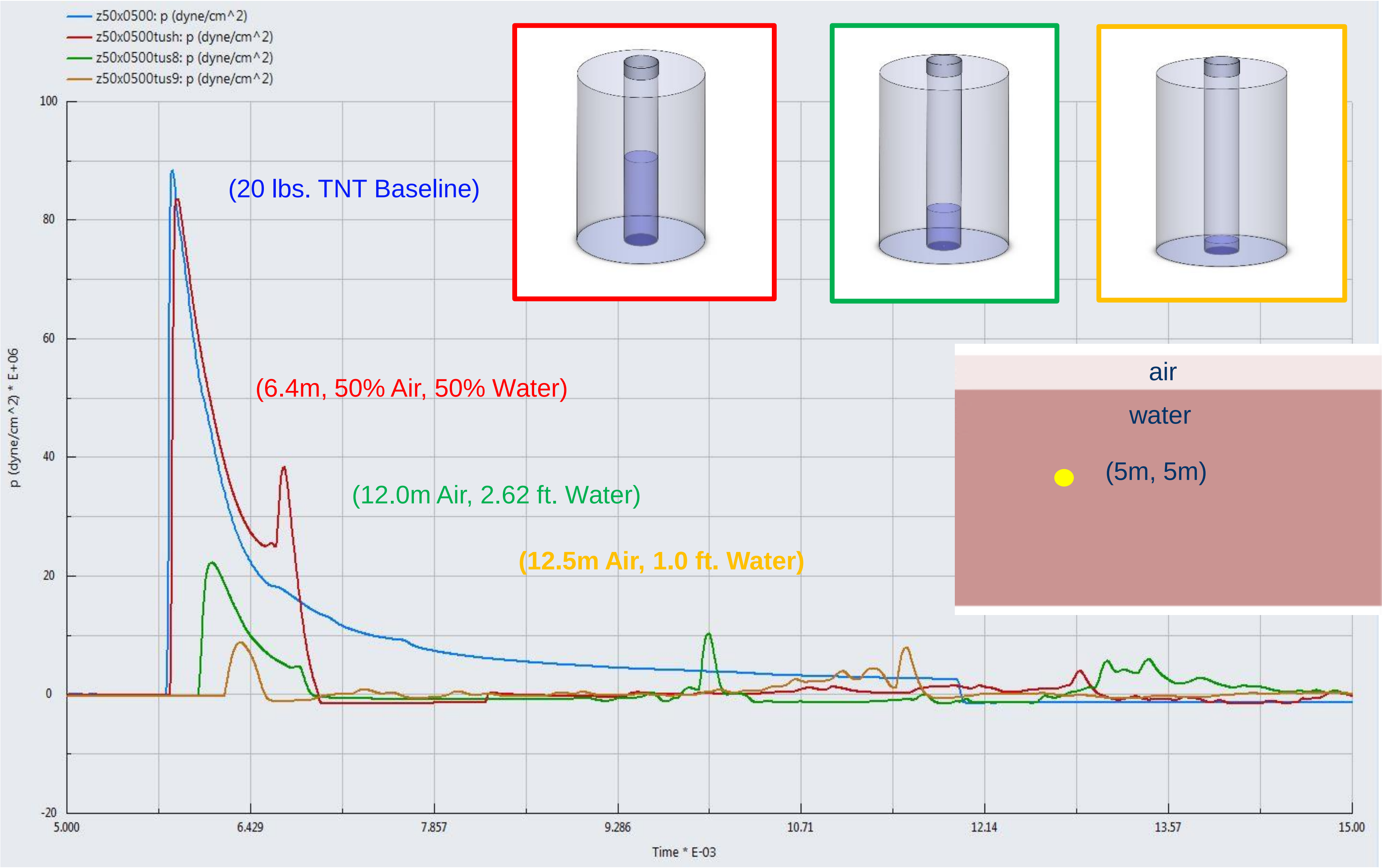
Type II - 20 lbs. TNT DYSMAS Results at (5m, 5m)



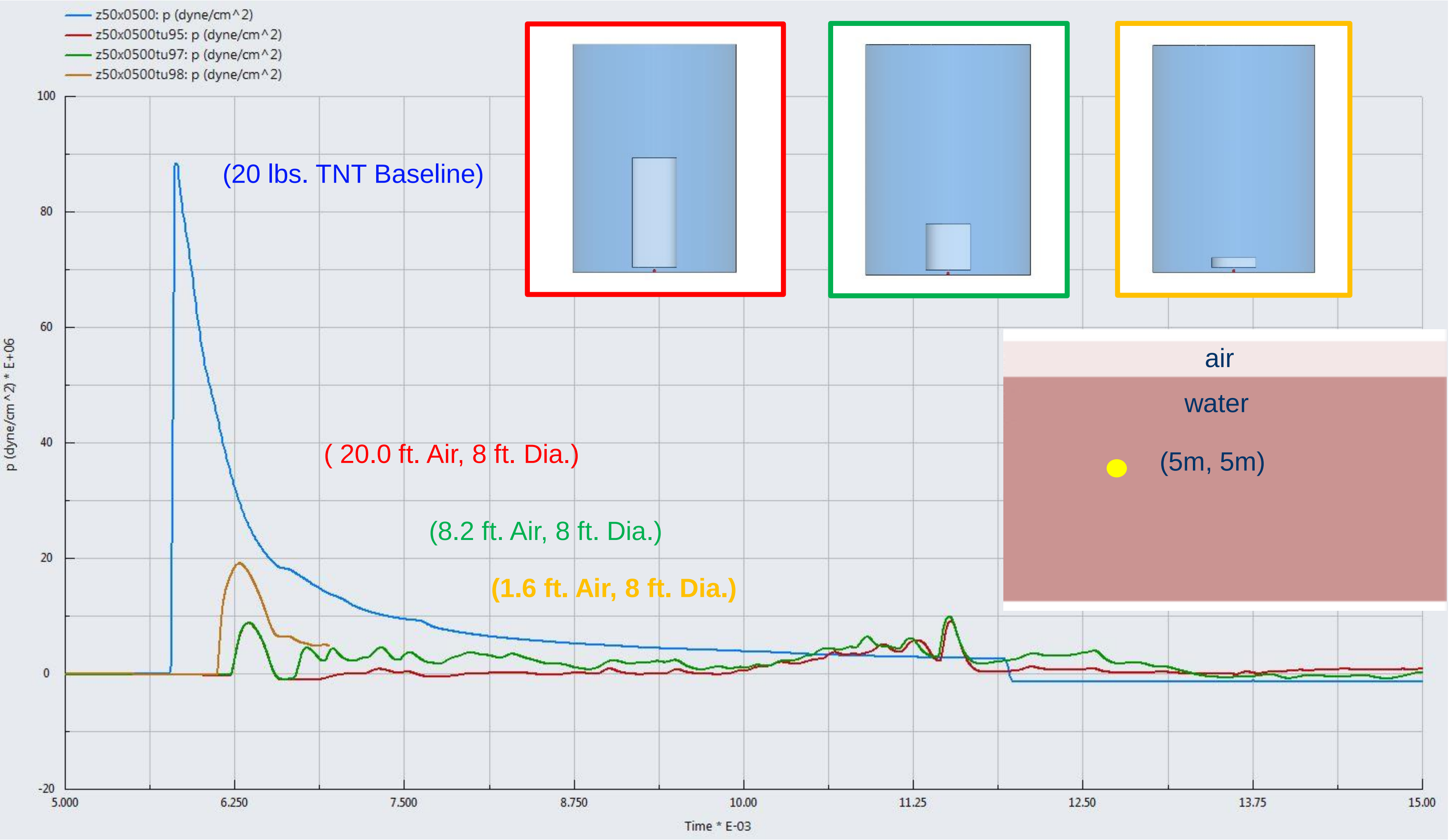
Type II - 200 lbs. TNT DYSMAS Results at (10m, 10m)



Type III - 20 lbs. TNT DYSMAS Results at (5m, 5m)



Type IV - 20 lbs. TNT DYSMAS Results at (5m, 5m)



Summary of Blast Mitigation Effects at (5m, 5m)

TNT	Baseline	Type II -12 Air		Type II- 24 Air		Type IV	
20 lbs. (P_{max}) psi	1,282	212	83%	No Data Available		149	88%
(I_p) psi. sec.	0.84	0.42	50%			0.53	37%
(E_p) ft.-lbs. / in^2	6.76	0.77	89%			0.31	95%
200 lbs. (P_{max}) psi	3,146	No Data Available		816	74%	1,294	59%
(I_p) psi. sec.	3.16			1.83	42%	2.50	21%
(E_p) ft.-lbs. / in^2	58.6			9.47	84%	17.6	70%

Notes:

(i) peak pressure

$$P_{max} = 52.1 \left(\frac{\sqrt[3]{W}}{R}\right)^{1.18}$$

(ii) impulse intensity

$$I_p = \int_0^t p(t)dt$$

(iii) energy flux density

$$E_p = \frac{1}{\rho c}\int_0^t p(t)^2 dt$$

where $\rho \approx 1000$ kg/m^3 water density, and $c \approx 1515$ m/s. sonic speed in the water.