REDGUARD®

2020 BLAST TEST SUMMARY

IT WILL BE SENDING SHOCK WAVES THROUGH THE INDUSTRY FOR YEARS.

Conducted by:

STONE Security Engineering

Washington DC Metro Office:
777 6th St NW, 11th Floor
Washington, DC 20001

Witnessed, supported and advised by:

OMEGA RISK

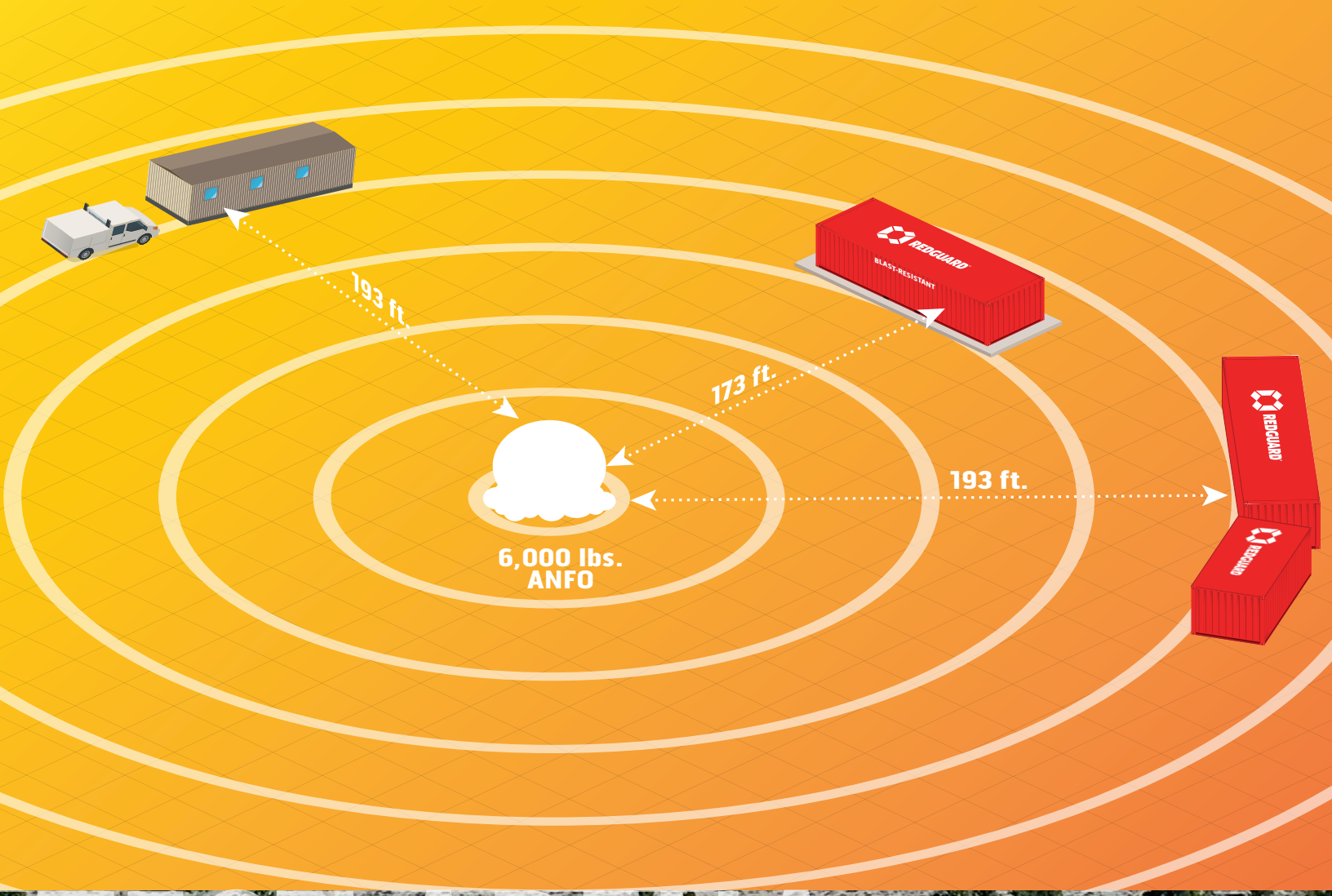
Blast Test Summary

On August 11, 2020, one arena-style blast test was conducted against a 12 foot by 40 foot Anchored Blast Resistant Building (BRB), a 12 foot by 40 foot Unanchored BRB, an 8 foot by 20 foot BRB placed on the ground, a general jobsite truck, and a general jobsite wooden trailer. These units were placed on an arc, around a 6,000-pound ammonium nitrate/fuel oil (ANFO) charge, located 173 feet from the Anchored BRB, and 193 feet from all other specimens. The charge was detonated and each unit's responses were documented.

Upon inspection following the blast, there were no notable structural damages to any of the RedGuard BRBs, while the wooden trailer had collapsed. Each RedGuard building, as a whole, satisfies the requirements for a LOW DAMAGE LEVEL from American Society of Civil Engineers's "Design of Blast-Resistant Buildings in Petrochemical Facilities." Among the RedGuard units, there was notable non-structural damage to the flooring and interior finishing work, but the global movement of the structure was minimal.

Stone-OBL Blast Testing Site
The testing program was carried out on the Stone-OBL blast testing site. Information about the testing site is provided in the following subsections.

Site Location
The blast testing site is located in Deschutes County, Oregon approximately 30 miles east of Bend, Oregon. The site, shown at right, is located approximately 4600 feet from the nearest utility, 6700 feet from the nearest structure, and approximately 8500 feet from the nearest public roadway. The blast testing site is accessed via a private access road.


193 ft.
REDGUARD
BLAST-RESISTANT
173 ft.
193 ft.
REDGUARD
REDGUARD
6,000 lbs.
ANFO

TEST ARENA


ANFO
ANFO
ANFO
6,000
lbs.

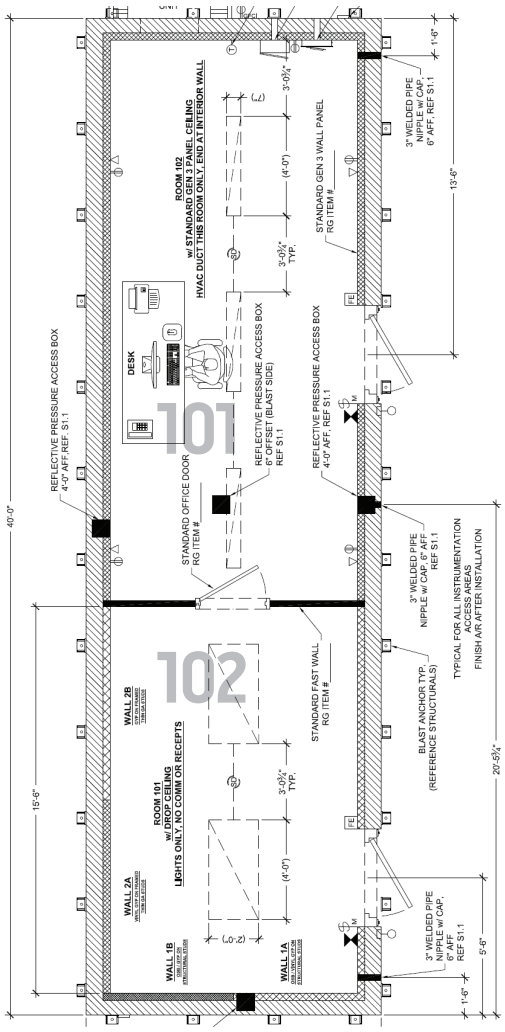
LeaseFleet GEN III

The Anchored Unit was equipped with a dividing wall which created two separate rooms within the building (Room 101 and Room 102), as shown in the floor plan in at right. Room 101 was designed to test various wall and ceiling interior finishes. The wall configurations can be seen here. The ceiling was finished with a 2-foot by 4-foot suspended ceiling grid, 2-foot by 4-foot ceiling tiles, and two 2-foot by 4-foot LED lights. Per RedGuard interior finish standards, the LED lights were restrained directly to the building structure, independent of the suspended ceiling grid. Room 101 was devoid of interior furnishings with the exception of one 5-pound fire extinguisher, which was mounted on the blast wall closest to the charge.

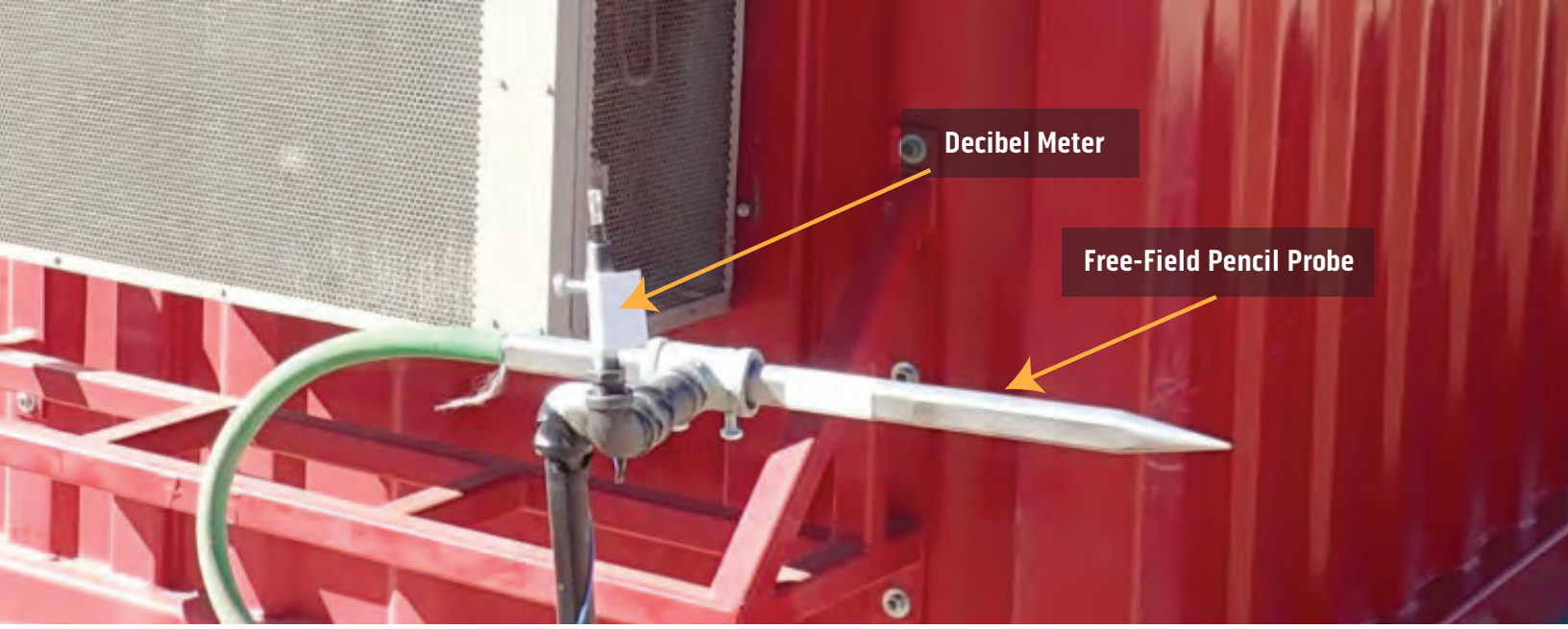
The interior wall was constructed with RedGuard's fast-wall design, which is intended primarily for use in LeaseFleet buildings. This design consists of an upper and lower .063-inch aluminum track with 2.75-inch thick EPS Core Panels finished with .090-inch FRP on either side. Vertical .063-inch aluminum trim pieces were installed where the interior wall met the blast resistant building's exterior walls. A 3-foot by 6-foot 8-inch steel door was approximately centered in this wall.

Room 102 was designed to test RedGuard's Gen III interior finishes and to document the human response in a properly utilized steel BRB. The walls and ceiling were finished with 3.45-inch thick panels which were constructed with a .032-inch aluminum face, 5mm bubble insulation layer, and 2.8-inch polyiso foam board insulation layer. The panels were held in place with aluminum tracks. The floor was finished with 26-lbs/ft3 polyurethane foam/fiberglass reinforced composite boards. Electrical and communication outlets and wiring were mounted in surface mounted wire mold, while supply HVAC air was distributed through fabric ductwork.

A desk, office chair, and mock office equipment set-up was placed approximately 12 inches from the wall facing the charge. The wheels were removed from the office chair and wood blocks were taped to the chair, but the chair and desk were not secured to the floor. All office equipment placed on the desk was also unsecured to document the reaction of these items during the blast.



The Anchored Unit was a 12-foot by 40-foot BRB supplied by RedGuard. It was anchored to a 14-foot by 42-foot concrete pad, reinforced per RedGuard's specifications. #7 Rebar was spaced 10-inches on-center, on each face and in each direction. RedGuard supplied the 7/8-inch diameter, 13-inch long anchors used to anchor the unit to the foundation. The pad was constructed using a 15-inch thick foundation, 4,000-psi concrete, and 60-ksi rebar.



Load Cells Before (left) and After (right) Installation

Uninstrumented ATD Positioned at Desk within Anchored Unit

LeaseFleet GEN II

The Unanchored Unit was a 12-foot by 40-foot BRB supplied by RedGuard. It was placed on a 16-foot by 44-foot concrete pad, constructed with #5 reinforcement spaced at 12 inches on center on each face and in each direction, as shown here. The pad was constructed using a 10-inch thick foundation, 4,000-psi concrete, and 60-ksi rebar.

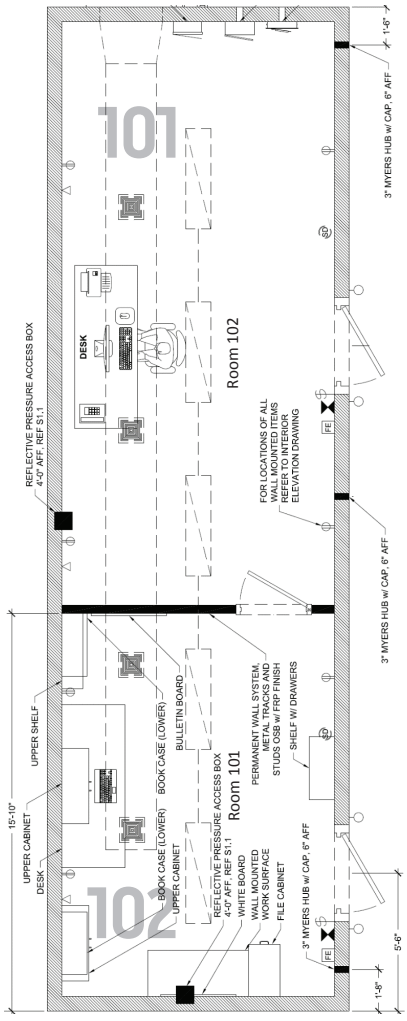
The Unanchored Unit was equipped with a dividing wall which created two separate rooms within the building (Room 101 and Room 102), as shown. Room 101 was designed to demonstrate the reaction of components improperly placed in a modular blast resistant building. This room contained a free-standing 4-drawer file cabinet, two 2-shelf book cases, one desk, and one shelf with lower drawers. All free-standing items were placed directly against the exterior wall. In addition, there was also a white board, two upper MDF cabinets, one open face shelf, and one bulletin board. Finally this room contained two 1-foot by 4-foot lights, one 5-pound fire extinguisher, and EMT surface-mounted conduit with electrical and communication outlets.

In addition to the furniture, shelving, and cabinets in Room 101, a number of items were staged throughout the room. These included a number of books, a laptop computer, 3-ring binders, a steel bracket, and backpack. Similarly, these items were placed to demonstrate the reaction of improperly placed items in a modular blast resistant building.

The interior wall was constructed with 18 gauge galvanized studs and was finished on either side with 7/16-inch OSB covered with FRP. A 3-foot by 6-foot 8-inch steel door was offset on the wall opposite the charge.

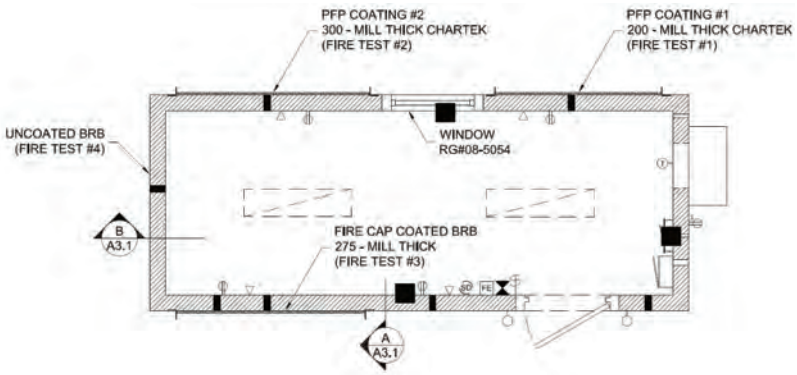
Room 102 was designed to test RedGuard's Gen II interior finishes and to document the human response in a properly utilized steel BRB. The walls and ceiling were finished with 7/16-inch OSB covered by FRP. The floor was 1-1/8-inch OSB covered by vinyl interlocking tiles. Electrical and communication outlets and wiring were installed in surface-mounted EMT conduit, while supply HVAC air was distributed through galvanized metal ductwork.

A desk, office chair, and mock office equipment setup was placed approximately 12 inches from the wall facing the charge. The wheels were removed from the office chair and wood blocks were taped to the chair, but the chair and desk were not secured to the floor. All office equipment placed on the desk was also unsecured to document the reaction of these items during the blast.



Instrumented ATD Positioned at Desk within Unanchored Unit

Tested for Blast and Fire
The Ground Unit was an 8-foot by 20-foot BRB supplied by RedGuard. It was placed on the ground near to the Unanchored Unit. This unit was equipped with the Passive Fire Protection coatings applied on the unit exterior surfaces prior to blast testing. The coatings were applied to the locations shown at right.



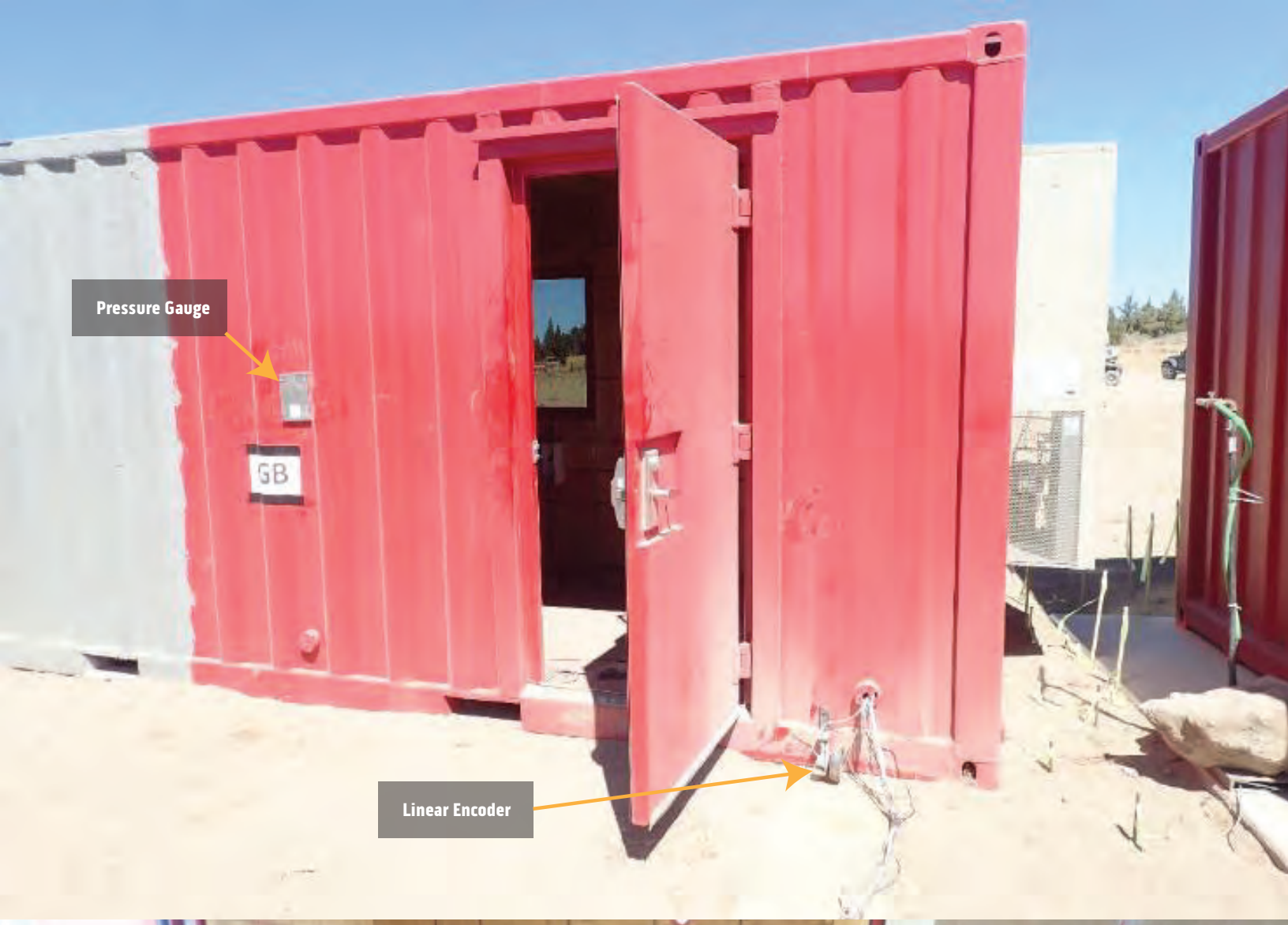
This unit was equipped with a 36-inch by 36-inch, 2-inch (nominal) thick glazing on the front face of the unit.

200-mil Chartek 8E Coating (Fire Test)
One 30-minute fire test was conducted on this surface prepared and coated by RedGuard per RedGuard's specifications. This sample was a 79-1/2-inch wide, 200-mil thick Chartek 8E coating. Due to safety concerns, the test was stopped after 5 minutes and 5 seconds; a second, full 30-minute test was subsequently conducted. The coating was applied to the entire height of the unit. This coating is present in the photo above.

300-mil Chartek 8e Coating (Fire Test)
One 30-minute Fire Test was conducted on this surface prepared and coated by RedGuard per RedGuard's specifications. This sample was a 91-inch wide, 300-mil thick Chartek 8E coating. The coating was applied to the entire height of the unit. The photo above shows this coating. At RedGuard's request, this test was extended to 45 minutes.

275-mil Fire Cap™ Coating (Fire Test)
One 30-minute Fire test was conducted on a surface prepared and coated by HIT per HIT's specifications. This sample was 92-1/2-inch wide, 275-mil thick Fire Cap™ coating that covered the entire height of the unit. The photo below shows this coating. Note that in order to ensure proper adhesion of Fire Cap™ material, the red-colored polyurea coating applied by RedGuard was removed. At RedGuard's request, this test was extended to 45 minutes, past the design criteria for this particular Fire Cap™ application. Fire Cap™ coating thickness is typically defined to protect against a specific duration of flame-impingement; in this case 30 minutes was the design duration. The coating is capable of withstanding longer durations; however, optimizing for a 30-minute test was the final deciding factor for this trial.

Uncoated BRB (Fire Test)
One 30-minute Fire test was conducted on a bare BRB surface.


Pressure Gauge
GB
Linear Encoder


Witness Panels
Pressure Guage
Accelerometers

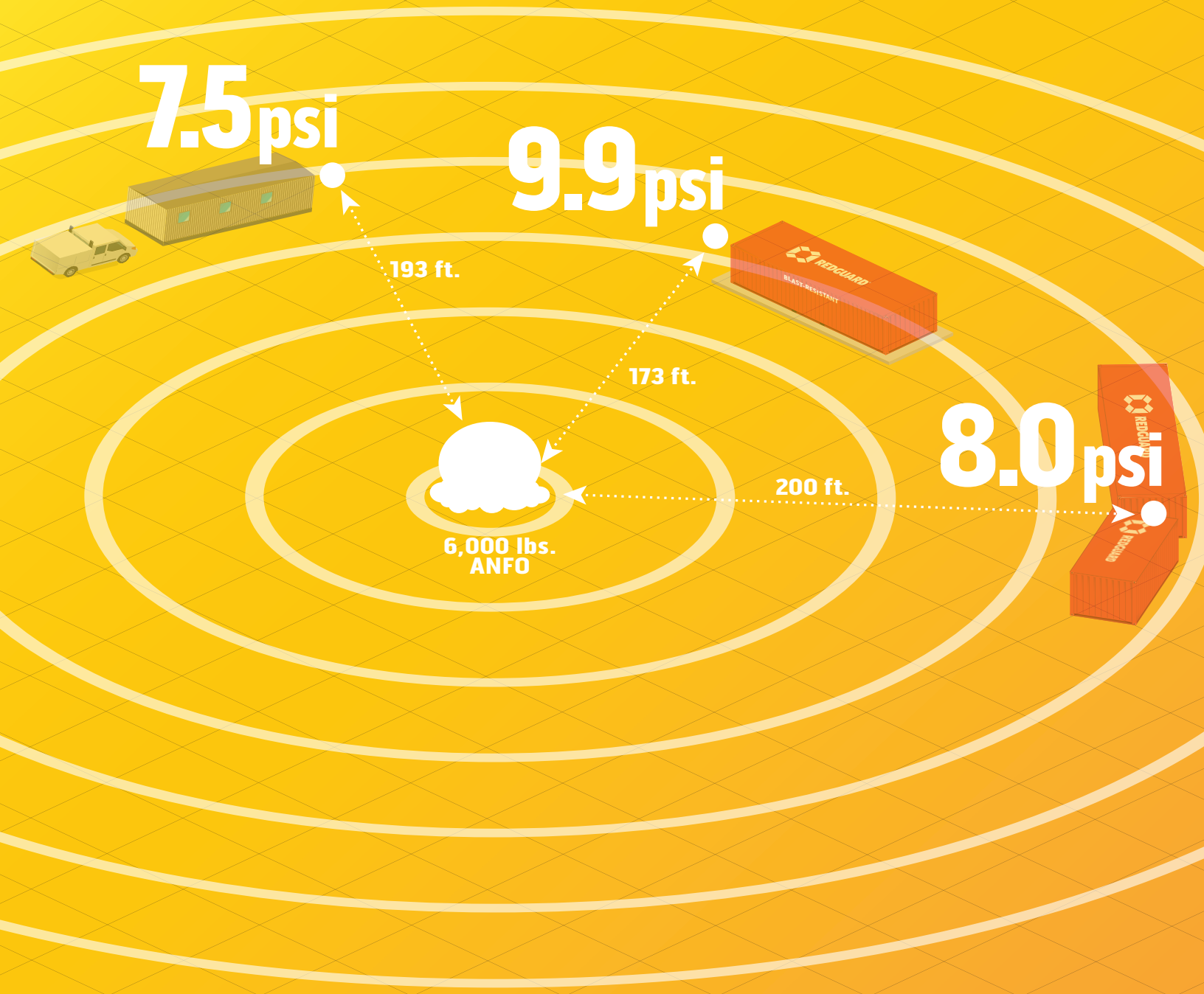
Wooden Trailer & Truck

The Truck/Trailer combination was supplied by OBL. It consisted of a truck and wooden trailer representative of standard jobsite equipment. These photos show the combination procured for this testing effort.

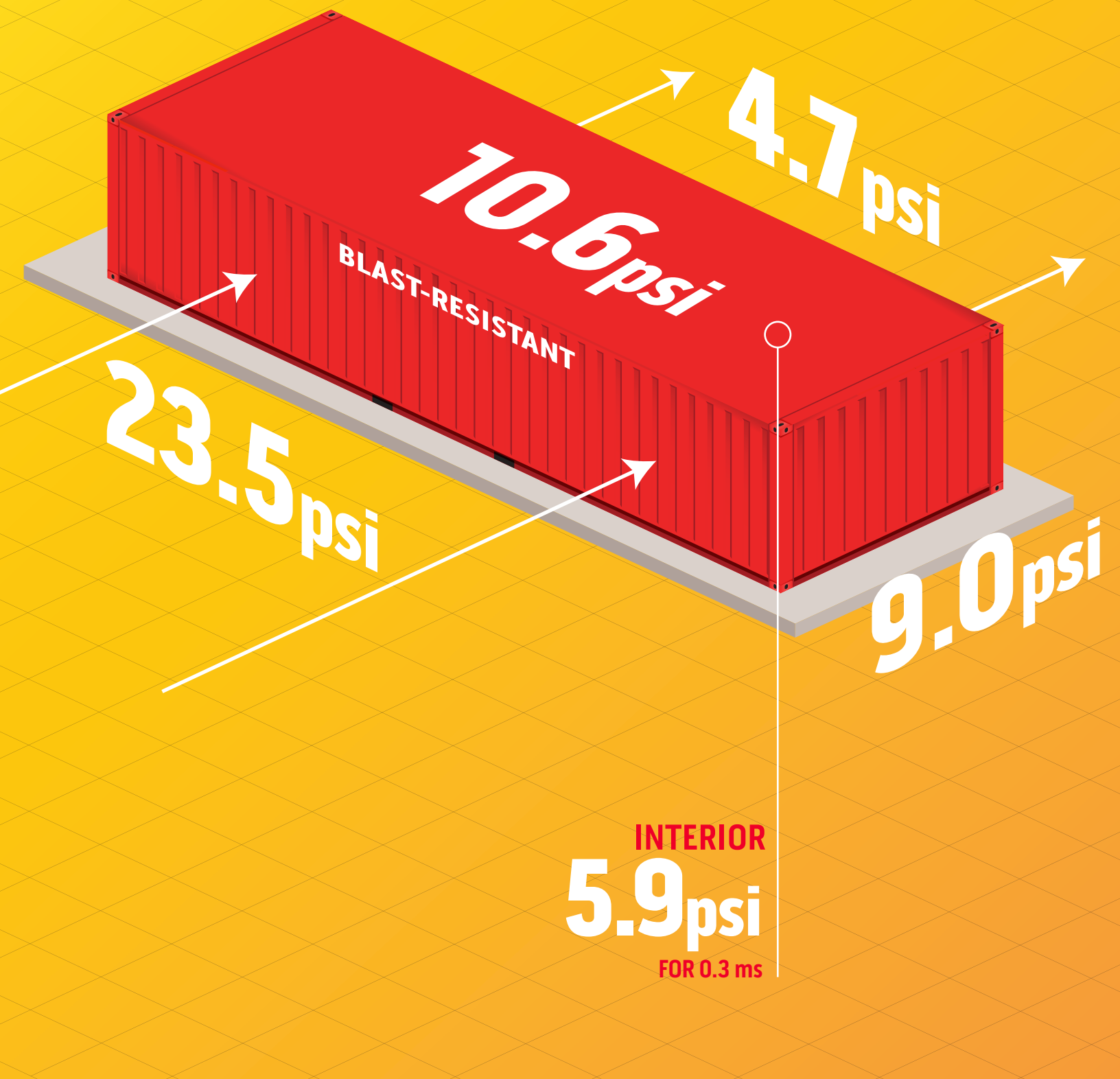

3,2,1


BLAST-RESISTANT

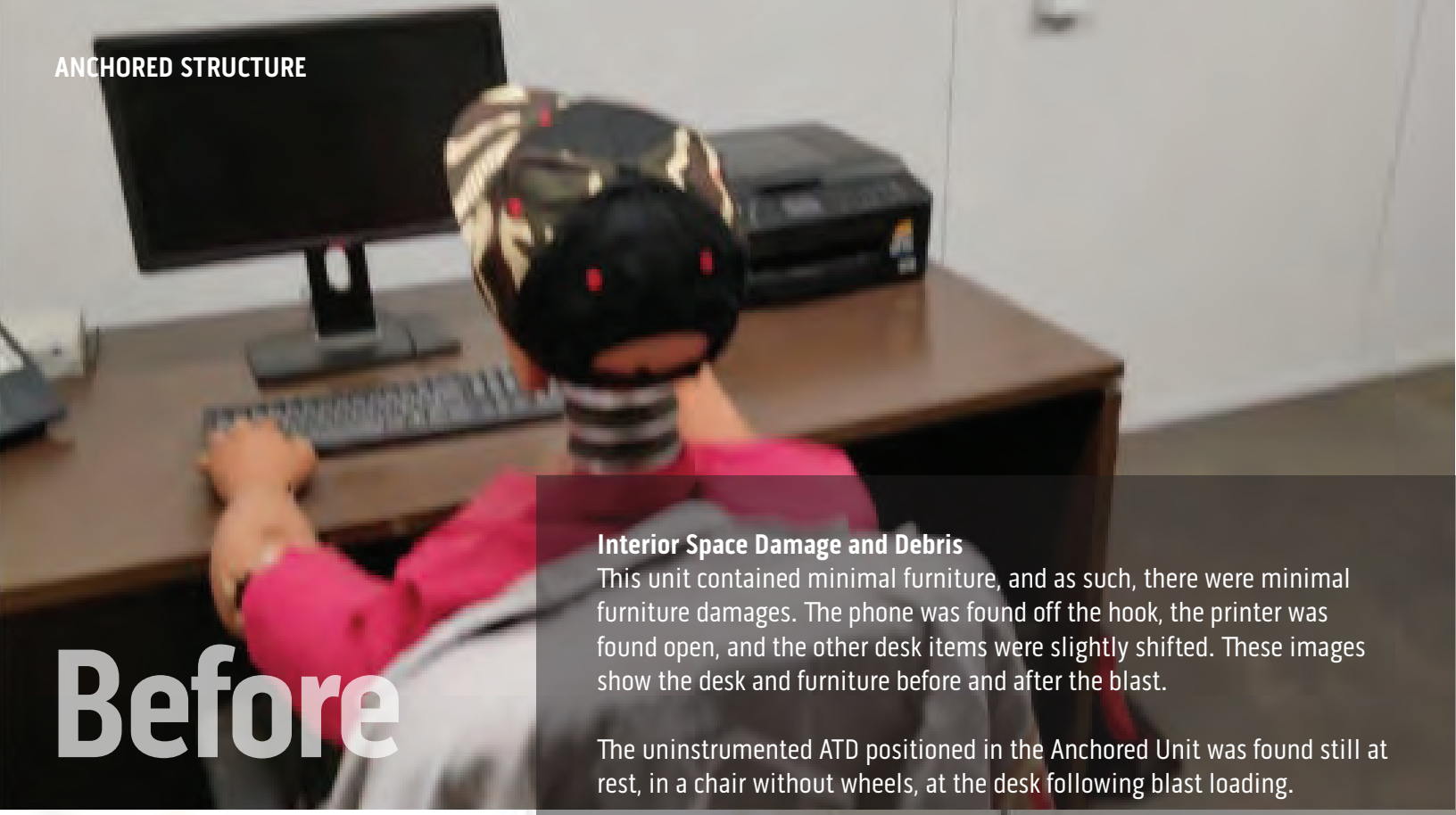
Free-field Pressures



Reflected Pressures



Exterior Results
There were no noticeable structural damages, nor was there notable permanent deformation of any of the exterior surfaces. These images show pre-test and post-test conditions of the Unanchored Unit.

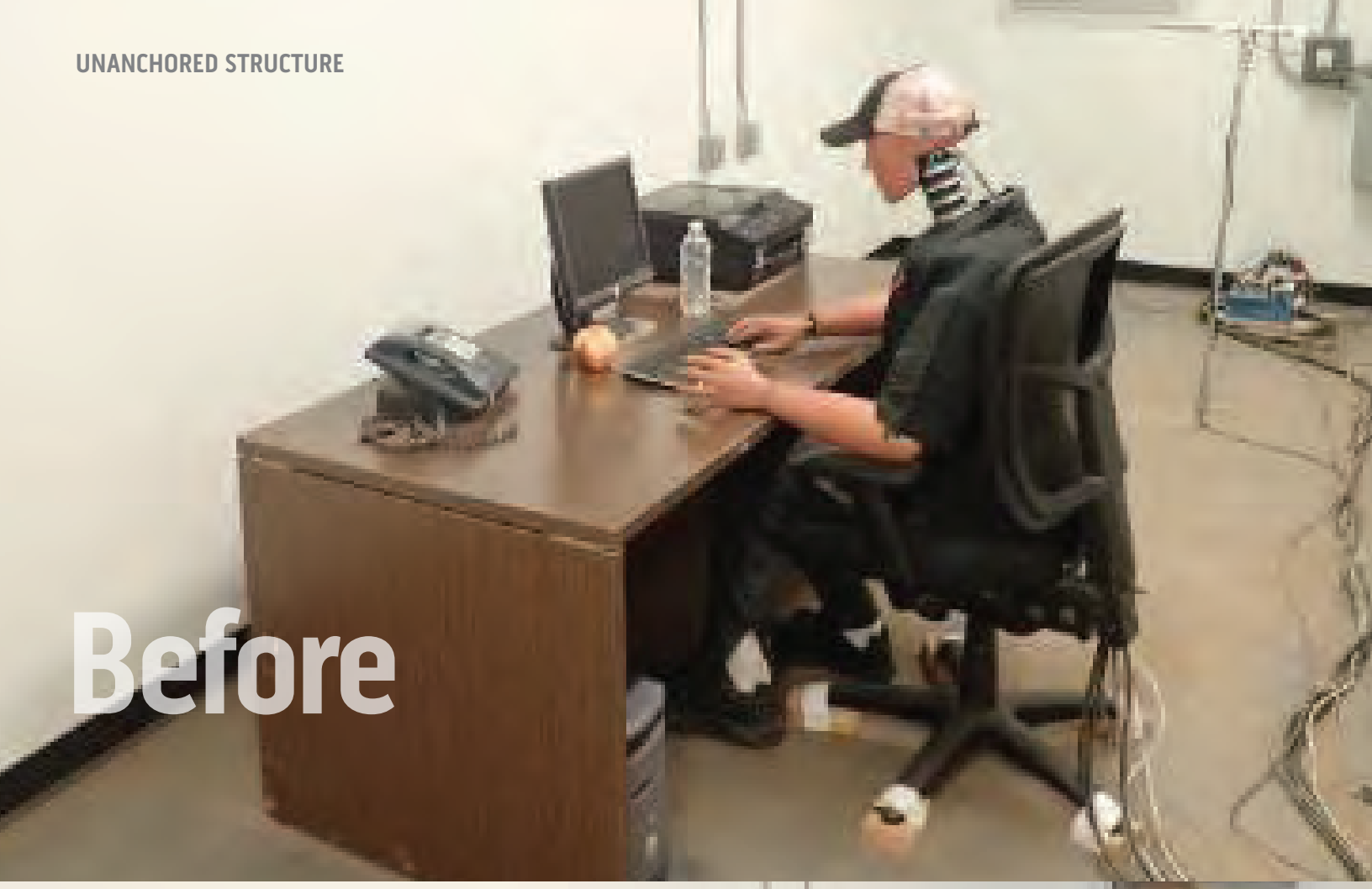


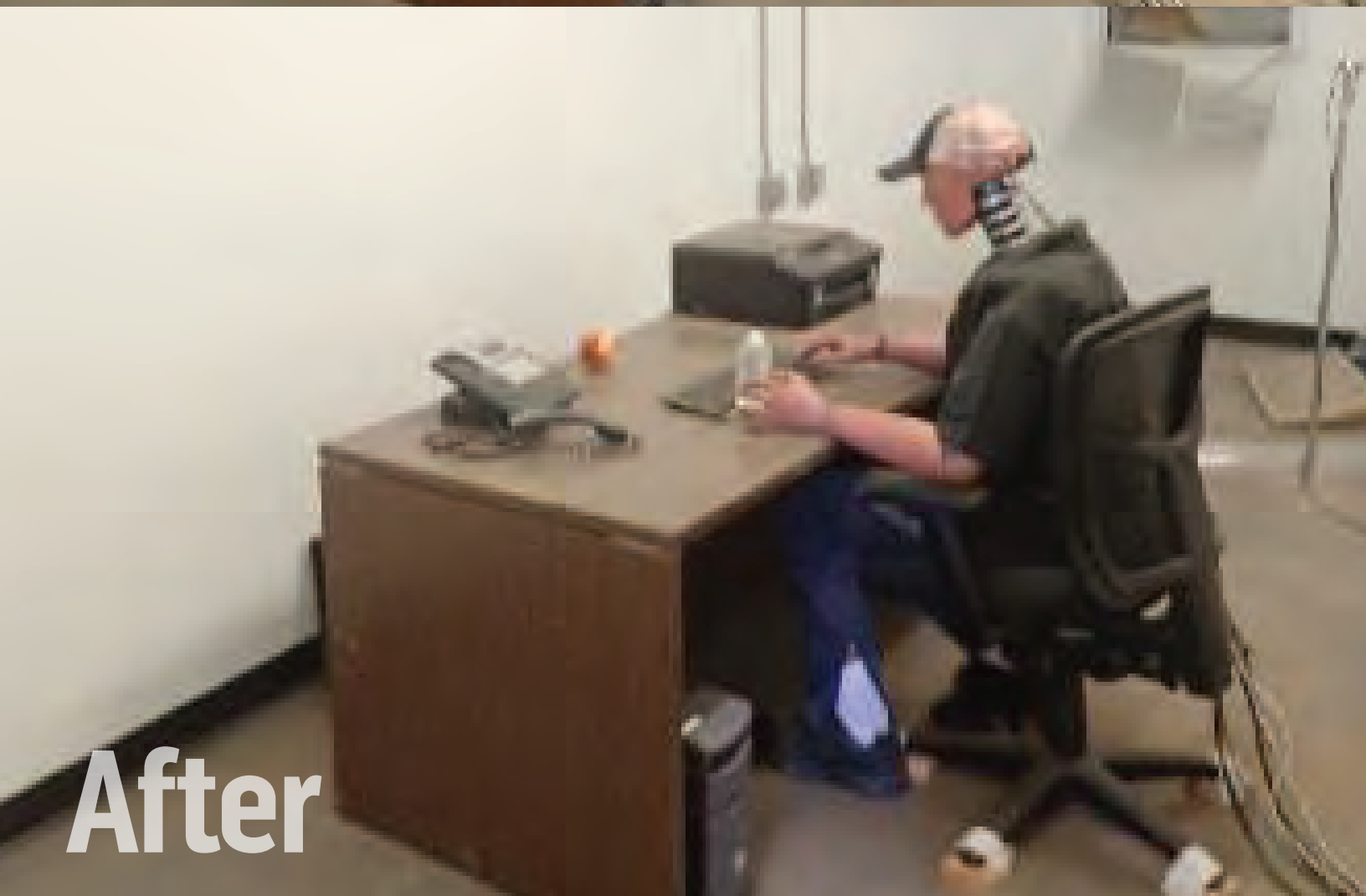
Before

Interior Space Damage and Debris
This unit contained minimal furniture, and as such, there were minimal furniture damages. The phone was found off the hook, the printer was found open, and the other desk items were slightly shifted. These images show the desk and furniture before and after the blast.

The uninstrumented ATD positioned in the Anchored Unit was found still at rest, in a chair without wheels, at the desk following blast loading.

After


Before


After

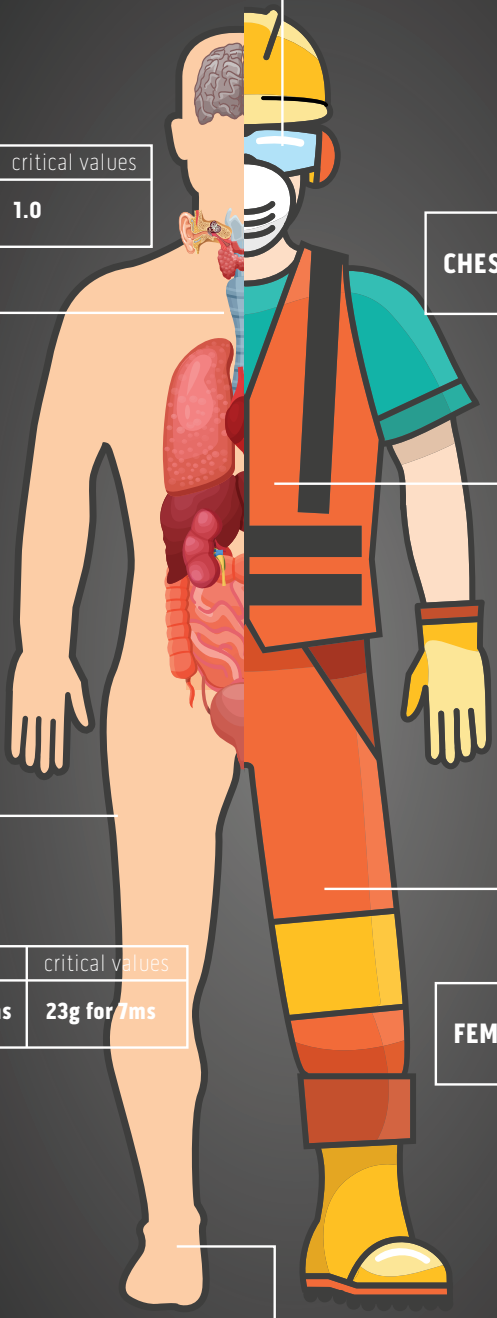
Human Response

The force and acceleration data from the instrumented ATD, placed in the unanchored unit, demonstrated that no injuries would likely occur to occupants of a similarly furnished RedGuard building.

HEAD	measurement	peak value	critical values
	Head Injury Criterion	**28.5**	**150 No Injury 500 Major Injury**

NECK	measurement	peak value	critical values
	Neck Injury Criterion	**0.04**	**1.0**

CHEST	measurement	peak value	critical values
	Resultant	**19.2**	**60g for 3ms 40g for 7ms**



PELVIS	measurement	peak value	critical values
	Vertical Acceleration	**25.6g for 2ms**	**23g for 7ms**

FEMUR	measurement	peak value	critical values
	Right Axial Force	**63.9**	**2250 lb (max) 1,700 lb for 10ms**

TIBIA	measurement	peak value	critical values
	Right Axial Force	**100.5**	**2040 lb (max) 1,700 lb for 10ms**

Conclusion

In general, Stone Engineering concluded that the RedGuard BRBs performed well against the 6,000-lb ANFO charge. The three RedGuard BRBs, each satisfied the requirements for a LOW DAMAGE LEVEL rating, per ASCE designations.

There were no notable structural damages to the Anchored, Unanchored, or Ground Units. There were no notable permanent deformations in structural members, no noticeable cracking in welds, and the anchor plates on the Anchored Unit were wholly intact. The Unanchored Unit slid 1/4-inch toward the blast.