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A New Explosion Test Facility at NSWC--The 50-Pound Bombproof

by

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ABSTRACT

A new test facility was recently dedicated at the Naval Surface Weapons Center, White Oak Laboratory, Silver Spring, Maryland--a bombproof with a 50-pound TNT equivalent explosive limit. Details of the facility concept, design, and construction will be presented. Before the facility was put into use, a series of validation tests were performed. These tests included test firings over the explosive weight range of 1 to 50 pounds of TNT. The following measurements were undertaken: (1) wall strains, (2) wall displacements, (3) floor vibrations, (4) explosion-produced noise both inside and external to the facility, and (5) gas leakage both into the work areas surrounding the facility and into the atmosphere outside the facility. The results of these measurements will be presented and summarized. Finally, a description of the capabilities and specialized equipment dedicated to this facility will be discussed.

BACKGROUND

The Naval Surface Weapons Center (NSWC) operates several explosion containment test facilities at its White Oak, Maryland site. These facilities range in capacity from a few ounces of energetic material (propellant, pyrotechnics, or explosive) to five pounds of energetic material. All of these facilities are over 30 years old. In the 30-years since their construction, the nature of the surrounding community has changed significantly--from a lightly populated rural area to a moderately--densely populated urban area. No explosion facility at White Oak is more than about 2000 feet from civilian residences.

Since the early 1950's, when the other facilities were constructed, the nature of the experimental programs being conducted have developed to the point where energetic material limits greater than five pounds are required. One of these drivers has been the development and usage of ammonium perchlorate, metallized-type explosives, as well as other highly insensitive energetic materials, which require the firing of larger charge sizes in ever increasing numbers. The tests are required to develop the basic data and knowledge concerning these materials, so that sound judgements can be made as to their suitability for specific weapons applications. This testing requires the full-time, year round usage of any new facility.

After a series of trade-off studies, it was decided that the new facility should be capable of containing the consequences of a detonation of a 50-pound (TNT equivalent) fragmenting charge, at the rate of at least one per week, or any number of smaller detonations. Moreover, because of the nearby urban residential area, the facility should minimize noise and ground shock transmissions to the surrounding areas and also meet all local, state, and federal pollution requirements.

With these and other requirements, the firm of Ammann and Whitney studied and developed the concept for the facility. Their proposal was completed in August 1980.[1] Drawings and specifications were released in 1982,[2] and the facility was accepted on 28 September 1984. Validation testing began shortly thereafter in December 1984, and the official dedication took place in July 1985.

FACILITY DESCRIPTION

The facility, as constructed, consists of an instrumentation and control building with four auxiliary structures. The important building is the instrumentation and control building, and this is what will be described in a subsequent section.

Figure 1 is a plan view of the instrumentation and control building. The building contains a gun room for two guns--a high pressure helium gun and a powder gun, a mechanical room containing all the HVAC (heating, ventilation, and air conditioning equipment), a control room, an instrumentation area, and a blast containment chamber. Figure 2 presents two additional views of the building-- a side view looking north, and a side view looking east.

The heart of the structure is the blast containment chamber. The chamber is octagonal in section and has plan dimensions of approximately 20 x 20 feet, and is 16 feet high. The volume of the chamber is approximately 6200 cubic feet.

The chamber is constructed of reinforced concrete having a minimum compressive strength of 4000 psi at 28 days. The reinforcing material consists of deformed billet steel bars conforming to ASTM A615 grade 60 except grade 75 is used for size 11 bars. The minimum concrete thickness is five feet. The blast chamber interior is lined with removable one inch thick steel fragmentation shields. The blast chamber is completely isolated from the surrounding building. In addition, efforts were taken to decouple the chamber from the soil beneath it. The chamber rests on a layer of polystyrene. Below the polystyrene is a layer of lean concrete, which, in turn, is supported by a four-foot layer of crushed rock. Below the crushed rock is natural soil.

The outside of the blast containment chamber is covered with corrugated metal siding attached to the chamber by steel channels and bolts which are embedded in the concrete and anchored around the reinforcement. This metal siding acts as a spall shield to protect personnel from flying fragments produced by the disengagement of portions of the concrete cover on the exterior of the five foot thick containment walls, should it ever occur. (No evidence of this has occurred to date.)

Blast pressure relief within the chamber is provided by an exhaust stack above the chamber roof. A muffler is attached to this stack to achieve noise attenuation.

Access to the chamber is via a single, hydraulically-operated door. The door is not solid--rather, it has an inner face (towards the inside of the chamber) of three inch thick high strength pressure vessel steel alloy. The outer surface is a thinner version of the same alloy. The total weight of the door is approximately 9600 pounds. The door hinges are only intended to support the door weight--not the blast loading. The blast loads are transferred from the door into the door frame. The frame is constructed of structural steel and cast into concrete. Steel stiffener plates and reinforcing bars welded to the frame provide positive anchorage. The door is sealed by a continuous elastomeric gasket adhered into a groove with a machine finish.

FACILITY VALIDATION

After the facility was accepted, but before it was placed into operational use, it was determined that a series of validation tests should and would be performed. These tests were designed with several functions in mind:

(1) To determine if the building could, indeed, safely contain the effects of the detonation of up to 50 pounds of TNT.

(2) To determine if the detonation of materials within the blast chamber produced any adverse effects either on personnel or equipment contained within the facility.

(3) To determine, as far as possible, if the detonation of materials within the blast chamber produced any adverse effects on the environment surrounding the building.

With these goals in mind, a series of TNT charges with weights ranging from one to 50 pounds were detonated and their effects in, on, and around the facility were measured. The TNT charges were right circular cylinders, placed on a wooden table, four feet above the floor in the center of the chamber.

The measurements undertaken included strain in the exterior walls of the chamber, wall displacement, floor motion, carbon monoxide levels in the instrumentation area, and sound pressure levels both inside the building and at several locations external to the building. These results are reported in detail in NSWC TR 85-385,[3] and will be summarized below.

Wall Strain

Strain measurements were made at three locations on the exterior walls of the blast containment chamber. Each position used two gauges, measuring vertical and horizontal strain. Each gauge was mounted directly on the concrete wall. Figures 3, 4, and 5 summarize the measured strain data. The maximum strain recorded was approximately 350 micro-strain on the 30-pound shot. On the 50-pound, it dropped back to about 200 micro-strain.

Wall Transient Displacements

Transient wall displacements were measured on all four blast containment chamber walls. The transducers were capable of measuring ±0.250 inch of displacement, with a resolution of 0.001 inch. Figure 6 summarizes the results obtained for all four walls. The maximum transient displacement was approximately 0.06 inches. All four walls exhibited an interesting phenomena. The displacements produced by the 30-pound charge were considerably less than those produced by either the 20- or 50-pound charges.

Floor Vibrations

Floor motion was monitored in one location in the instrumentation room--10 feet from the north wall of the blast chamber. A three component velocity gauge was utilized. Measurements were made in the vertical, transverse (east-west), and radial (north-south) directions. Figure 7 presents the peak-to-peak velocities recorded for each charge size. Figure 8 presents the predominant frequencies associated with the motions presented in Figure 8.

Noise Measurements

Sound pressure level measurements were made at several locations both inside the facility and on the grounds outside. Within the instrumentation and control rooms, both time-resolved pressure instrumentation and peak holding meters were utilized. Peak holding meters were used outside the facility. All peak holding devices were set to record peak flat sound pressure levels. Figure 9 shows the measurement locations inside the chamber. Figure 10 presents the results recorded at each location. Figure 11 presents similar results recorded outside the facility. Figure 12 presents pressure-distance information for the 50-pound charge size. The predominant frequency for the noise recorded in the instrumentation area was 100-170 Hz.

Carbon Monoxide Levels

Carbon Monoxide (CO) gas concentration levels were monitored both in the control room and in the instrumentation area. Within the control room, carbon monoxide levels above background were recorded only on the 20-pound shot. Even here, the CO level only went up to 10 parts per million (ppm). Excessive (greater than the allowed level of 50 ppm) levels of CO were recorded in the instrumentation area on both the 30- and 50-pound shots. The CO levels recorded in the instrumentation area are shown in Figure 13. Once the chamber and instrumentation areas were properly vented, the recorded levels went down to zero.

VALIDATION TEST SUMMARY

These validation tests showed that, indeed, the new facility could safely contain the effects of a 50-pound TNT detonation. Based on the measurements, it is felt that equipment within the instrumentation area or personnel within the control room, should suffer no adverse effects from a 50-pound detonation. The amount of pollutants (noise and gaseous) released into the surrounding environment are in total compliance with all existing environmental regulations.

FACILITY CAPABILITY/INSTRUMENTATION

Data Collection:

The Building 327 complex is equipped with various data collection systems including:

1. Lecroy Digital Oscilloscopes
2. Nicolet Digital Oscilloscopes
3. Tektronix Logic Analyzers
4. HP7912, and HP7612 Digitizers

All of these systems are connected/controlled by an HP9020 computer system. The computer system consists of eight stations with a printer, plotter and terminal emulation/communication capabilities. This computer is used as a controller, word processor, database filing system and terminal emulator. It is also used to perform data analysis and hydrocode work.

The following equipment either has been or is currently being installed in the Building 327 complex.

Laser Interferometer - Visar - The Visar interferometer uses doppler shifting of coherent laser light off of a reflective surface in order to establish the acceleration and velocity profiles of the reflective surface. The reflective surface may be a gas gun projectile, an aluminized free surface of an explosive, or a kapton flyer on an insensitive high explosive "slapper" detonator.

Laser Interferometer - Fabry Perot - An inexpensive version of the "Visar," the Fabry Perot will be used with a fiber optic bundle to record laser light shifts on an image converter streak camera.

Microwave Interferometer - The microwave interferometer works similar to a laser interferometer, the only difference is the wave length of the probe radiation. Explosives and propellants are largely invisible to microwaves; however, microwaves are easily reflected and doppler shifted by a detonation front. Thus, burn rates and detonation velocities can be directly determined.

Laser Raman Spectroscopy - This technique will be used to determine what types of free radicals and ions are formed within the detonation zone.

Laser Schlieren Photography - Laser schleiren methods will be used to photograph shaped charge jet stretching and erosion within a water cavity. The coherent. single band light which is cavity-dumped will, theoretically, allow closer study of jet/water interactions.

Imacon 790 - This image converter camera uses photo-multiplier tubes to photograph low light level events at 20 million frames/sec (16 frames may be recorded) in the framing mode and 1 mm/ sec in the streak mode. It can also be used in conjunction with fiber optic probes and laser interferometry.

Three other types of optical cameras will also be available: Cordin 375, Cordin 121, and Cordin 132. The Cordin 375 can record a total of 500 frames at rates up to 200,000 frames/sec. The Cordin 121 can take up to 25 frames at rates up to 2.5 million frames/sec. The Cordin 132 is a 70-mm format streak camera.

Flash X-rays - The explosive facility is equipped with several 300 KV and one 2.3 MeV flash x-ray tubes for radiography. These are used to study fragmentation patterns, shaped charge jets, and other events with contrasting density gradients.

SUMMARY

The new 50-pound explosion test facility at NSWC has become a unique asset both to the Navy and the free world. Its ever-increasing capabilities will place it at the forefront of detonation research.

References

1. "Feasibility Study for Explosive Test Facility," prepared by Ammann & Whitney, consulting engineers, under Contract N62477-78-C-0351, August 1980.

2. "Drawings and Specifications for Explosive Test Facility at the Naval Surface Weapons Center, White Oak, Maryland," Ammann & Whitney, World Trade Center, New York, New York, March 1982.

3. Swisdak, M. and Peckham, P., "Validation Tests in Building 327 - 50-Pound Bombproof," NSWC TR 85-384, 30 October 1985.

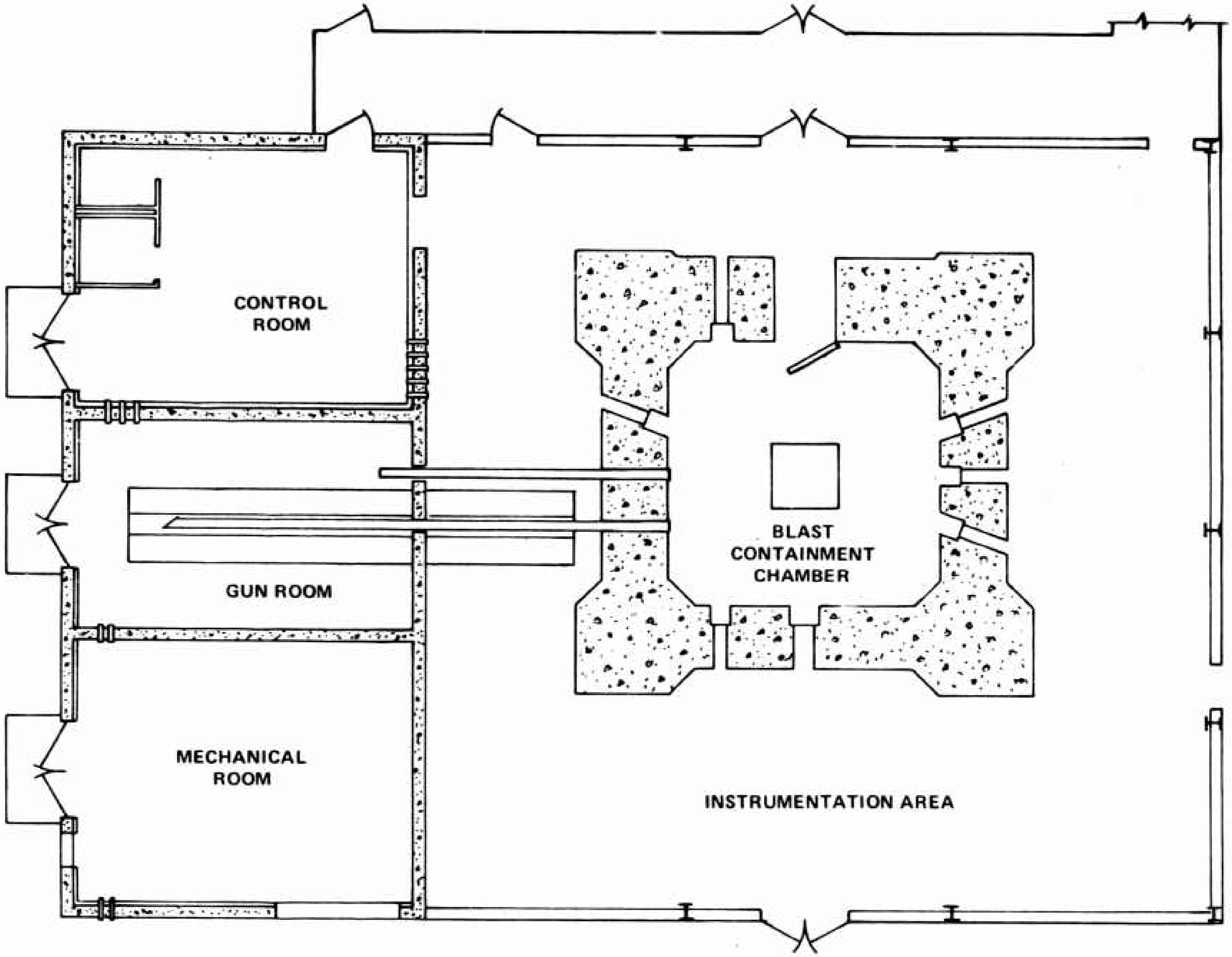
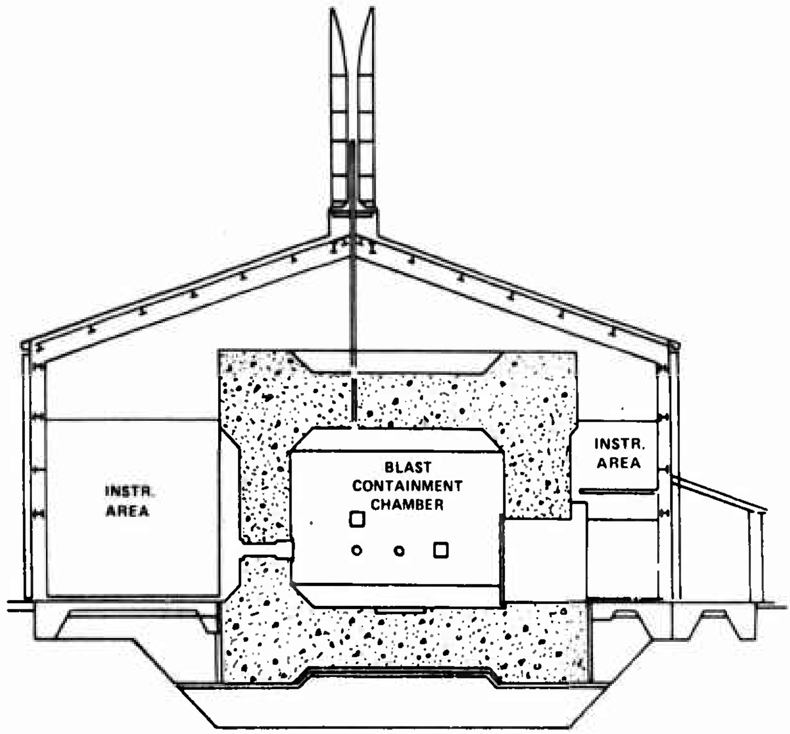
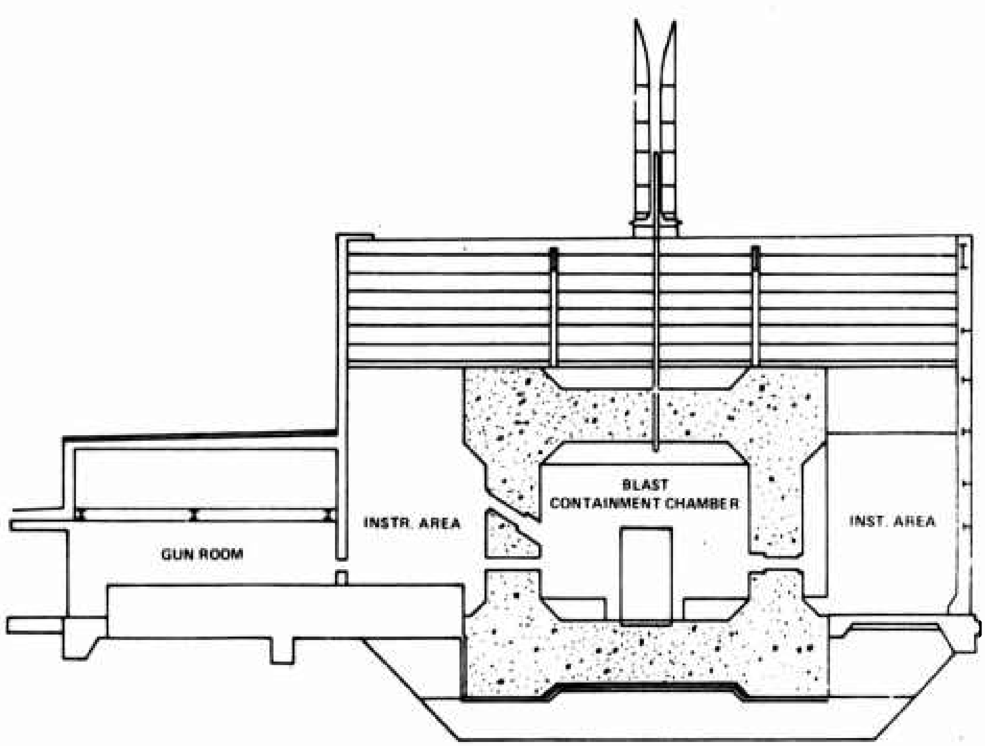


FIGURE 1. BUILDING 327, PLAN VIEW



BUILDING 327, SIDE VIEW, NORTH



BUILC'NG 327, SIDE VIEW, EAST

FIGURE 2. BUILDING 327- - SIDE VIEW, NORTH & EAST

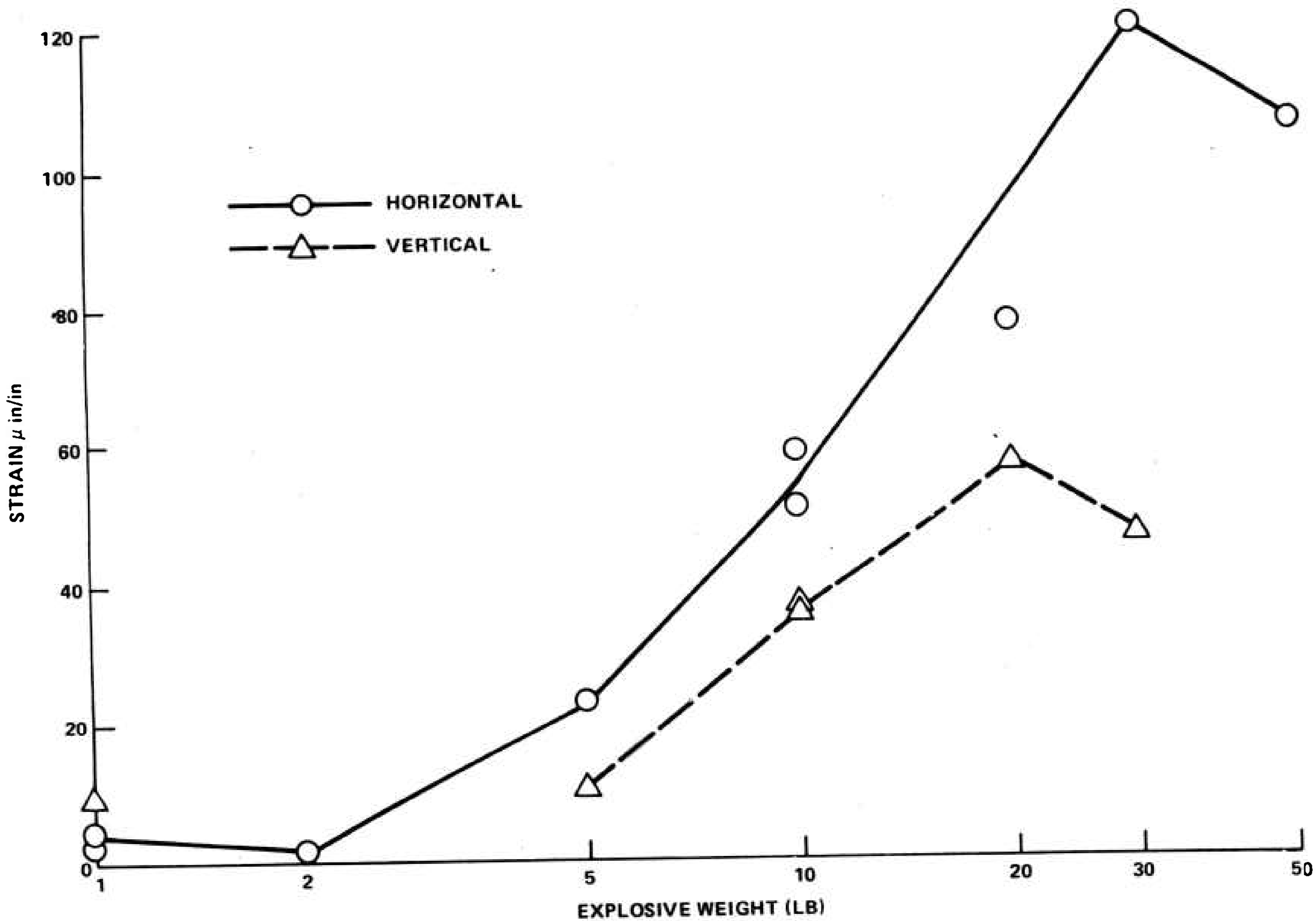


FIGURE 3. STRAIN VERSUS EXPLOSIVE WEIGHT, EAST WALL

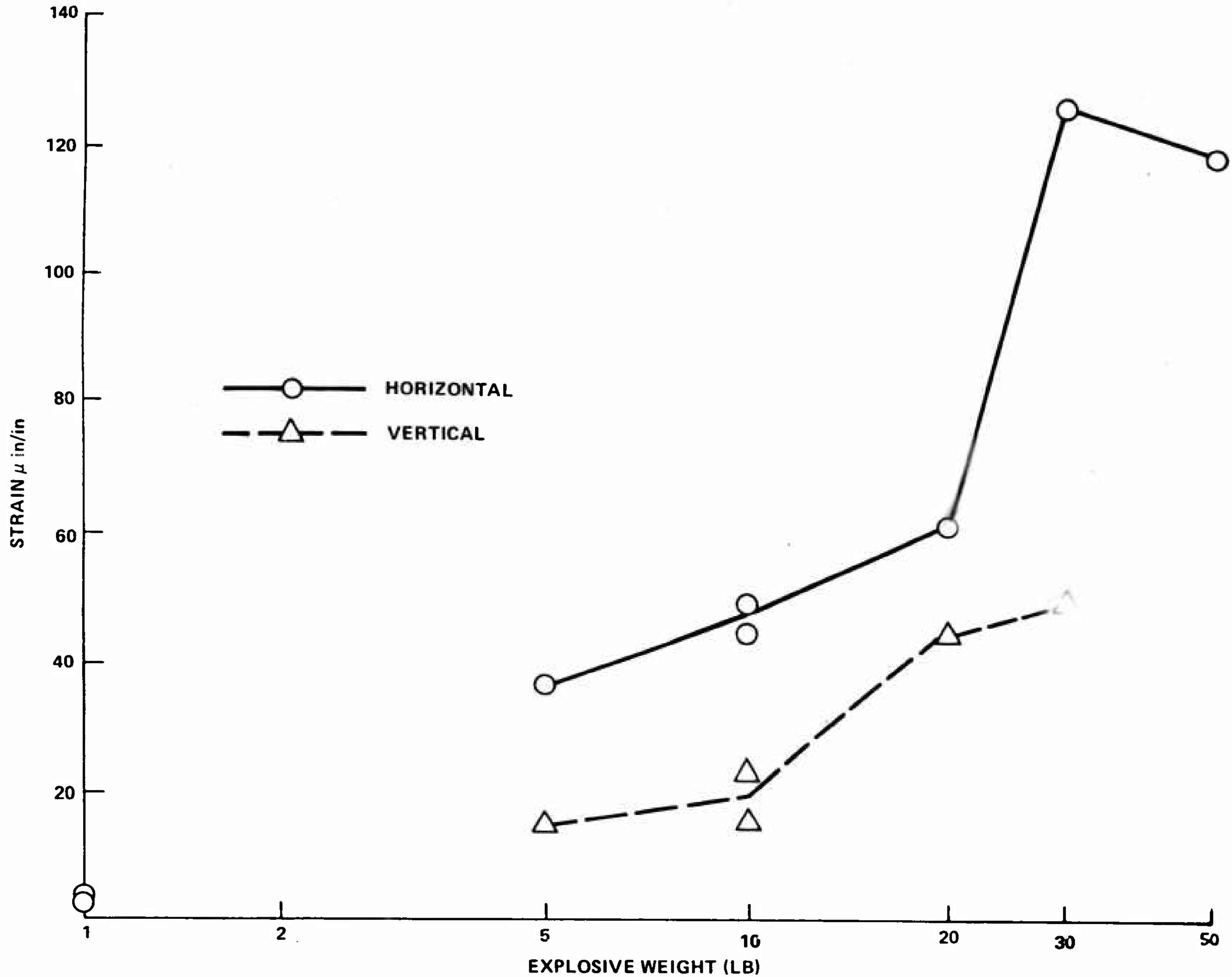


FIGURE 4. STRAIN VERSUS EXPLOSIVE WEIGHT, NORTH WALL

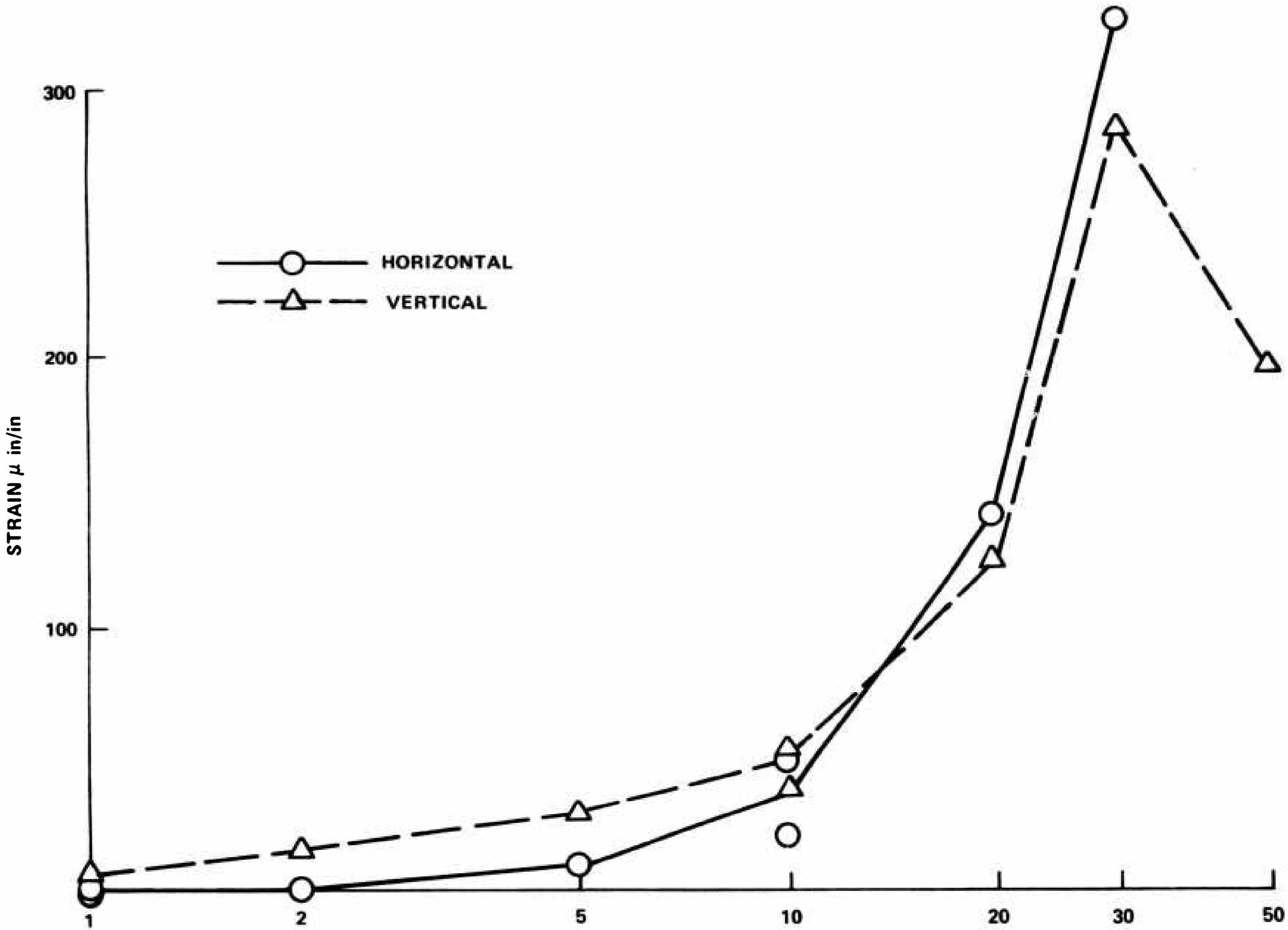


FIGURE 5. STRAIN VERSUS EXPLOSIVE WEIGHT, SOUTH WALL

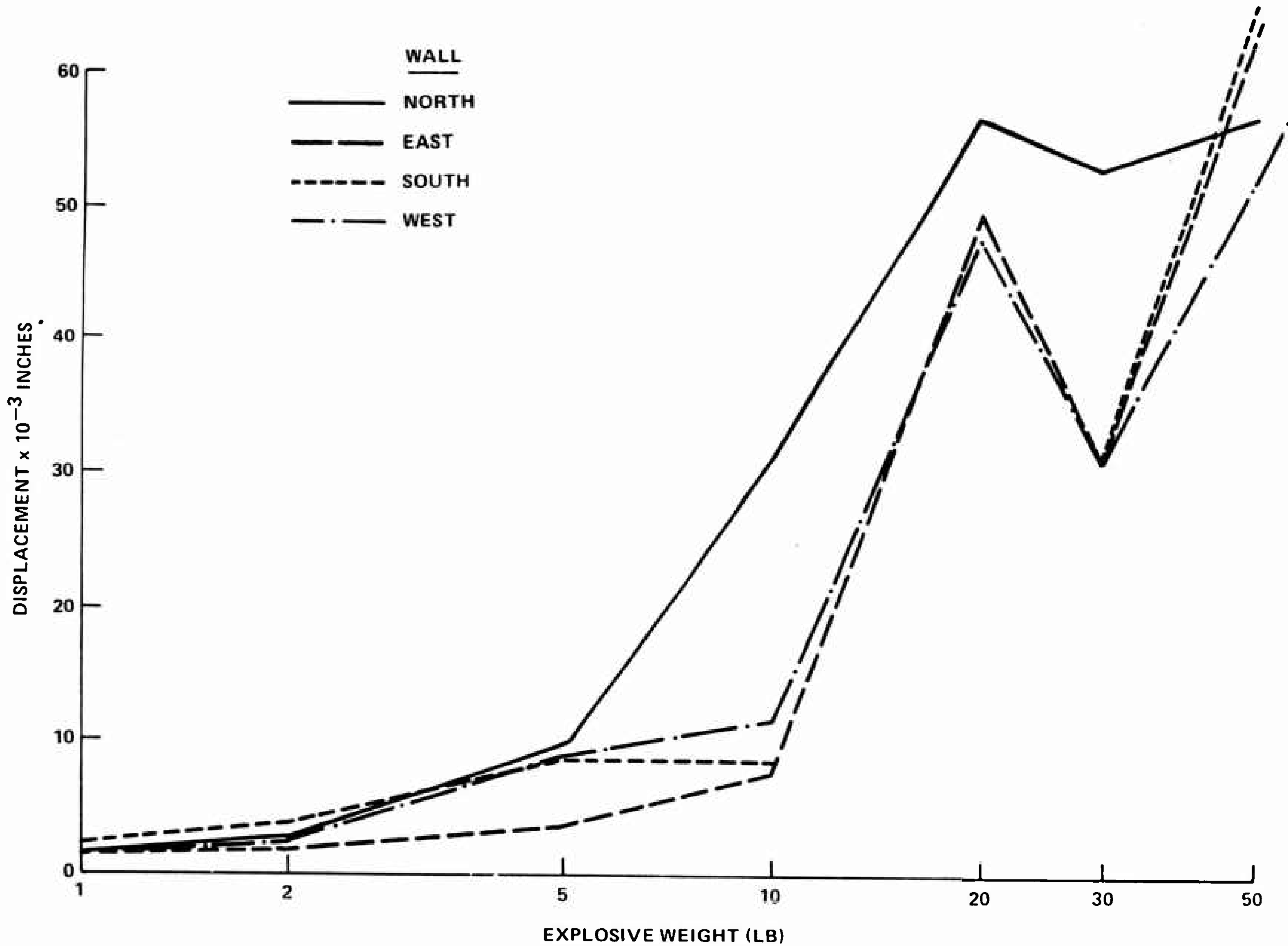


FIGURE 6. MAXIMUM WALL DISPLACEMENT VERSUS EXPLOSIVE WEIGHT

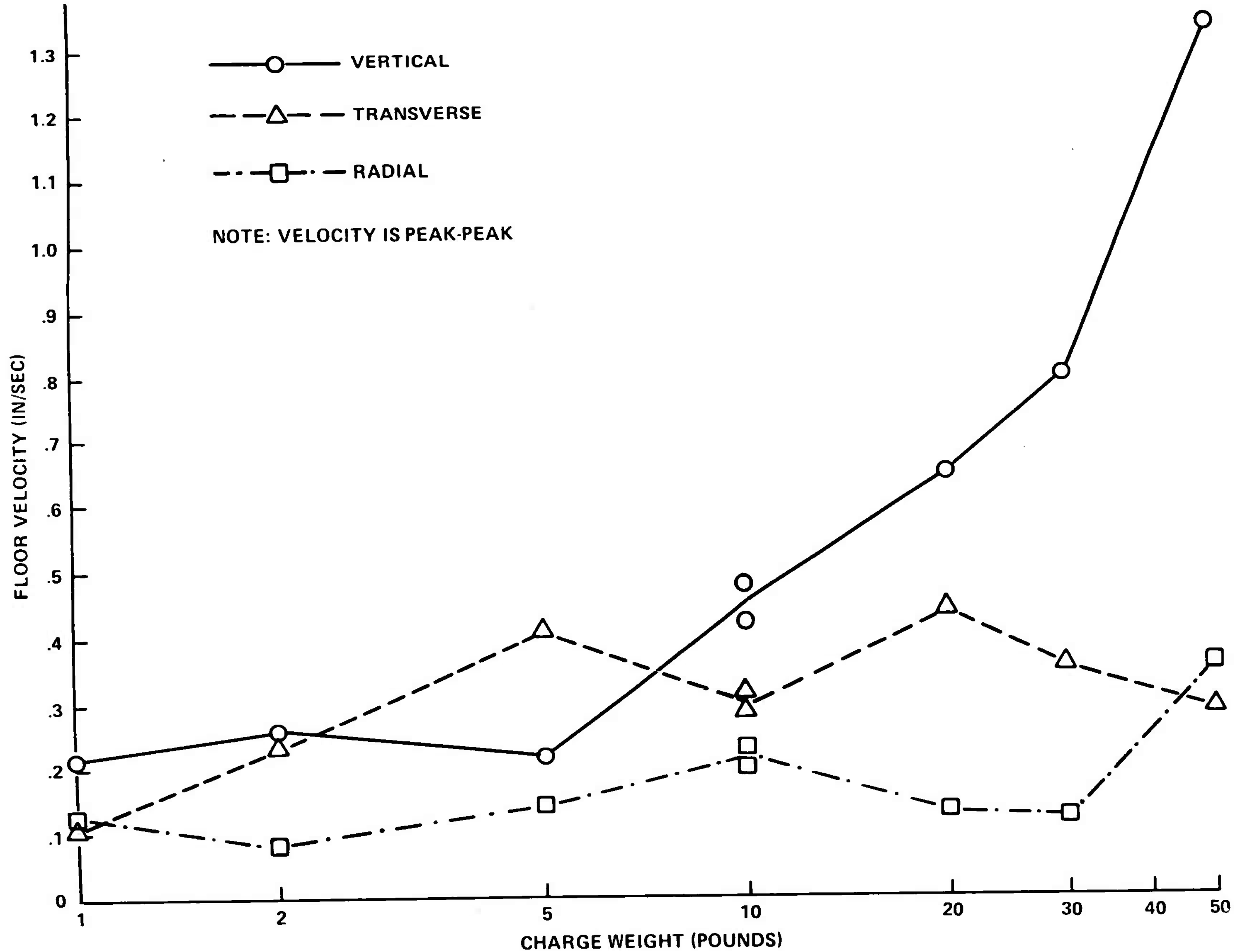


FIGURE 7. FLOOR VELOCITY VERSUS CHARGE WEIGHT

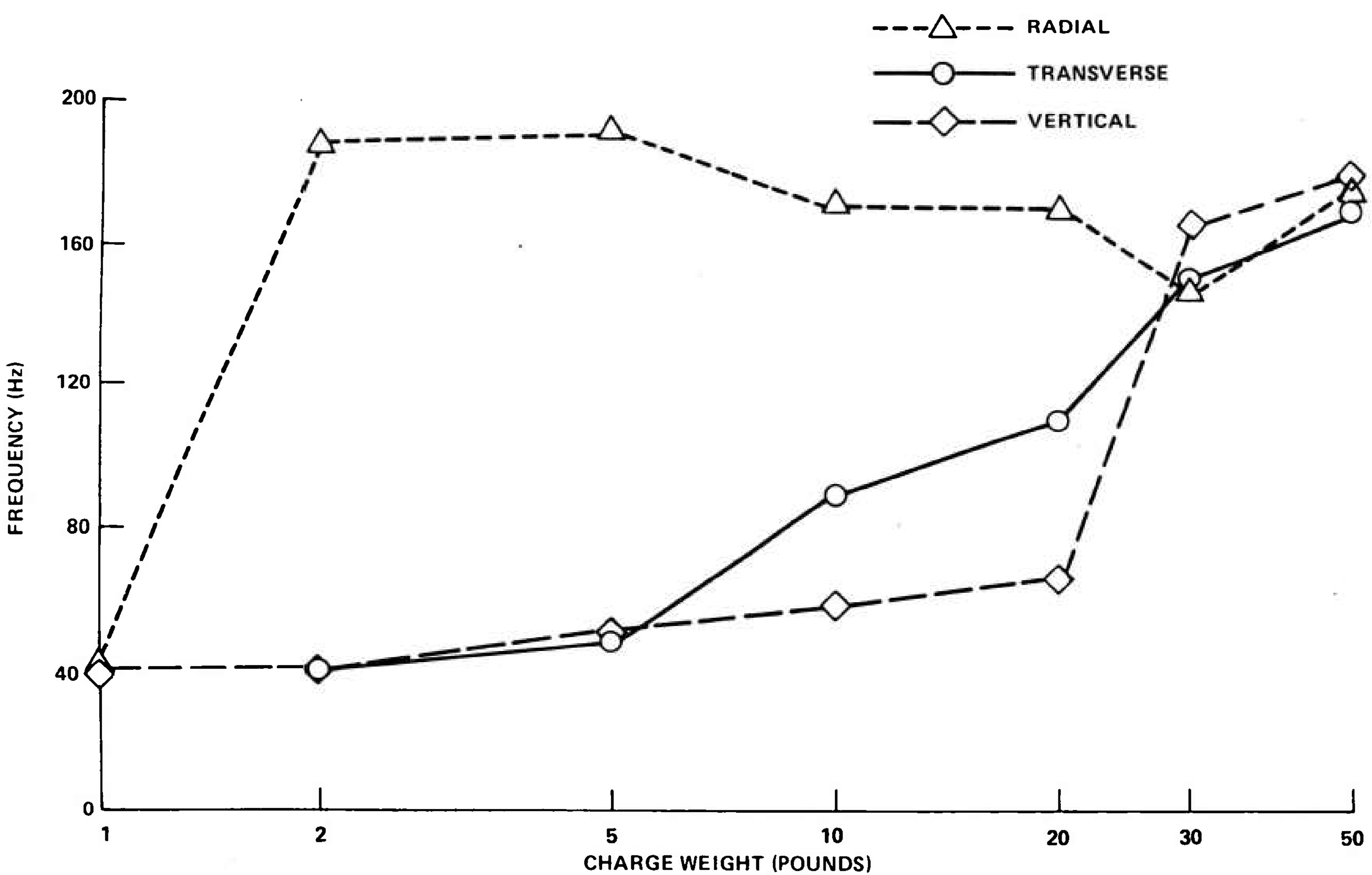


FIGURE 8. FLOOR MOTION FREQUENCY VERSUS CHARGE WEIGHTBUILDING

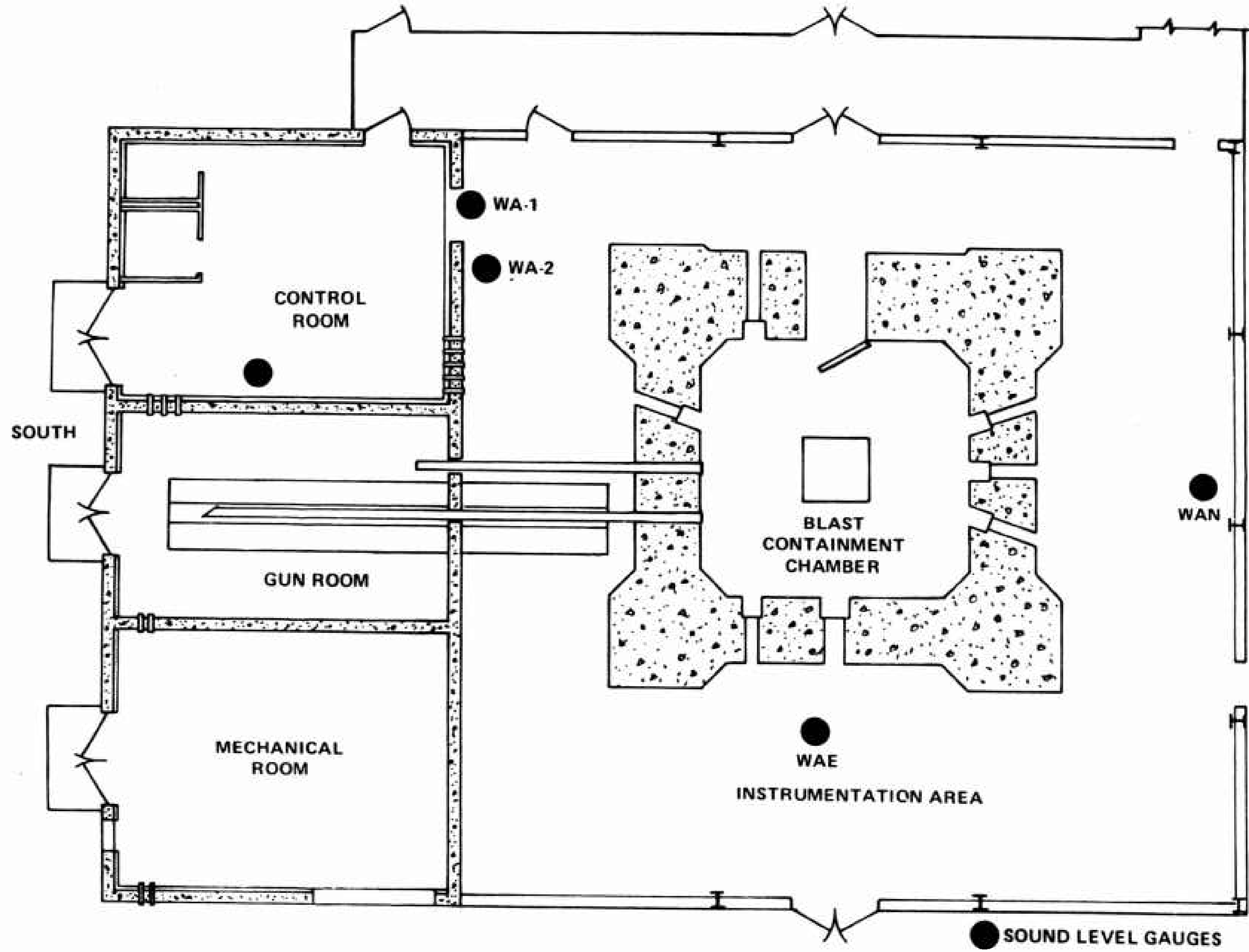


FIGURE 9. LOCATION OF SOUND LEVEL GAUGES

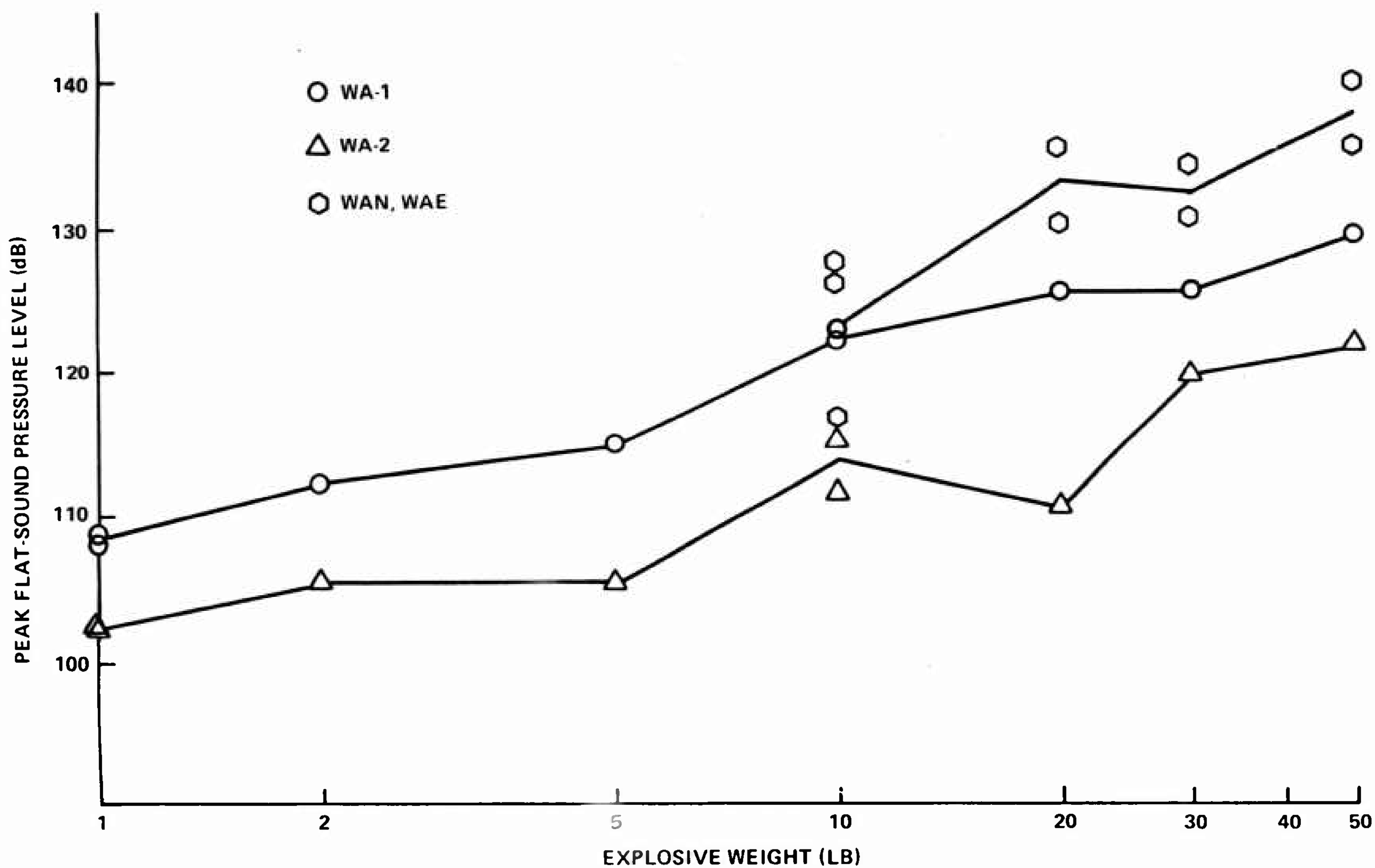


FIGURE 10. SOUND LEVEL VERSUS WEIGHT IN WORK AREA AROUND BLAST CHAMBER

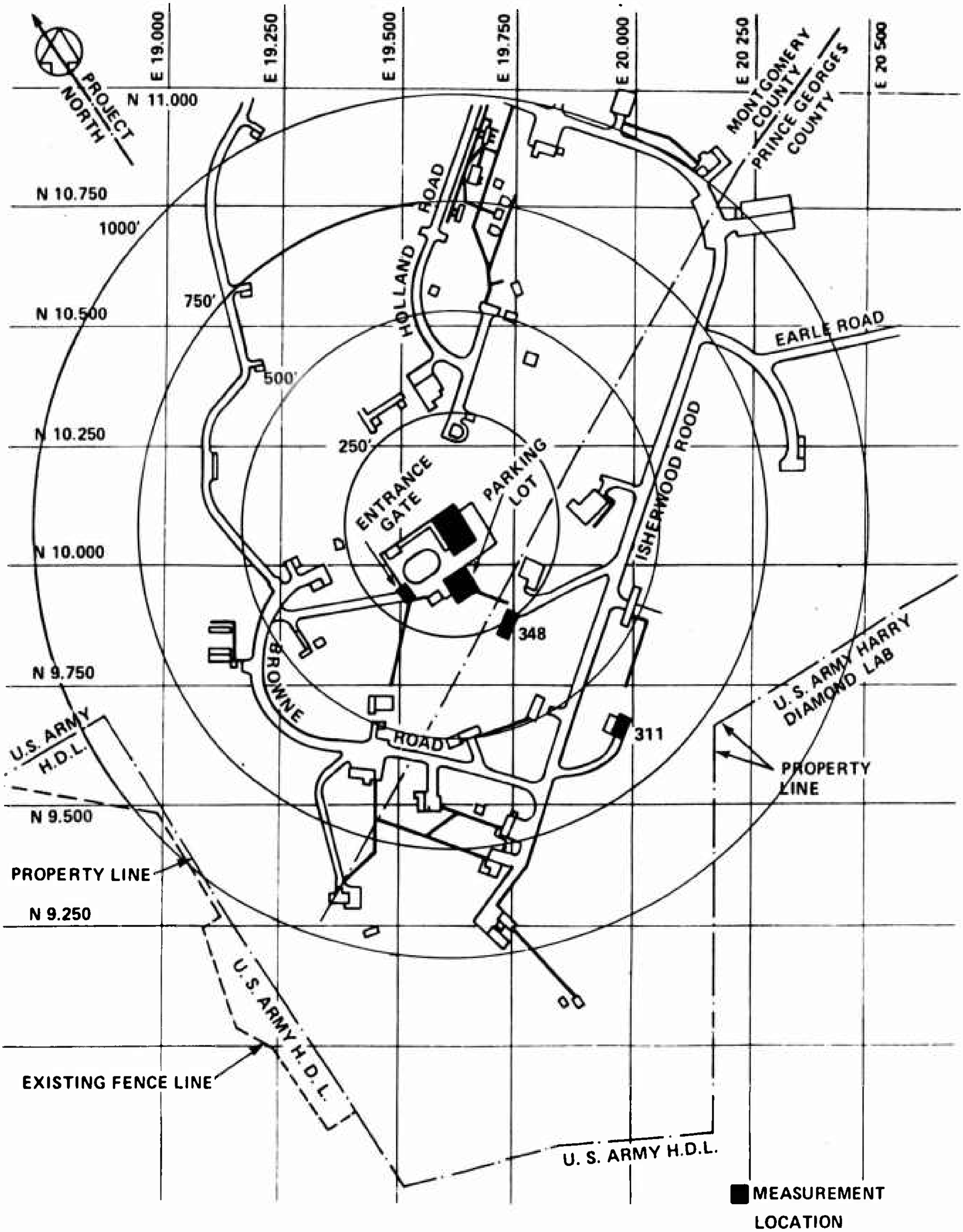


FIGURE 11. 300 AREA

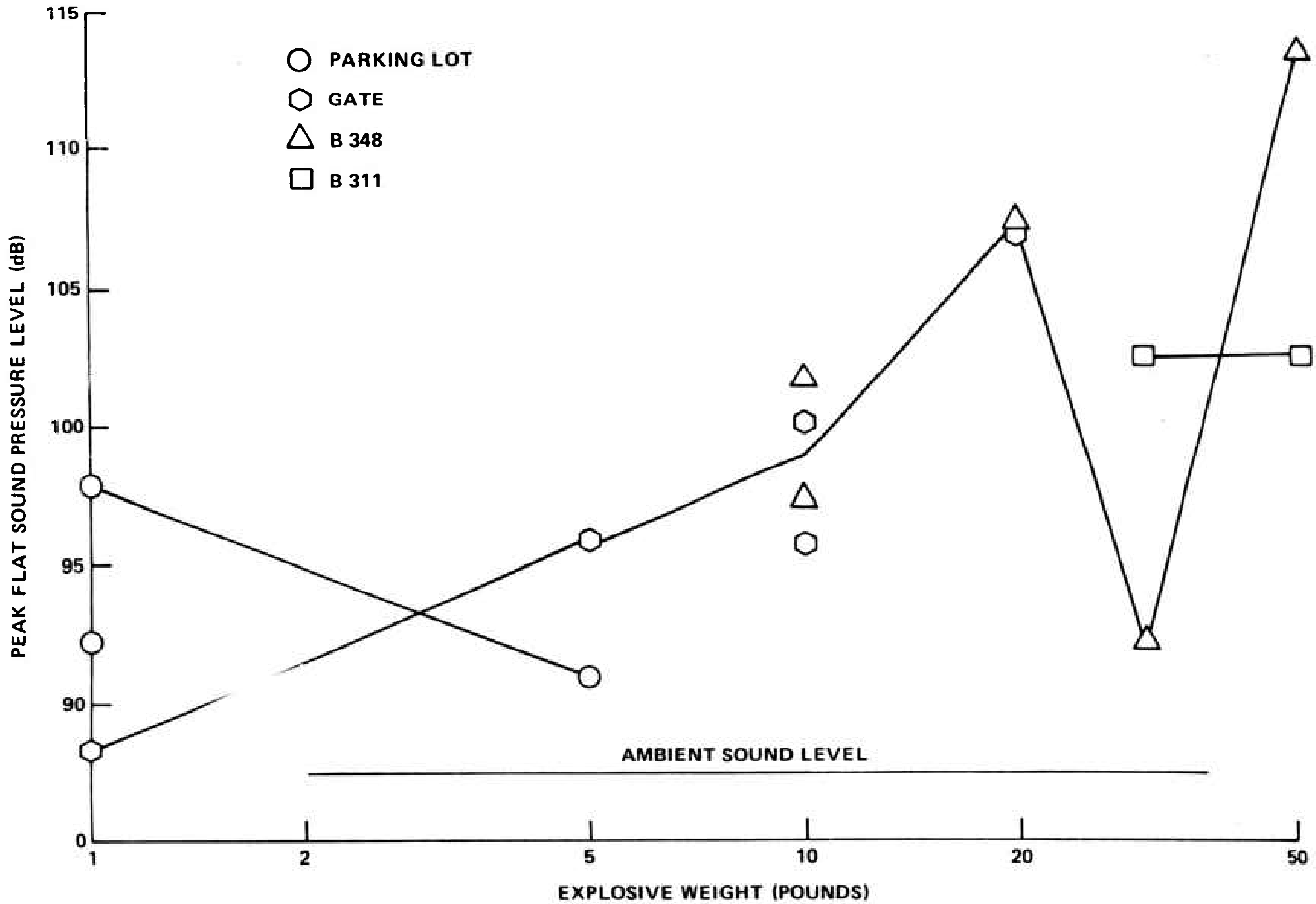


FIGURE 12. SOUND LEVEL VERSUS EXPLOSIVE WEIGHT OUTSIDE BUILDING 327

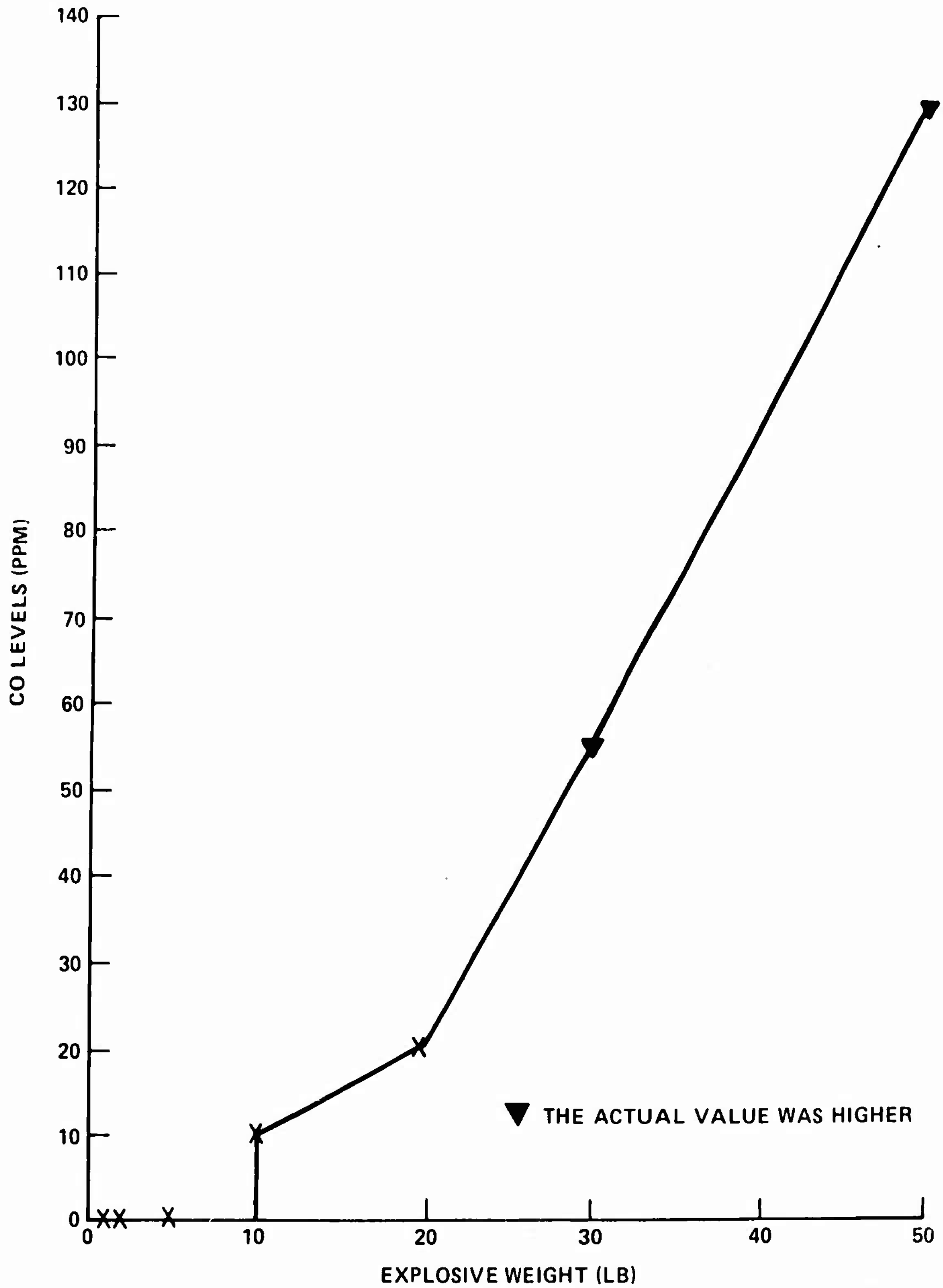


FIGURE 13. CO LEVELS RECORDED IN WORK ROOM