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Flush Mounting a Pressure Transducer for Combat Vehicle Ammunition Compartmentation and Survivability Experiments

by Travis Payne

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14. ABSTRACT
The proper use of pressure transducers for experiments investigating combat vehicle ammunition compartmentation is critical to obtain accurate pressure data. There are many factors in the installation process of the transducers that can affect the validity of the pressure data captured during an experiment. This report discusses why it is necessary to obtain accurate pressure data during a combat vehicle ammunition compartmentation experiment, and the method of transducer installation used by the US Army Combat Capabilities Development Command (CCDC) Army Research Laboratory's (ARL's) Explosive Effects Branch for Ammunition Compartmentation and Survivability.

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flush mount pressure transducer, blast pressure, ammunition compartmentation, survivability, internal pressure measurement

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1. Introduction

In the process of conducting ammunition compartmentation experiments, collecting valid pressure data is critical in determining the outcome of each experiment. The pressure data collected is used to create ammunition load plans for the different types of stowed ammunition as well as to determine vehicle crew vulnerability and survivability. Typically, the main concern in these experiments is discerning if an explosive round that is struck by an incoming threat is detonated. Also, does the detonation of the impacted round create a sympathetic detonation scenario with the remaining rounds stowed in the ammunition compartment? With the pressure data collected during these experiments, calculations can be accurately made as to how many rounds in the ammunition compartment reacted and the severity of each round's reaction. This information assists in determining the severity of the damage sustained to the vehicle and its crew and allows safer load plans to be formulated. Thus, valid pressure data is a key component in the process for combat vehicle ammunition compartmentation experiments.

2. Pressure Transducer Overview

A pressure transducer is a device that converts pressure into an analog electrical signal that can be read as voltage, current, or a frequency and recorded for future evaluation. There are many different types of pressure transducers. The type used for compartmentation experiments is generally a flush diaphragm transducer.

2.1 Components of the Pressure Transducer

Flush diaphragm pressure transducers are generally comprised of three main components: the diaphragm, the body, and the electrical connection for the signal cable (Fig. 1). When pressure is applied to the diaphragm, the transducer outputs a corresponding electrical signal. The body houses all of the transducer components and is used for the overall mounting. The electrical connection is typically a hardwired cable or a connector that mates to an external cable and can be connected to a Data Acquisition System (DAS) to record the signal.

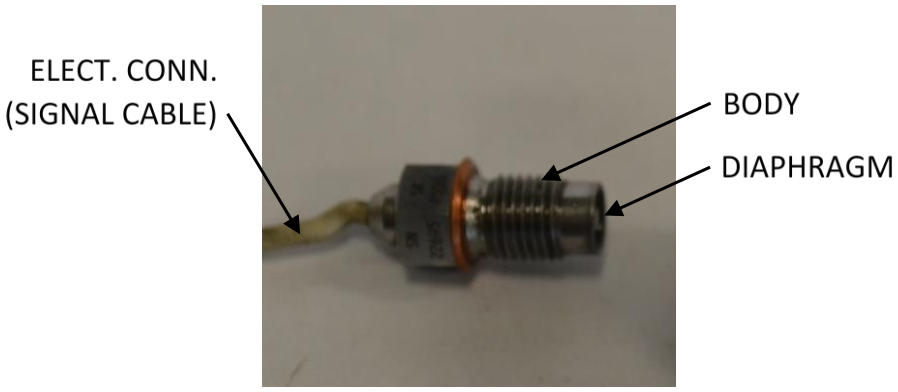

Fig. 1 Main components

2.2 Data Acquisition

To capture pressure readings from the transducer for a given experiment, a DAS is required. The transducer, when exposed to an increase in pressure, outputs an analog voltage signal (for most transducer types) that the DAS records. The voltage is converted to pressure by dividing by the sensitivity (often termed "calibration factor" at US Army Combat Capabilities Development Command [CCDC] Army Research Laboratory's [ARL's] Explosive Effects Branch facilities) for the transducer. The units for the "calibration factor" is typically volts/psi.

3. Pressure Transducer Flush Mounting

When using pressure transducers to capture data during an ammunition compartmentation experiment, it is vital to place the pressure transducer in locations where they will be protected from fragmentation but also allow peak pressures to be captured accurately with minimum reflective pressure waves. If a pressure transducer is installed in the ammunition compartment and is protruding from the compartment wall, it could adversely affect the data captured by introducing localized reflection and rarefaction waves. The potential for the pressure transducer to be damaged or sheared off from shock and fragmentation is also increased as the sensor is extended from the wall. Thus, a flush mount was designed and incorporated to alleviate these concerns. The mount places the pressure transducer so that it is flush with the internal compartment wall, allowing it to be protected while also capturing pressure data in a more effective manner.

3.1 Transducer Flush Mount Components

The pressure transducer flush mount consists of four parts that each play a key role in the collection of pressure data during ammunition compartmentation

experiments. There is a cylindrical outer mount housing (Fig. 2) that is normally machined out of either steel or aluminum to match the material of the ammunition compartment so that a hole can be drilled into the compartment wall and the outer mount inserted into the hole and welded flush to the compartment wall. It also has threaded holes to allow an inner mount to fasten to the outer mount and a hole drilled in the back to allow the pressure transducer and cable to be inserted.

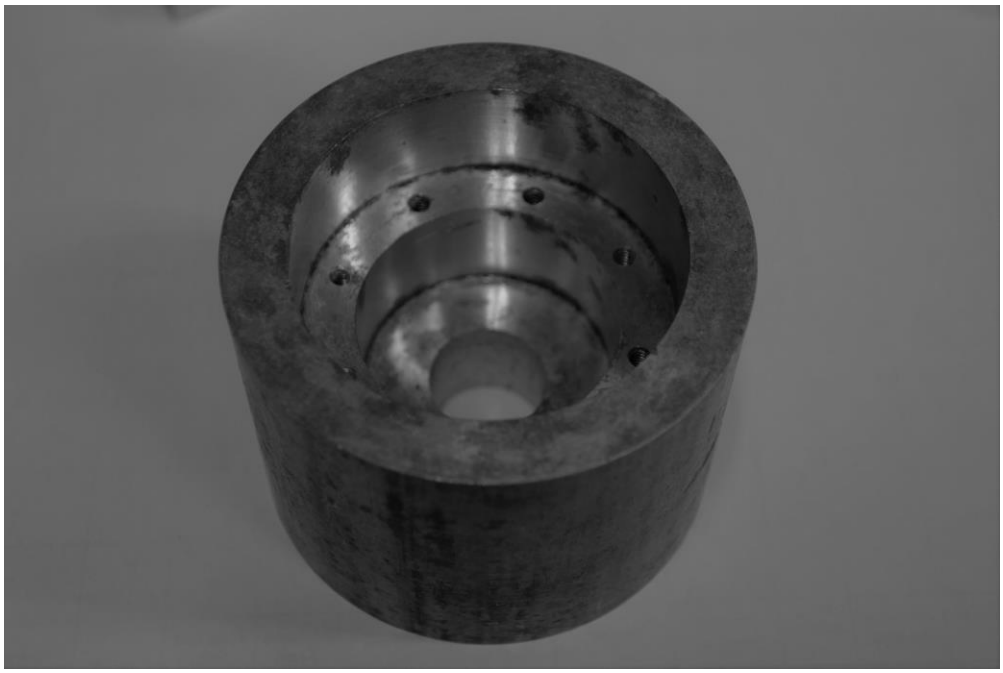

Fig. 2 Outer housing

The second component of the mount is the inner mount housing (Fig. 3), which is typically machined out of brass. This component is made out of brass because it is a softer metal allowing it to assist in the isolation of the pressure transducer from the compartment wall. It is pushed into place and fastened by using four #10-32 × 3-inch machine screws that thread into the tapped holes in the outer mount. It too has a hole drilled in the back for the pressure transducer and cable to pass through that aligns with the same hole on the outer mount.

Fig. 3 Inner mount housing

The third part of the gauge assembly is the mount for the pressure transducer itself (shown in Fig. 4 and with the transducer in Fig. 5). This machined piece of brass is drilled out and tapped to the thread pattern of the pressure transducer. It also has four grooves machined into it to accommodate O-rings. There are two O-ring grooves machined on the outer circumference and one on the front and rear necks. These O-rings are used as a secondary isolation barrier (the brass material serves as the first isolation barrier) as well as a seal for the mount. The pressure transducer mount is greased and then slipped into the inner brass housing.

Fig. 4 Pressure transducer mount

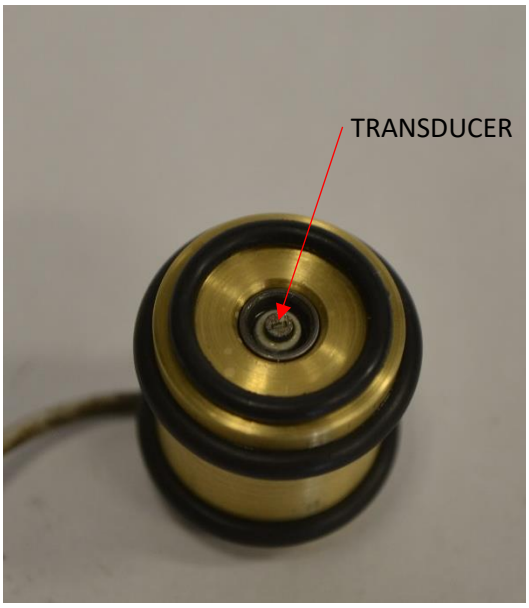

Fig. 5 Mount with transducer

The fourth part of the gauge mount is the steel faceplate (Fig. 6) used to protect the pressure transducer from fragmentation. This faceplate is a steel disc that is machined to fit into the recess in the brass inner mount. It has four mounting holes

drilled on the outer perimeter so that four 10-32 × 1/2-inch machine screws can be used to hold it in place. It also has 12 small holes drilled at set distances around the center axis of the disc. These holes allow the blast pressure to pass through the faceplate and be sensed by the pressure transducer. All of the inner components of the mount are shown together in Fig. 7 and assembled in Fig. 8.

Fig. 6 Steel faceplate

Fig. 7 Inner components

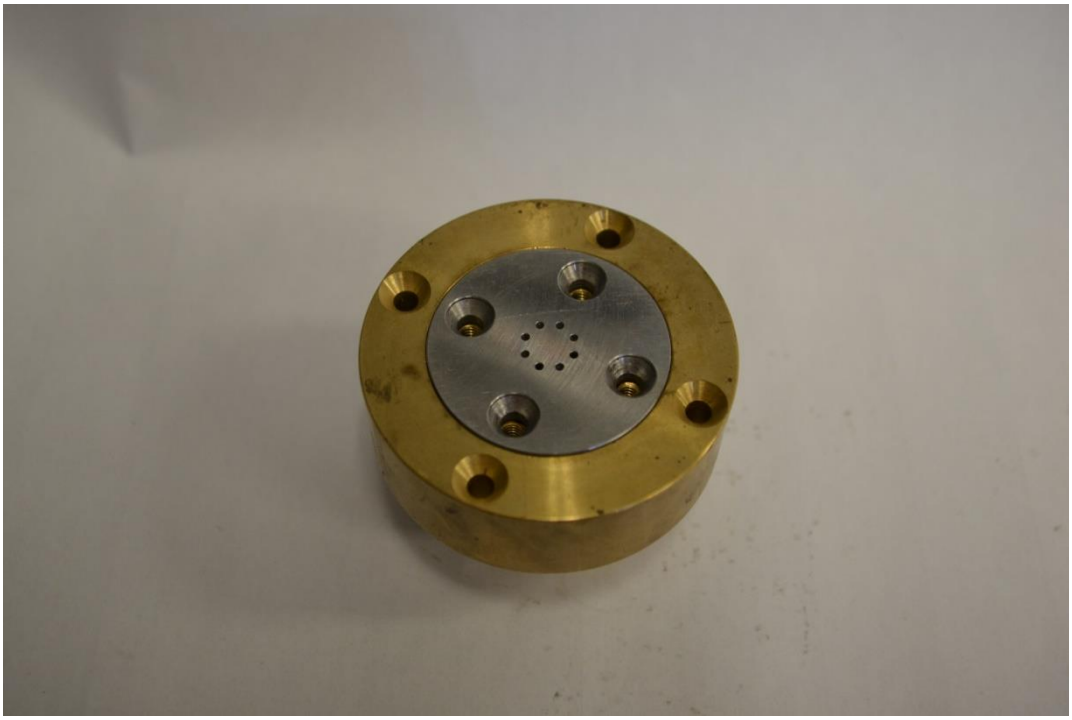

Fig. 8 Assembled inner components of the mount and gauge

3.2 Installation

The proper installation of the pressure transducer into the gauge mount is critical to successfully acquire valid data. Typically, the outer and inner mount housings described previously remain secured to the fixture and are only removed if they are damaged or need to be replaced. The following steps must be adhered to for accurate measurements:

1) Before installation can begin, verify there is no visual cracking of the welds that hold the outer mount housing.
2) Verify the four screws that hold the inner brass mount housing in place are tight and the inner mount housing is secure.
3) Once this is completed, feed the selected pressure transducer and cable through the rear hole of the inner and outer mount housing.
4) After the pressure transducer and cable have protruded from the other side of the mount, pull the transducer and approximately 10 inches of slack cable through the mount housing.
5) The next step is to secure the pressure transducer into the brass transducer mount.

6) First, coat all O-ring grooves with a light coat of vacuum grease. Once the O-ring grooves are coated, install the two outer O-rings by sliding them into the milled ring grooves. Take a third O-ring and install it into the ring groove on the rear face.

7) After the two outer and the rear O-rings have been installed, the transducer is threaded into the mount. To begin this process, hold the pressure transducer in one hand and the brass mount in the other.

8) Insert the pressure transducer into the mount and begin to thread it in place by twisting the mount on to the pressure transducer until it is hand-tight. To tighten it the remainder of the way requires a specialty tool that is shown in Fig. 9.

9) This tool is custom-made for this application out of a thin-walled socket that has a slice cut through the side and a welded handle. The slice is to accommodate the pressure transducer cable so it does not get damaged during the installation process. Insert the tool onto the pressure transducer with the cable slid through the sliced part of the socket and tighten it until it is snug.

10) After mounting the pressure transducer into the mount, install the mount into the inner mount housing. Apply a liberal coating of vacuum grease to the two outer O-rings and the rear O-ring. Once the O-rings are coated, insert the mount into the mount housing by pushing it into the mount housing while simultaneously pulling the pressure transducer cable slack through the back side of the mount housing. It should be pushed in until you feel it seat as far as it can into the inner mount housing.

11) After completing Step 10, place the fourth O-ring into the O-ring groove on the front face of the transducer mount.

12) After installation of the fourth O-ring, apply a thin coat of vacuum grease to the sensing element of the pressure transducer. This is a very critical step because the vacuum grease provides a thermal barrier for the pressure transducer during the explosive event. If too much grease is applied, your pressure transducer may not read accurately. If an inadequate amount of grease is applied, the thermal barrier will not be present to prevent false pressure readings from the event. Greasing the sensing element before each shot is critical for collecting valid data.

13) Once the pressure transducer is greased and installed, the steel faceplate can be installed. Insert the faceplate into the recess of the mount housing while aligning the screw holes. Use a Phillips-head screwdriver to install the four

required screws to fasten the faceplate to the mount. Upon completion of this step, the pressure transducer is installed and ready to capture data. See Fig. 10 for a fully installed mount and gauge.

Fig. 9 Gauge installation tool

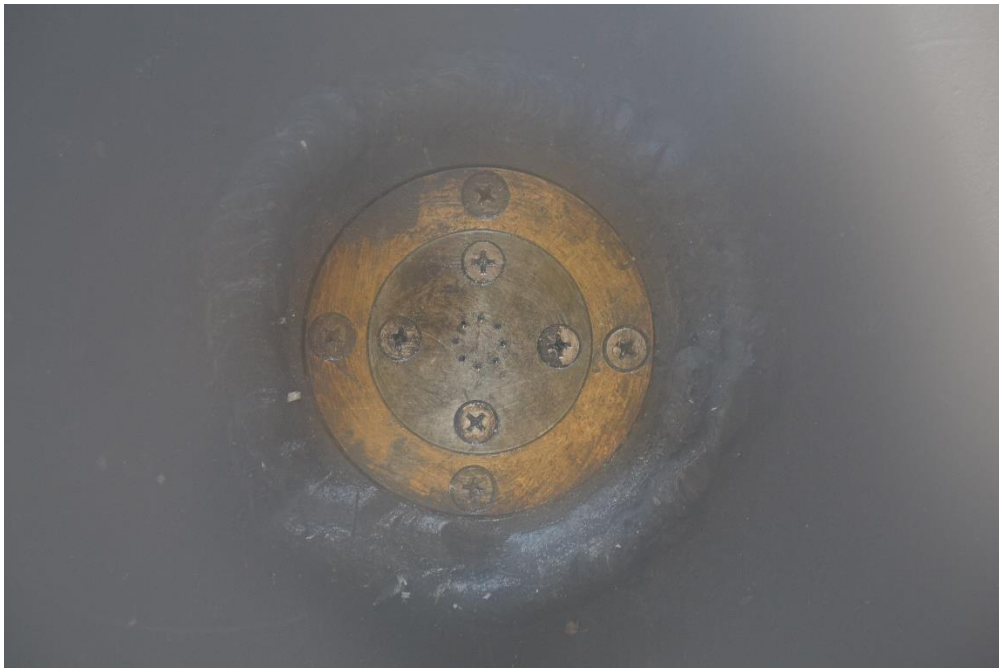

Fig. 10 Flush mount pressure gauge installed in an ammo compartmentation experiment

4. Conclusion

Capturing pressure data plays an important role in experiments investigating ammunition compartmentation. The valuable data provides information that could not be captured via other means and allows insight into the dynamic nature of ammunition compartmentation experiments. This information is then used to enhance the design safety of combat vehicles as well as crew survivability. Without accurate pressure data, inaccurate determinations could be made that could adversely affect a combat vehicle's design to protect its crew. Proper installation methods of pressure transducers must be adhered to so that accurate pressure data with validity can be obtained. Steps in this process cannot be skipped, and care must be taken throughout the process to ensure accurate recording of the pressure inside the ammunition compartment during the experiment.

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