PORTABLE CALIBRATORS

USRD Types G19 and G40 with an F61 Standard Hydrophone

Introduction

A portable calibrator is basically a vertical, cylindrical column of water in a thick-walled tube, with a free and open water-air surface at the top, and an electrodynamic transducer at the bottom. The water column functions as a very short acoustic transmission line. The acoustic pressure at any point in the column, when driven by the transducer at the bottom, is proportional to the inertia of the water load above that point.

These calibrators provide a simple, rapid, economical, and reliable calibration for small hydrophones at mid- and low-audio frequencies.

The G19 calibrator was designed as a "bench test" instrument for quality control or other low-cost purposes. The G40 calibrator was designed for use aboard research ships at sea. The high-frequency limit of both is 1,000 Hz. The low-frequency limit of the G19 is 100 Hz and of the G40 is 25 Hz.

It is possible to make absolute calibrations in a portable calibrator and the theory and methodology for this is described in section 2.5.2 of Ref. 5 and in Refs. 13 and 14. However, comparison calibrations using a calibrated standard hydrophone are much easier and are standard practice. A USRD Type F61 hydrophone is furnished for this purpose. The procedures described herein will be limited to comparison methods.

Pictures and drawings of the G19, G40, and F61 are presented in Figs. 3 through 10.

Limitations and Advantages

The limitations of the portable calibrators are: (1) The acoustic centers must be known when comparing hydrophones of different shapes and sizes. (2) The vertical position in the tube of the acoustic center must be accurately known. (3) The acoustic impedance of the hydrophone must be at least as high as the same volume of water (a requirement easily met by conventional piezoelectric hydrophones). (4) The frequency range is limited.

Advantages of the portable calibrator are: (1) Hydrophones can be easily inserted and removed. (2) There is no coupling problem as with other low-frequency methods. (3) The equipment is rugged and, with the G19, easily handled and carried. (4) There are negligible problems with temperature. (5) High sound pressures are available and this, in turn, usually eliminates any need for amplifiers.

Sound Field Characteristics

The sound pressure is greatest near the face of the transducer diaphragm and decreases linearly as the distance from the diaphragm increases, reaching close to zero at the water-air surface. There is no horizontal gradient at low frequencies because the column diameter is kept at a small fraction of a wavelength in water and the thick-walled tube prevents displacement in the horizontal plane. In the G19, a driving signal of 1.0 V will produce about 160 dB re 1 μPa. In the G40, 1.0 V will produce about 163 dB re 1 μPa. The sound pressure is sensitive to the vertical position and, for this reason, it is important that the acoustic center of the hydrophone be accurately known and accurately placed relative to the water-air surface.

USRD Type F61

The F61 transducer was designed for use primarily as a standard hydrophone for the G19 and G40 calibrators. Its sensor is a PZT cylinder encapsulated with polyurethane. Its specifications are as follows:

Frequency Range:	10 to 1,000 Hz
Nominal FFVS:	-205.5 dB re 1 μPa at end of 12-m cable
Nominal Capacitance:	0.009 μF
DC Resistance:	>1,000 MΩ
Temperature Range:	0 to 35°C
Directivity:	Omnidirectional

Other calibrated hydrophones may be used providing they are small enough to be omnidirectional at 1,000 Hz and have a constant sensitivity in the 10- to 1,000-Hz frequency range.

Figure 10 is a drawing of the F61 and identifies its acoustic center.

The transducer hanger should be clamped to the cylindrical neck near the cable gland.

Individual calibrations are provided for each F61.

Calibration Procedures

There are two procedure options for making a conventional comparison calibration. In the first, the standard hydrophone is laced i the water column at a fixed distance from the diaphragm and with a marked level of the water-air surface, and the sound pressure is measured. Then the unknown hydrophone replaces the standard with care taken to insure that the fixed level of the acoustic center is the same as for the standard and that the water-air surface level is also the same. The open-circuit output voltage of the unknown together with the pressure measured by the standard then provides the calibration data.

The second option is to have both hydrophones in the water column at the same time, side-by-side, with their acoustic centers at the same level. The choice of options is sometimes dictated by the size of the unknown hydrophone. The cross-sectional area as measured in the horizontal plane of the hydrophones should be small compared with the water column horizontal cross section. Here, "small" means less than about 25%. However, if there is any question about the choking effect of hydrophones that may be too large, it is advisable to test for this effect by comparing the sound pressure as measured by the standard with and without the unknown hydrophone in place beside it. With a constant water-air surface level, the two sound pressures should be the same.

A typical calibration circuit is shown in Fig. 8. Components as amplifiers, filters, oscilloscopes, and frequency counters are useful but not always necessary. The signal generator and the output voltmeter are the two vital components.

Preparation Directions

Fill the calibrator tube with clean, fresh water, with the hydrophone already submerged, and to a level a few centimeters from the top of the tube. After filling, dislodge any clinging air bubbles with a bottle brush or some similar device. Also follow the general directions given in Appendix D. It is helpful in eliminating air bubbles to acoustically drive the water column at a very low frequency (less than 10 Hz) for several hours or to merely allow the water to sit unused overnight. In any case, complete elimination of air bubbles is of vital importance.

The hydrophone should not be closer than about 12 cm from the diaphragm because there is a short distance immediately in front of the diaphragm where in the sound field is not uniform.

The G19 needs no further preparation other than placing it on a horizontal surface as a bench top. The G40, however, needs further attention due to its larger size and the provisions for keeping it vertical while on a rolling or pitching ship (within 10°). The static weight of the water column on the G40 transducer diaphragm requires air pressure compensation below the diaphragm or inside the transducer. A pump is provided with the calibrator for this purpose and also to inflate the air bags which support the water-filled tube and still allow tilting.

Four heavy-duty casters are installed on the bottom of the G40 support structure to facilitate positioning the calibrator. After moving it to the desired location, the calibrator can be fixed in place by pressing down on foot pads of the three truck floor locks to shift the weight off the casters. Before filling the tube, release the three restraining cables from the lower end of the tube so that it swings freely. Inflate the inner tube until the clearance between the plywood disk and the top of the support frame is approximately 10.5 cm or 4⅛ in., as shown in Fig. 7. Check the position of the transducer diaphragm by reaching into the tube and touching the face of the diaphragm. If it is displaced downward, restore it to a neutral position by applying air pressure with the pump furnished. The air guage mounted near the bottom of the tube is calibrated in inches of water and, therefore, the reading should approximate the depth of water in the tube. ***CAUTION*** - *Do not use a compressed air hose or other means of air pressure that could accidently over inflate and explode the transducer.*

G40 Storage

When the G40 calibrator is not being used, attach the three restraining cables to the bottom of the tube. For short-term storage, the water can remain in the tube to avoid more bubble removal steps. For periods in excess of a few days, and because of algae growth, the water should be drained through the small valve at the bottom and simultaneously the compensation air pressure inside the transducer should be released.

Fig. 3 - Type G19 calibrator.

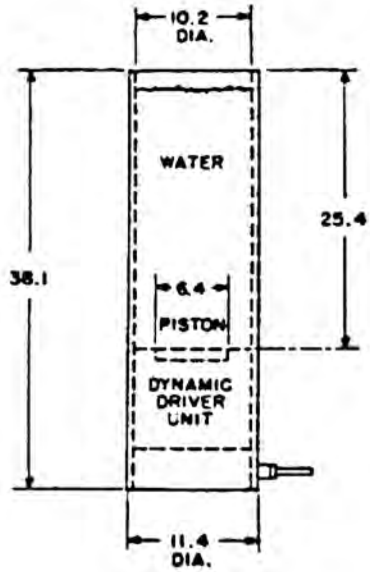

Fig. 4 - Dimensions (in cm) of Type G19 calibrator.

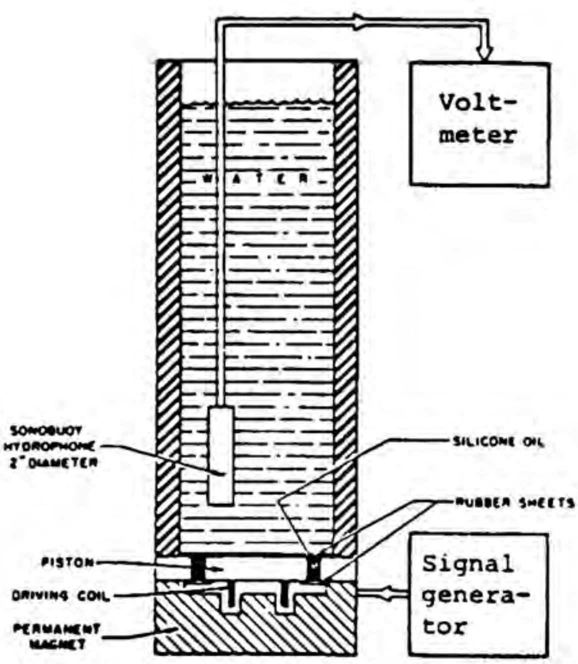

Fig. 5 - Cross section of Type G19 calibrator.

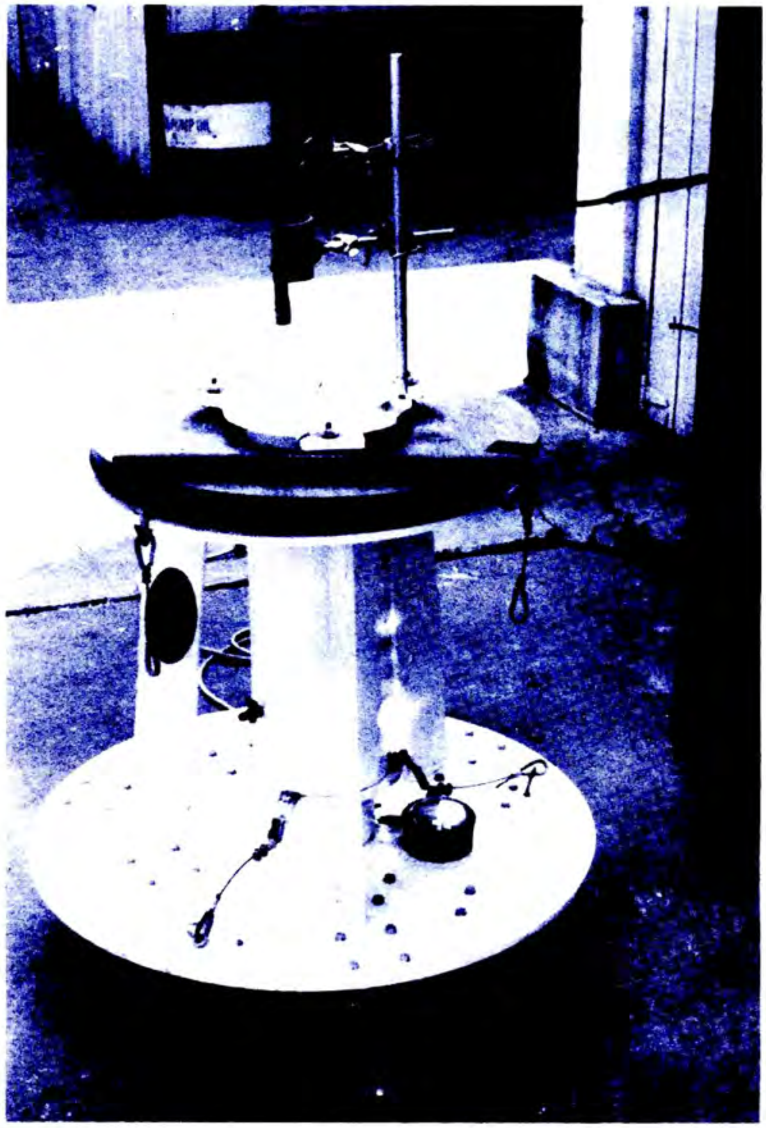

Fig. 6 - Type G40 calibrator.

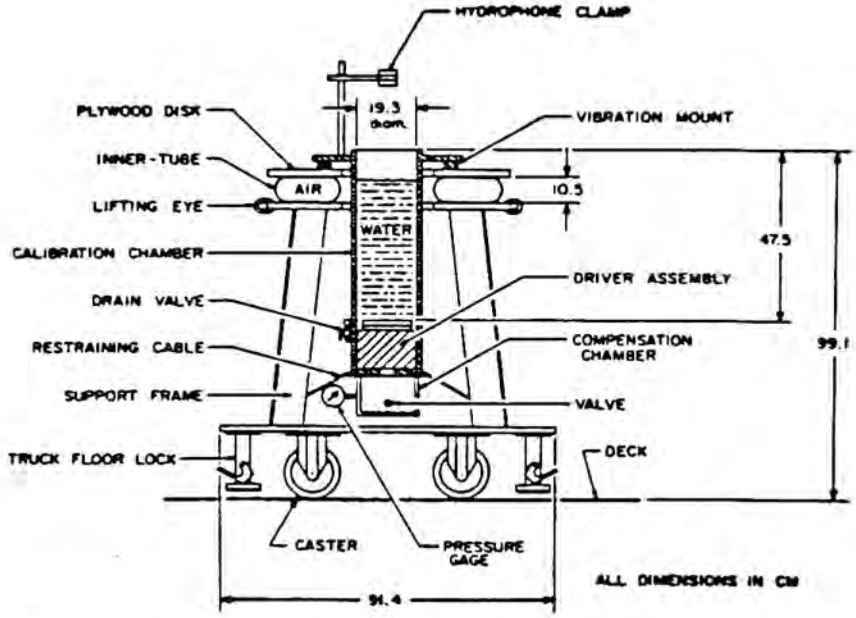

Fig. 7 - Sectional view of Type G40 shipboard calibrator (measurements in cm).

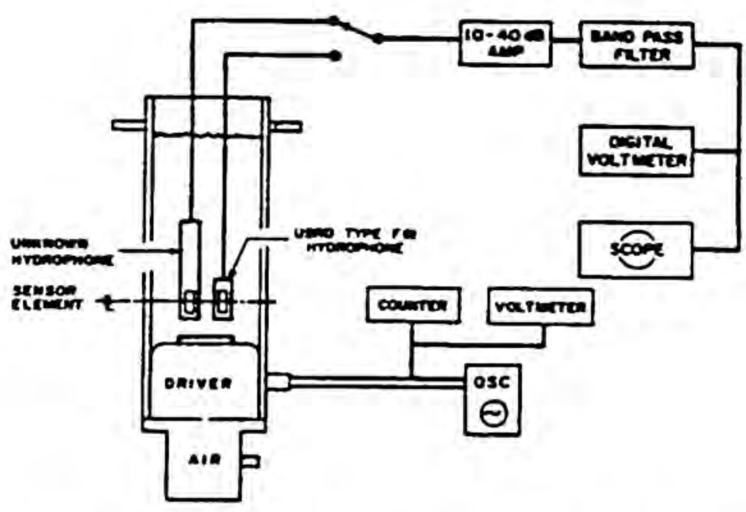

Fig. 8 - Block diagram of typical calibration circuit for Type G40 calibrator.

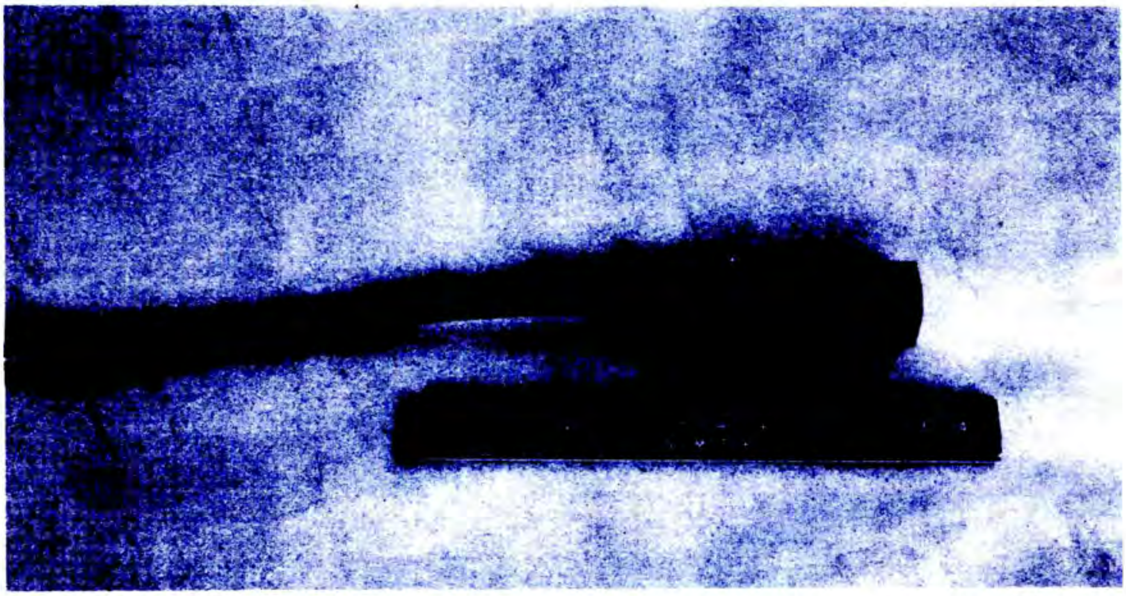

Fig. 9 - Type F61 transducer.

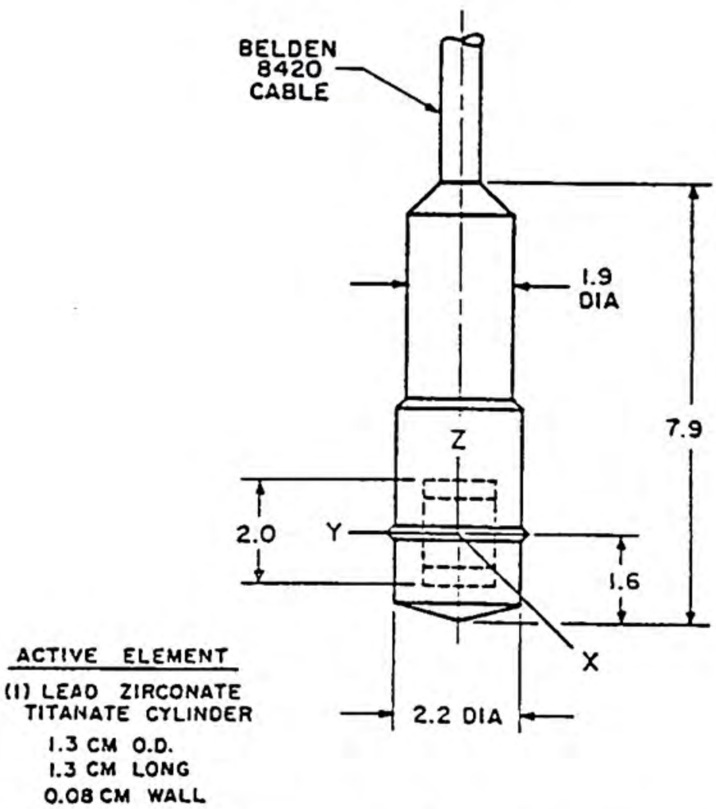

Fig. 10 - Dimensions (in cm) and orientation of Type F61 transducer.