PRESSURE VESSEL FOR CALIBRATING SONAR TRANSDUCERS

Acoustically transparent fiber glass capsule permits testing at pressures to 800 psig

C. E. Green • Research and Development Report • 26 July 1965

U. S. NAVY ELECTRONICS LABORATORY, SAN DIEGO, CALIFORNIA 92152 • A BUREAU OF SHIPS LABORATORY

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PROBLEM

Design, develop, and construct a pressure vessel that will encapsulate a sonar transducer under test and permit calibration under pressure.

RESULTS

1. A pressure vessel with favorable acoustical properties was built under contract.

2. It was designed to house only the test transducer.

3. Maximum operating pressure is 800 psig for long-term cycling.

4. Maximum operating frequency is 500 kc/s.

5. The mounting mechanism holds the transducer on the regular calibration column either inside or outside the vessel.

RECOMMENDATIONS

1. Consider the use of acoustically transparent pressure vessels for evaluating sonar transducers.

2. Consider a mounting mechanism that holds the vessel on the regular calibration column with the test transducer inside the vessel.

3. Consider the vessel as part of the rotating system to obtain polar patterns of the transducer.

ADMINISTRATIVE INFORMATION

Work was accomplished under SF 101 03 18, Task 8049 (NEL L30151). The report covers work from October 1964 to March 1965 and was approved for publication 26 July 1965.

CONTENTS

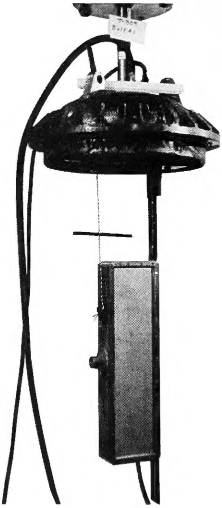
ILLUSTRATIONS

INTRODUCTION

Requests for calibration of sonar transducers at depths beyond normal station capability are becoming more frequent. The NEL solution to the problem is a system for applying pressure to a transducer within an acoustically transparent vessel. The acoustical transparency permits other transducers involved in the tests to be located outside the vessel in their normal environment.

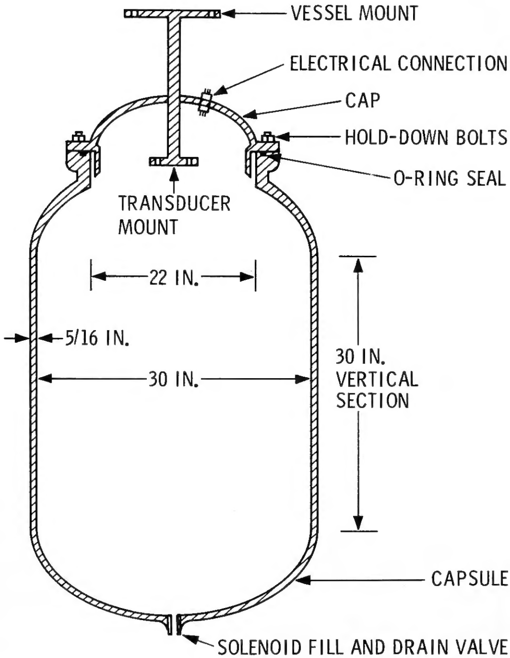
MECHANICAL DESIGN

The pressure vessel is cylindrical with elliptical end sections. Fiber glass-consolidated resin providing both acceptable wall thickness and acoustical transparency is used for the walls of the capsule. A geodesic winding pattern minimizes the amount of fiber glass required. The radial strength of the vessel is increased by a cylindrically-wound additional layer. The wall has a breaking strength of several thousand psig. The consolidated windings were vacuum-cured to reduce air entrapment.

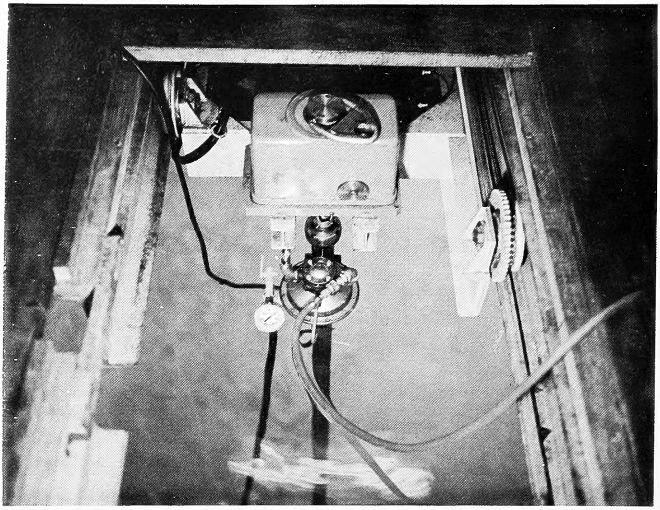


End cap, with transducer bolted in place prior to assembly of pressure vessel. Mounting plate (top of photograph) couples directly to calibration column in Transducer Evaluation Center (Transdec) facility.

Pressure vessel, with fiber glass capsule and steel end cap assembled.



Pressure vessel accommodates transducers up to 22 inches in diameter and 36 inches long. Electrical leads are coupled to watertight connectors and extended to calibration equipment. High-pressure solenoid valve permits filling or draining of vessel as it is lowered or raised. Pressure relief is provided by bolts of high tensile strength and nuts which strip on pressure increase to failure limit (three times operating pressure of 800 psig); when threads strip, cap rises slightly and water escapes past O-ring seal.



Pneumatic-hydraulic pump on calibration column in shed supplies water to vessel at pressure 10 times that of supply air.

ACOUSTICAL DESIGN

Maximum operating pressure was set at 800 psig by the demand for calibration at the depth it represents. Acoustic attenuation is acceptable with the wall thickness required by this pressure.

The steel cap was considered to be located far enough from the transducer under test to be of no acoustical consequence. If it had become a source of significant reflections, it would have been coated with Goodrich absorbent rubber SOAB.

EVALUATION OF THE VESSEL

In the evaluation of the vessel it was necessary to determine acoustically (1) the circular uniformity of the capsule walls, (2) the reflective and absorptive behavior due to pressure alone, (3) the effect of the vessel on frequency response, and (4) the effect of the vessel on directivity patterns.

Capsule Walls Uniform

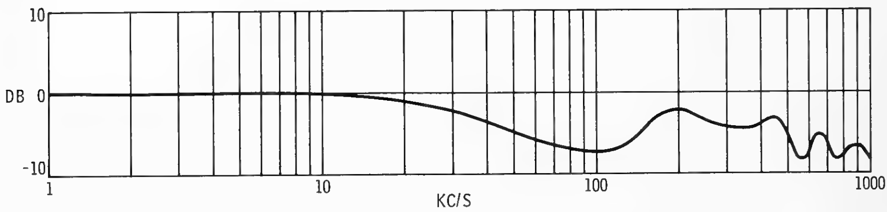
Uniform wall thickness of the capsule permits transducers to be mounted in random orientation with respect to the walls. Thickness is more important acoustically at high frequency, where the behavior of materials is more critical. Specifically, a high-frequency test checks the uniformity of the consolidation of the fiber windings and the thickness of the epoxy. The high-frequency measurement was performed by comparing cylindrical free-field polar patterns made by a probe mounted on the cap with and without the capsule attached. No measurable difference in patterns was observed. Several checks of this type indicated that the walls are uniform enough for this application.

Directivity Unaffected by Pressure

The vessel was tested for change in acoustical behavior due to pressure alone with a selection of nonpressure-sensitive transducers with directivity indexes varying from very low to very high. Patterns plotted at 0 psig and at increments of 100 psig to 800 psig show no change, and it is presumed that vessel behavior is independent of pressure.

Attenuation Uniform to 100 kc/s

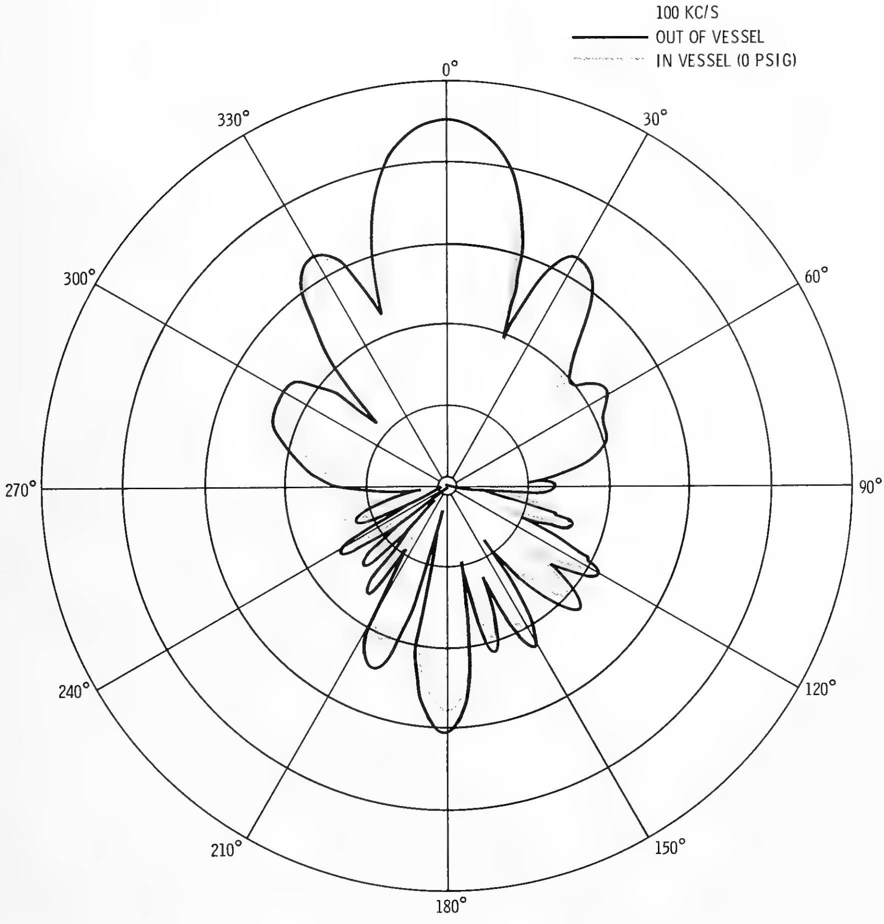
Change in acoustical behavior as a function of frequency was expected, since the frequency spectrum of interest encompasses the range from a fraction of a cycle to several cycles within the thickness of the plastic. A number of transducers of various sizes were calibrated inside and outside the capsule at 0 psig. Very little capsule effect on signal strength was revealed below 8 kc/s. As shown in the chart, the transmitted signal is reduced smoothly and uniformly up to 100 kc/s, and fluctuates above that frequency. These results seem quite predictable. Results of tests on unknown transducers can be checked against duplicate measurements made without the capsule, if necessary.



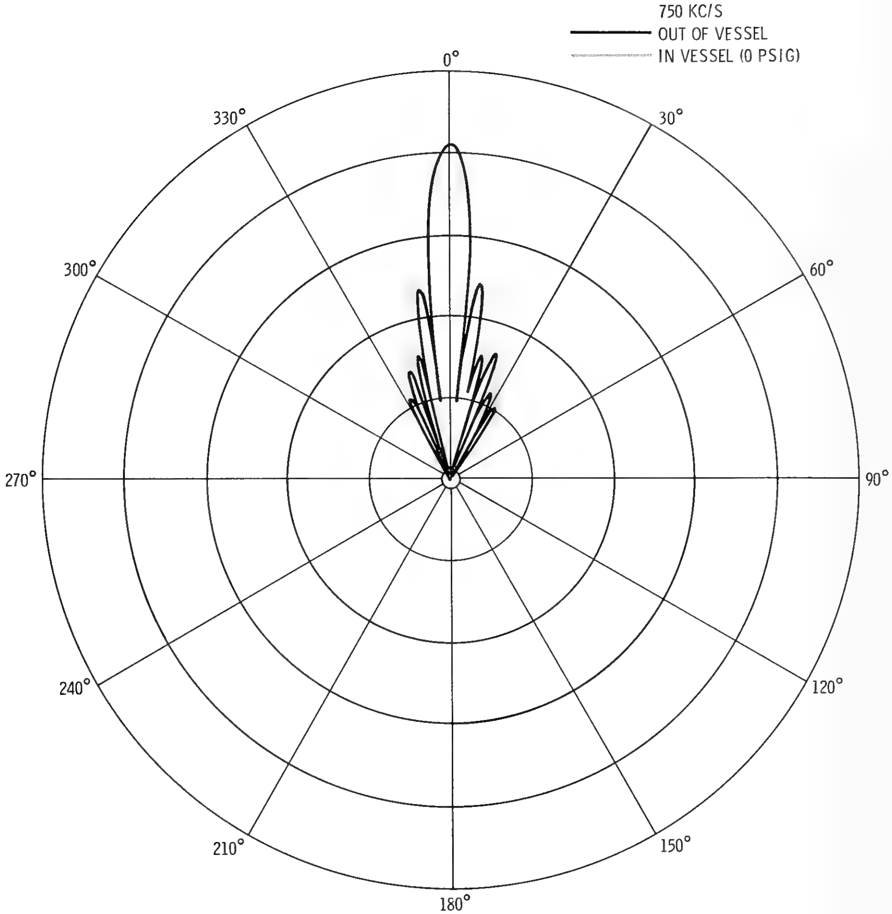
Attenuation as a function of frequency.

Since for frequencies below 8 kc/s the walls of the capsule have little effect on the signal, measurements can be steady state or pulse. At higher frequencies reflections from the walls add to or subtract from the signal, and pulse measurements are required. The vessel is large enough compared to the transducer to provide adequate time delay in the reflected signal for true evaluation of the incident sound only.

Beam Patterns Unaffected by Vessel



Close correspondence of directivity patterns of transducer within and without the capsule indicates that transmission properties of the plastic are linear. Beam patterns are unaffected by the pressure of the vessel.



Lobes do not correspond so closely at higher frequencies. The divergence revealed by tests at 0 psig is useful in interpreting results of tests under pressure.

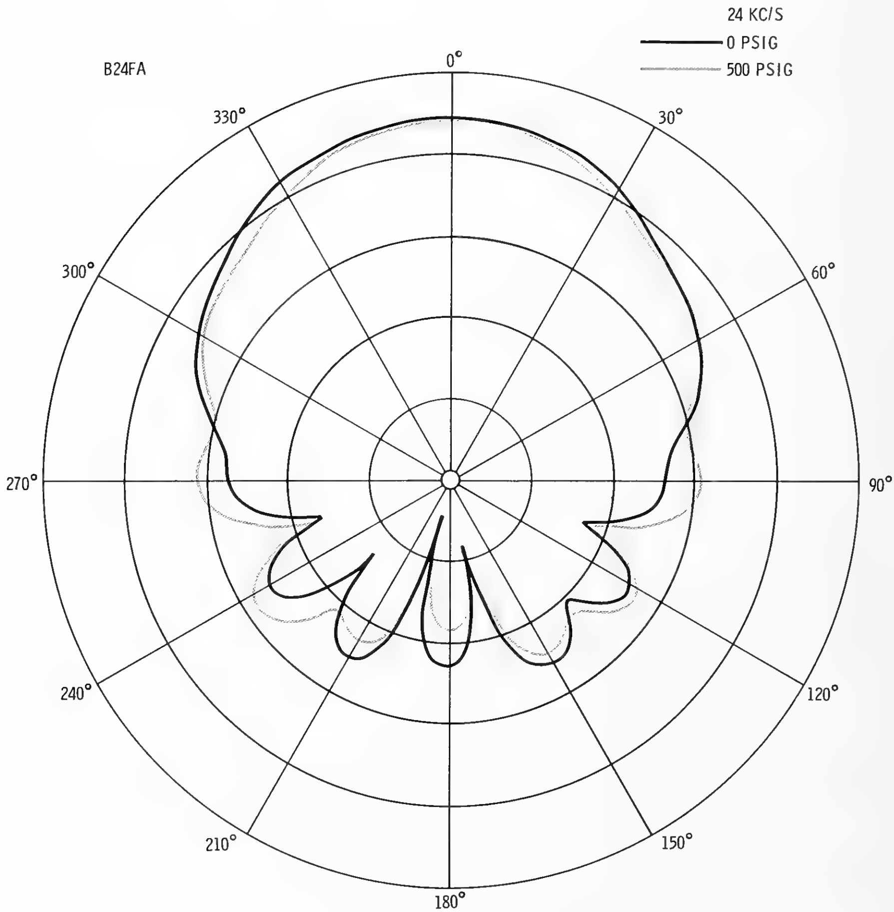
PRESSURE VESSEL SPECIFICATIONS

(Complete specifications are provided by drawing 153-SSK-1001, Rohr Corporation, Riverside, California.)

OPERATING PRESSURE	800 psig, max
METAL COMPONENTS	4340 steel
FIBER GLASS	S99-4, with tensile strength of 600,000 psi
RESIN	Union Carbide ERL-2772, cured with 22L-0820 hardener
VESSEL INNER SURFACE	Rubber
VESSEL OUTER SURFACE	Compliant plastic, Furane Plastics Company, 100 parts Epocast 202 to 150 parts 9615 hardener
DRAIN VALVE	Atkomatic Dymo Company, solenoid model EWPCV, with watertight case
ELECTRICAL CONNECTIONS	Marsh Marine XSK3PML 3-terminal pressure panel mount
WATER PUMP	Sprague air-actuated piston pump model S216C; hydraulic pressure is 10 times air pressure (50-psig air pressure provides 500-psig water pressure)
LIFE SPAN	1000 cycles over 10 years

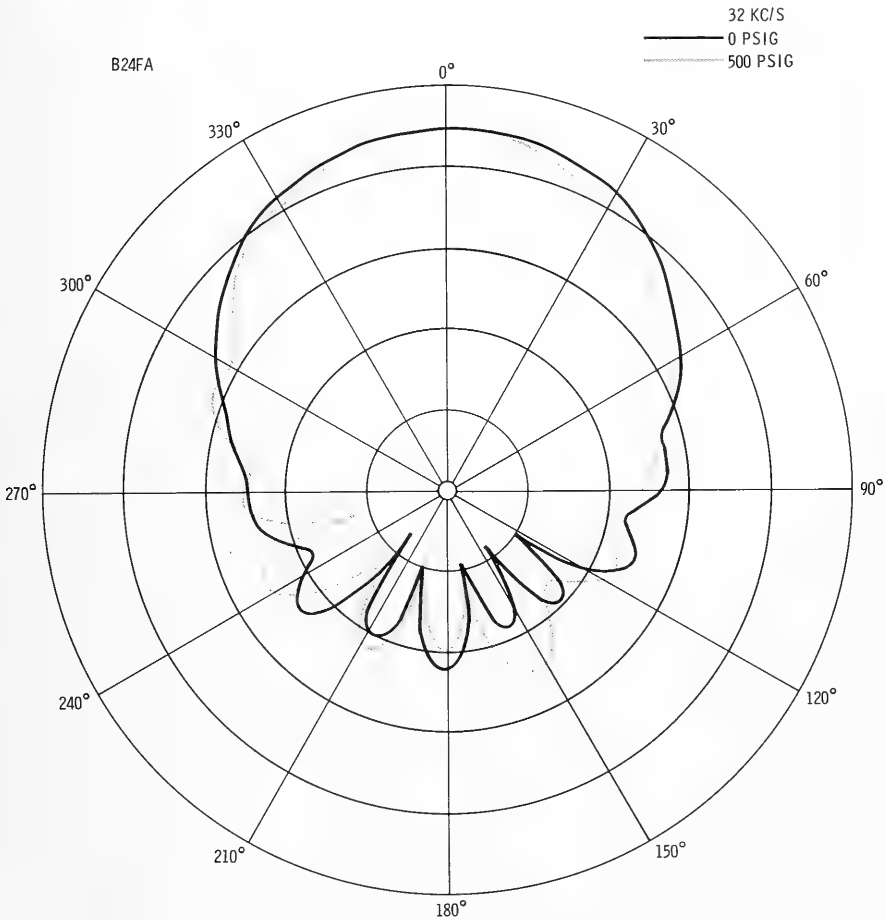
TESTS OF THE B24FA TRANSDUCER

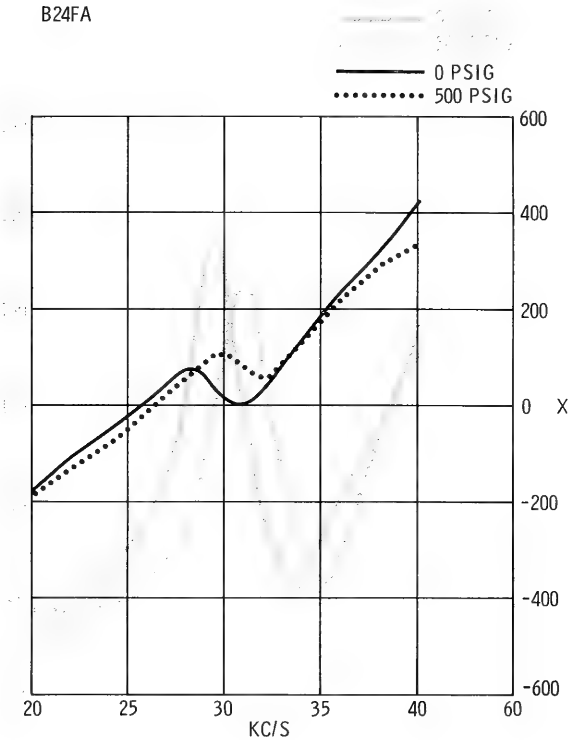
The B24FA transducer was designed for use on submarines at varying depths. A test transducer was calibrated at shallow depth at Transdec, repeatedly pressurized



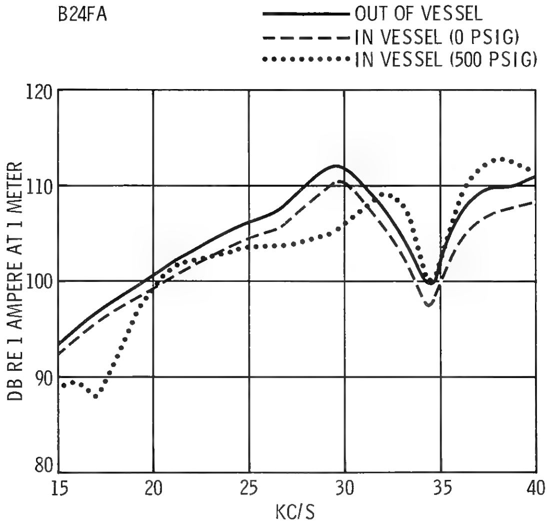
Directivity patterns for 0 and 500 psig are very similar at 24 and 32 kc/s.

to prove mechanical soundness, and calibrated again at shallow depth. No deterioration was revealed by this cycling. Transmitting response and impedance at 0 psig were the same before and after pressurization. However, test results demonstrate that transducer performance differs profoundly from surface to deep-sea operation.





Complex impedance is sufficiently changed by pressurization to detune the transducer and thereby change driver requirements.



Transmitting response therefore is markedly different at 500 psig.

CONCLUSIONS

The acoustic pressure vessel can be used on the regular calibration column for testing frequency response, directivity, and impedance of transducers. Water pressure can be controlled to any value up to 800 psig. The effect of the presence of the vessel is negligible for frequencies below 8 kc/s and predictable for frequencies up to 1 Mc/s. Calibration can be accomplished by cw or pulse at lower frequencies; however, pulse technique must be used above 8 kc/s for accurate readings.

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2. Transducers - Test results

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