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TITLE

WATER DEPTH AND DRIVE VOLTAGE DEPENDENCE OF THE ACOUSTIC PARAMETERS OF A BARREL-STAVE FLEXTENSIONAL PROJECTOR

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ABSTRACT

Water depth and drive voltage dependence of the acoustic parameters of a barrel-stave flextensional projector. Dennis F. Jones (Defence Research Establishment Atlantic, Dartmouth, Nova Scotia, Canada B2Y 3Z7) and Mark B. Moffett (Naval Undersea Warfare Center, New London, Connecticut, 06320)

A low-frequency barrel-stave flextensional projector for sonar and general underwater acoustics applications has been built at the Defence Research Establishment Atlantic in Dartmouth, Nova Scotia. The projector was calibrated at the Seneca Lake sonar test facility at Dresden, NY, as a joint research venture with the Naval Undersea Warfare Center, New London, Connecticut. The transmitting voltage response (TVR), mechanical quality factor (Q_m), electrical admittance, and electroacoustic efficiency (η_{ea}) were measured for driving voltages up to 5.0 kVrms at four depths: 30, 61, 91, and 123 m. At 5.0 kVrms, the resonance frequency (f_o) increased from 780 Hz to 840 Hz, Q_m decreased from 4.4 to 3.3, and η_{ea} decreased from 87% to 71%, as the depth was increased from 30 m to 123 m. The change in each acoustic parameter, averaged over the four depths of interest, was -10 Hz/kVrms for f_o, +0.4 dB/kVrms for the TVR at resonance, and +0.1 /kVrms for Q_m, as the driving voltage was increased from 0.1 to 5.0 kVrms. The dependence of the parameters on depth and driving voltage are discussed in terms of the interactions between the rubber boot and the staves. [Work sponsored in part by the US Office of Naval Research.]

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Telephone number: 902-426-3100 ext. 187 (D.F. Jones)
Send notice to: D.F. Jones

National Defence
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Bureau de Recherche
et Développement

Water Depth and Drive Voltage Dependence of the Acoustic Parameters of a Barrel-Stave Flextensional Projector

by

D.F. Jones and *M.B. Moffett
(*Naval Undersea Warfare Center)

Defence
Research
Establishment
Atlantic

Centre de
Recherches pour la
Défense
Atlantique

Canada

Overview

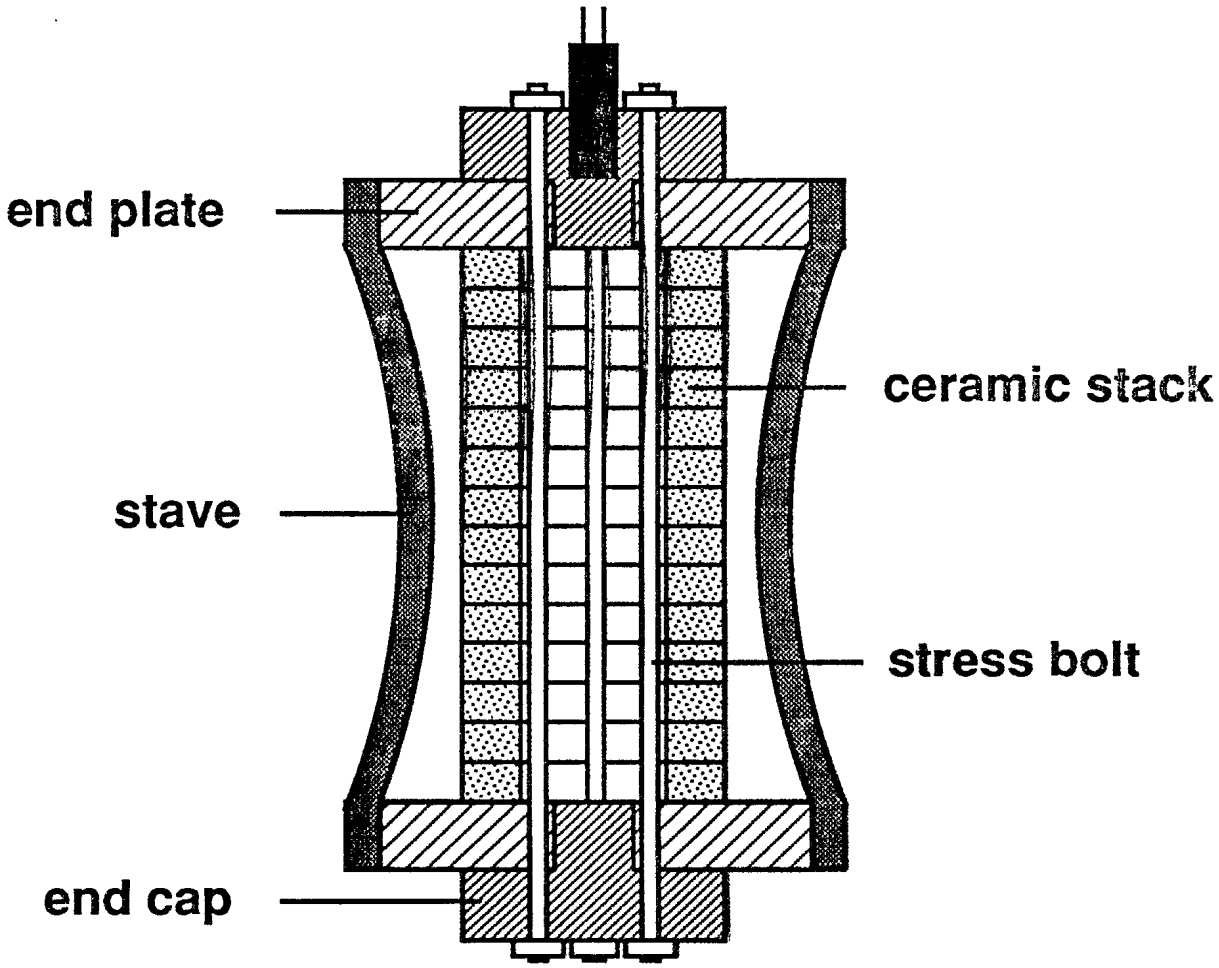
Barrel-stave projector construction

Measured acoustic parameters

Effects of rubber boot

Future work

BARREL-STAVE PROJECTOR

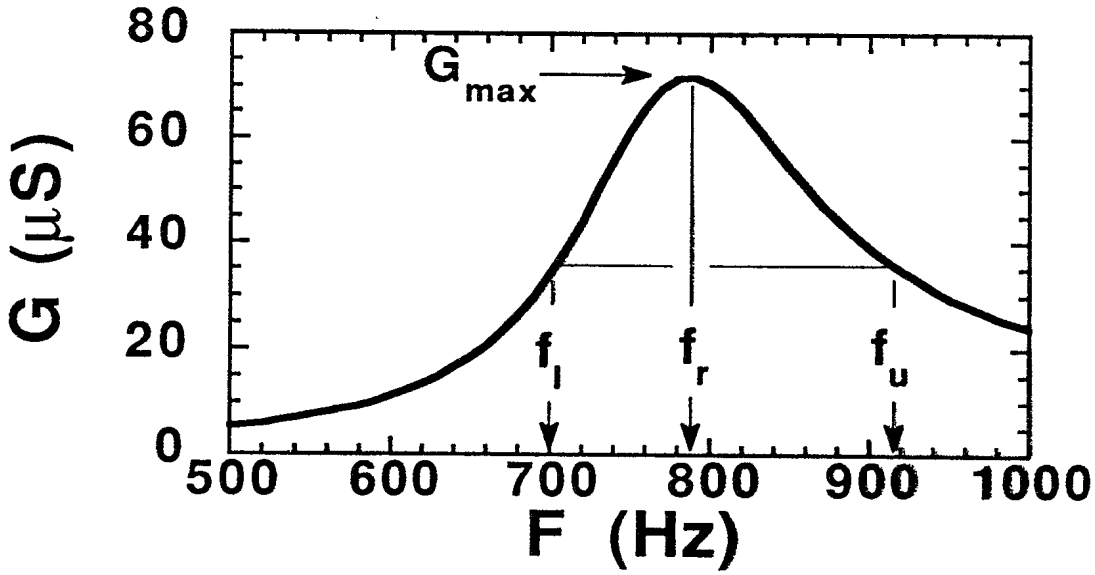


ELECTRICAL PARAMETERS

1. <u>Admittance</u>
   The electrical admittance is broken down into the conductance (G) and the susceptance (B) so that

$$Y = G + iB$$

   where Y, G, and B are in Siemens (S).



MECHANICAL PARAMETERS

1. <u>Resonance Frequency</u>
   Lowest flexural mode of the large barrel-stave projector ($f_r \approx 800$ Hz). Found from maximum conductance.

2. <u>Bandwidth</u>
   The bandwidth is the difference between the frequencies where the conductance falls to one half the maximum G. It is denoted by $f_u - f_l$.

3. <u>Mechanical Quality Factor</u>
   The mechanical quality factor, Q_m, shows the sharpness of the resonance of an untuned transducer. It is found from the G curve:

$$Q_m = f_r / (f_u - f_l).$$

ACOUSTIC PARAMETERS

1. <u>Transmitting Voltage Response</u>
   The TVR is the acoustic output of a projector for an input of 1 Vrms. The TVR is referenced to 1 m and 1μPa, hence the unit (dB re 1μPa/V @ 1m).

2. <u>Directivity Index</u>
   Improvement in signal to noise ratio by using a directive projector rather than an omnidirectional one.

$$DI = 10 \log D$$

For an omnidirectional source, D=1 and DI=0 dB.

CALCULATED PARAMETERS

1. Source Level
   The SL is the acoustic output of a projector at higher drive voltages.

$$SL = TVR + 20 \log V_{in}$$

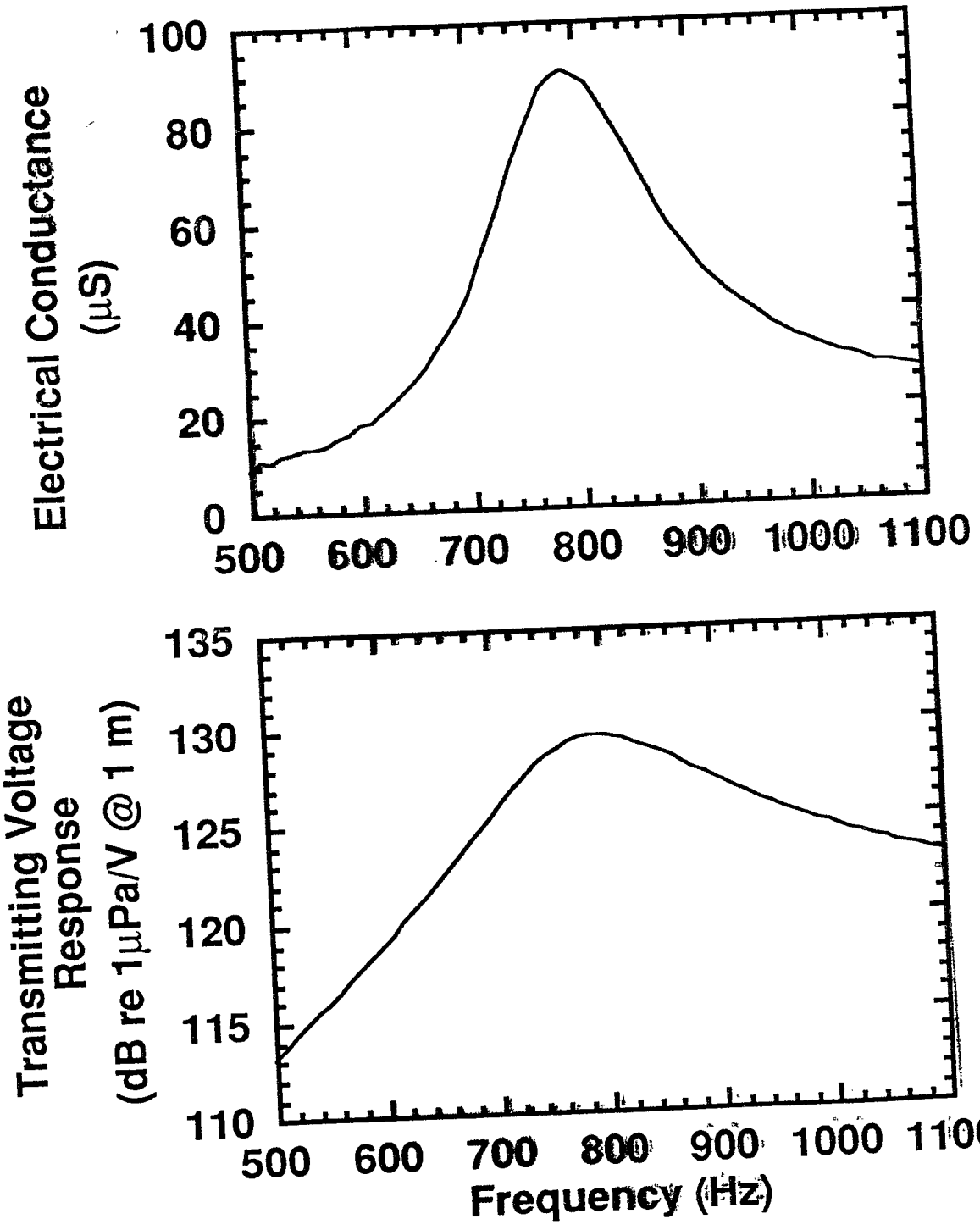
   The unit is (dB re 1μPa @ 1m).

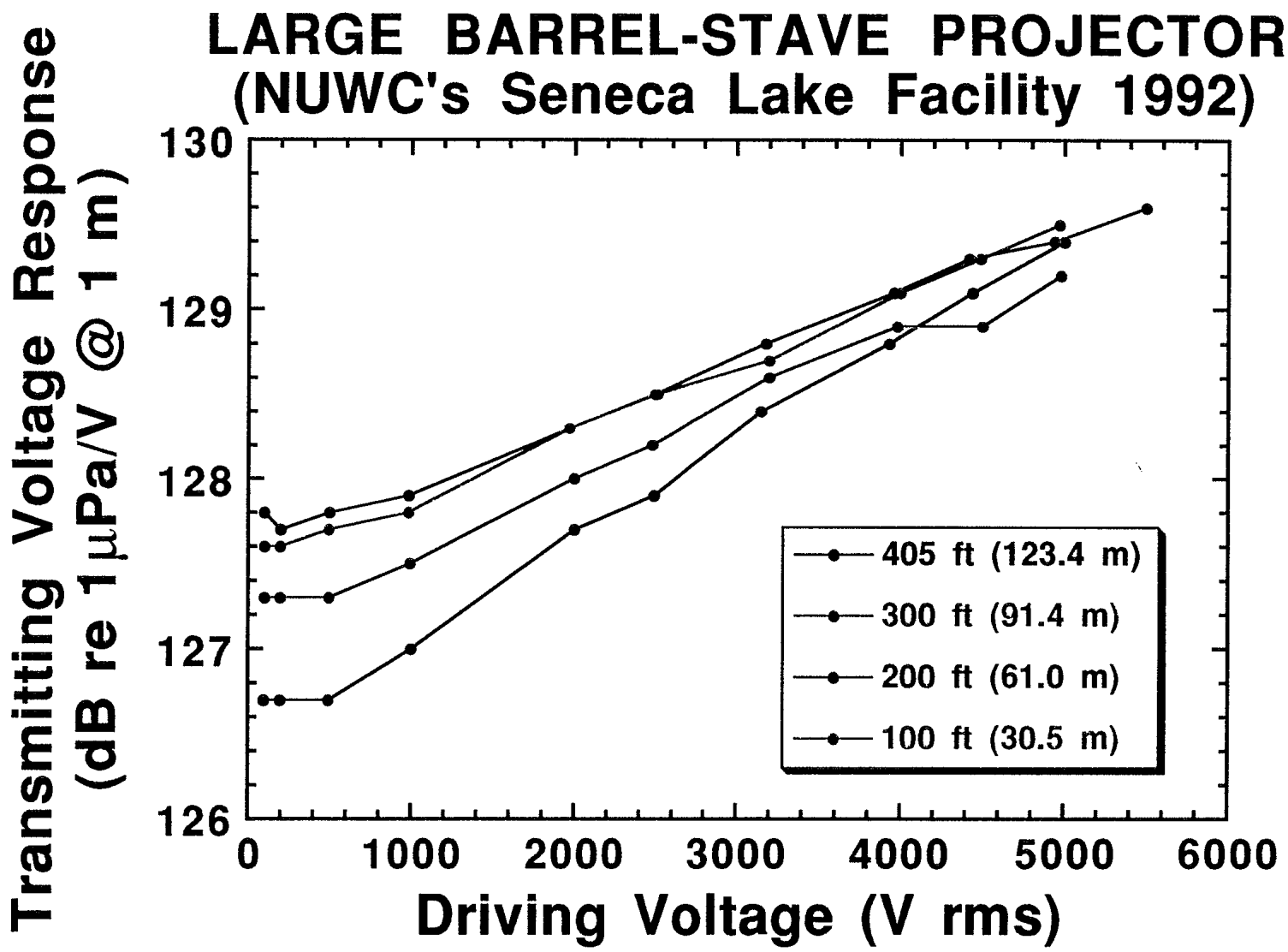
2. Electroacoustic Efficiency
   The ratio of the acoustic power generated to the total electrical power input. Can be calculated in % using

$$\eta = 100\% \times 10^{[TVR - DI - 10 \log(\rho c G / 4\pi) - 120]/10};$$

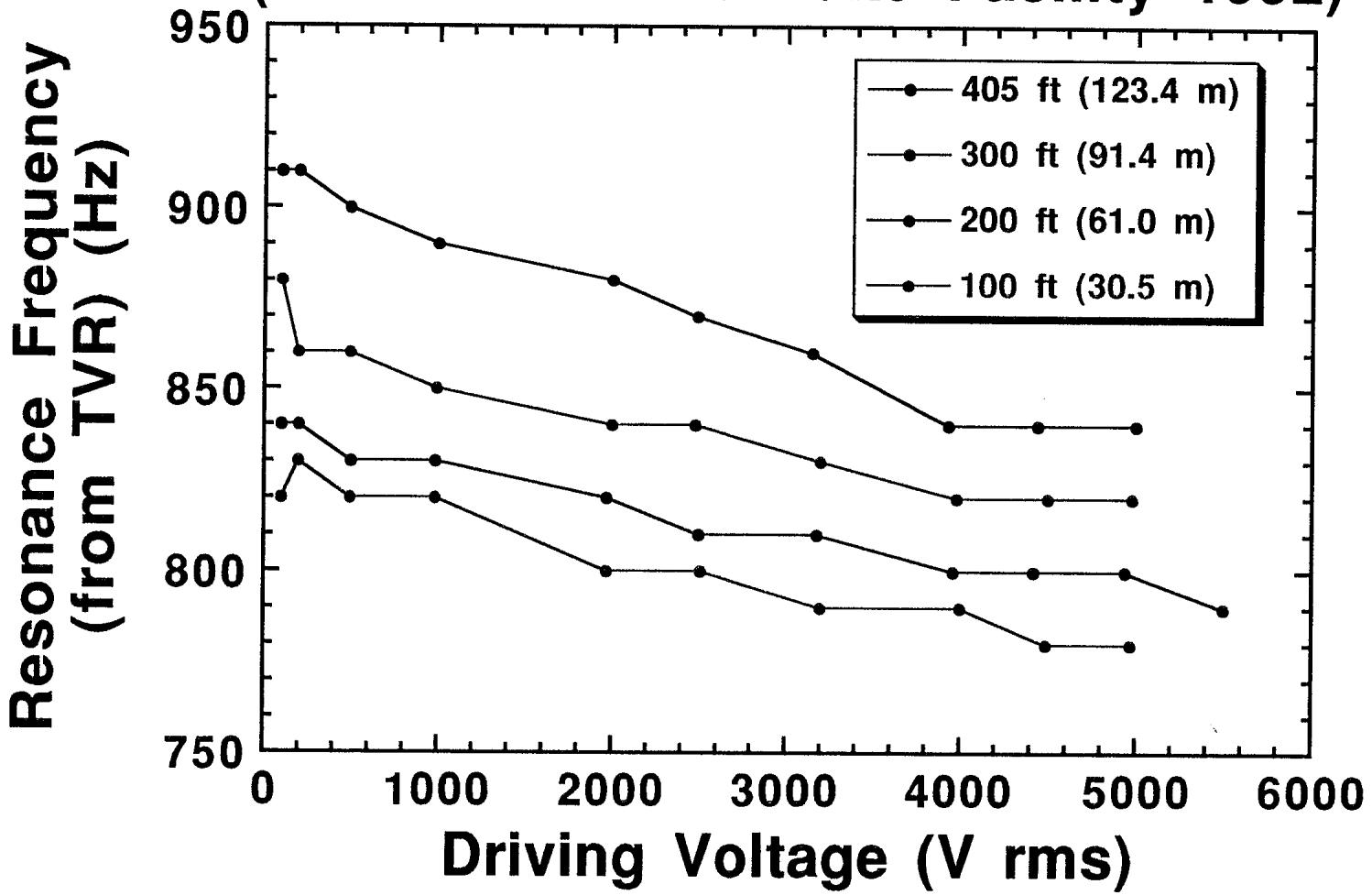
   water density (ρ), sound speed (c).

Measured G and TVR
(@ 61 m depth & 5 kV rms drive)

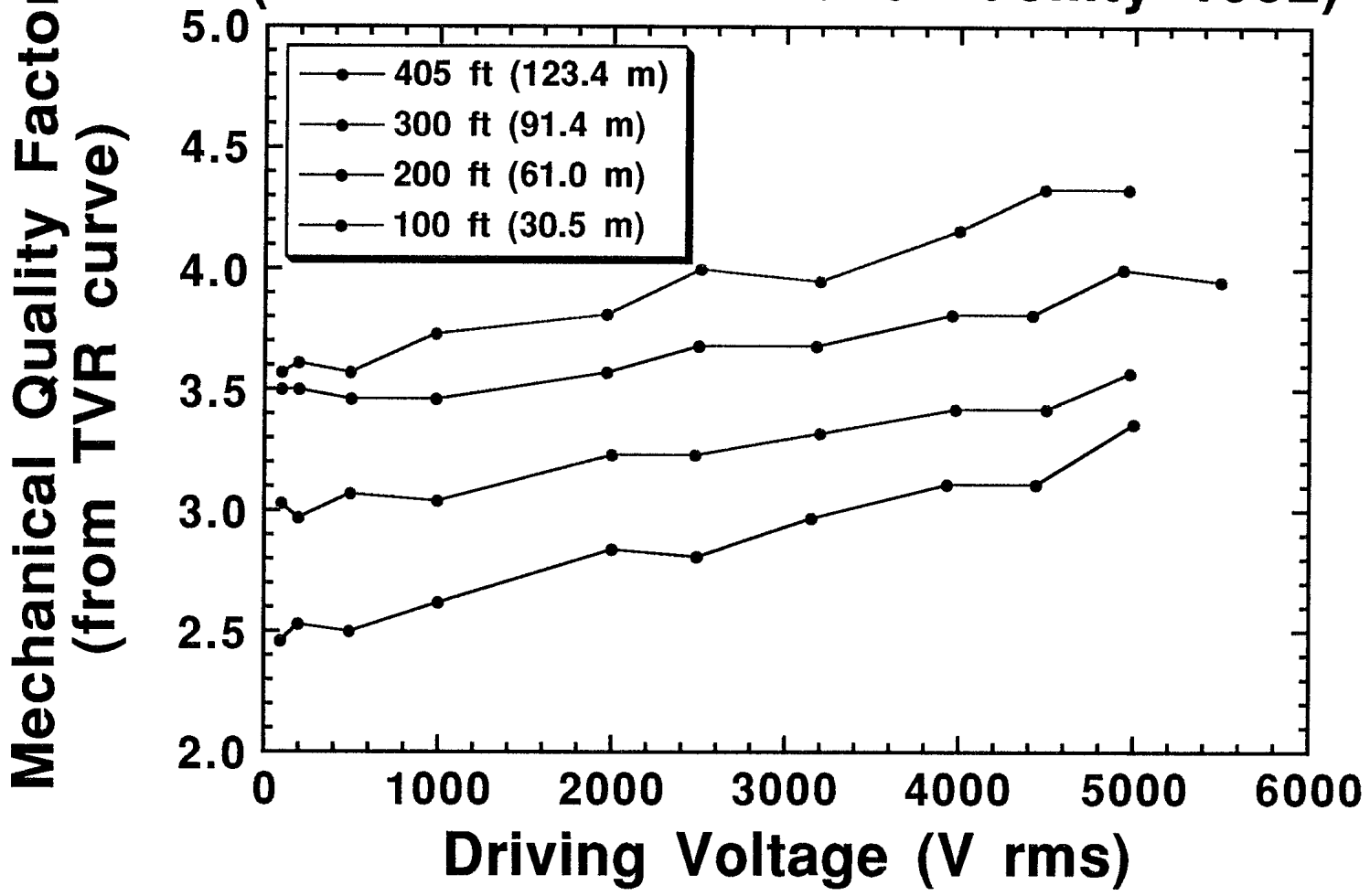



LARGE BARREL-STAVE PROJECTOR
(NUWC's Seneca Lake Facility 1992)
Transmitting Voltage Response
(dB re 1 µPa/V @ 1 m)
130
129
128
127
126
0
1000
2000
3000
4000
5000
6000
Driving Voltage (V rms)
405 ft (123.4 m)
300 ft (91.4 m)
200 ft (61.0 m)
100 ft (30.5 m)

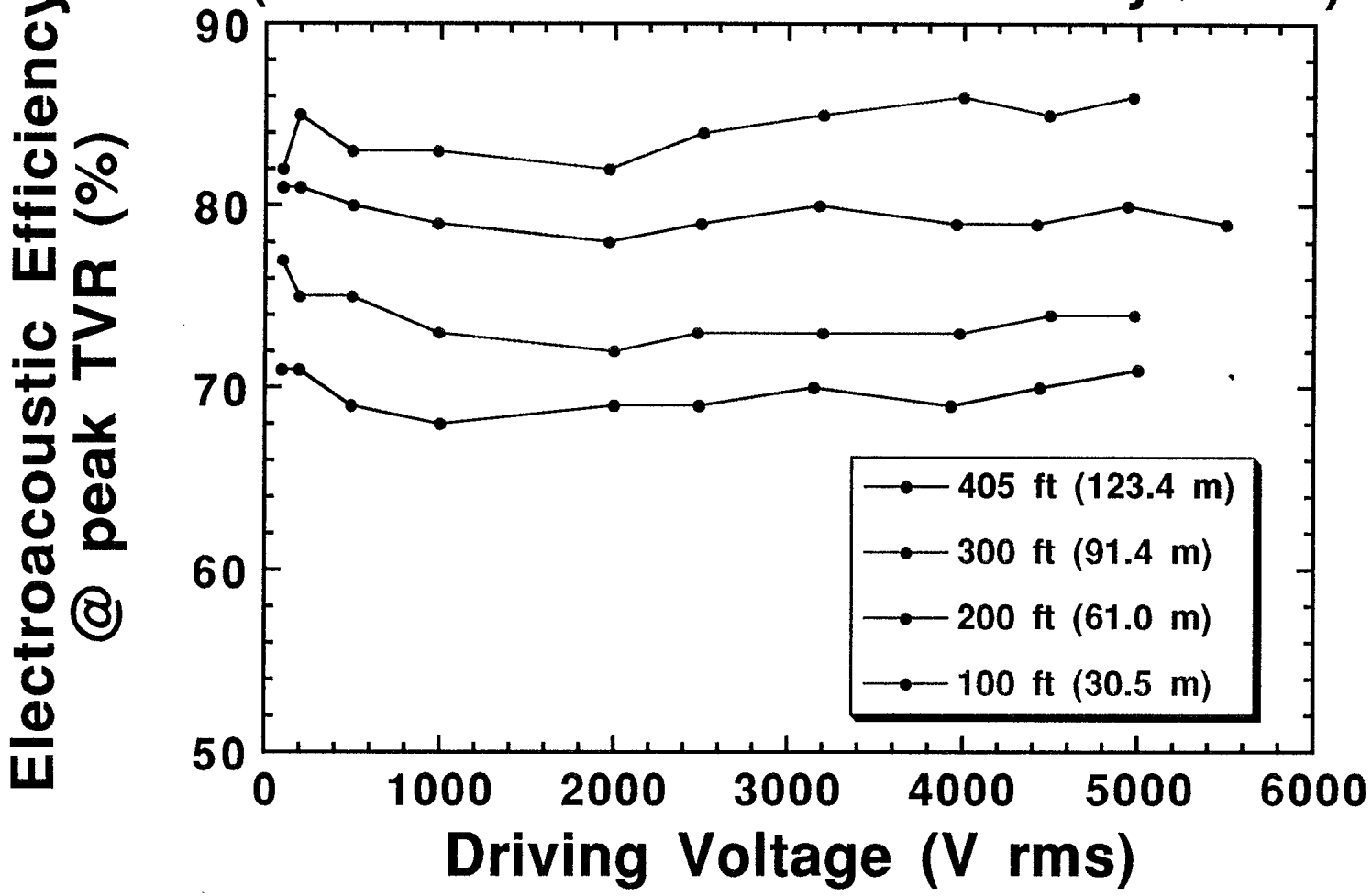
LARGE BARREL-STAVE PROJECTOR
(NUWC's Seneca Lake Facility 1992)



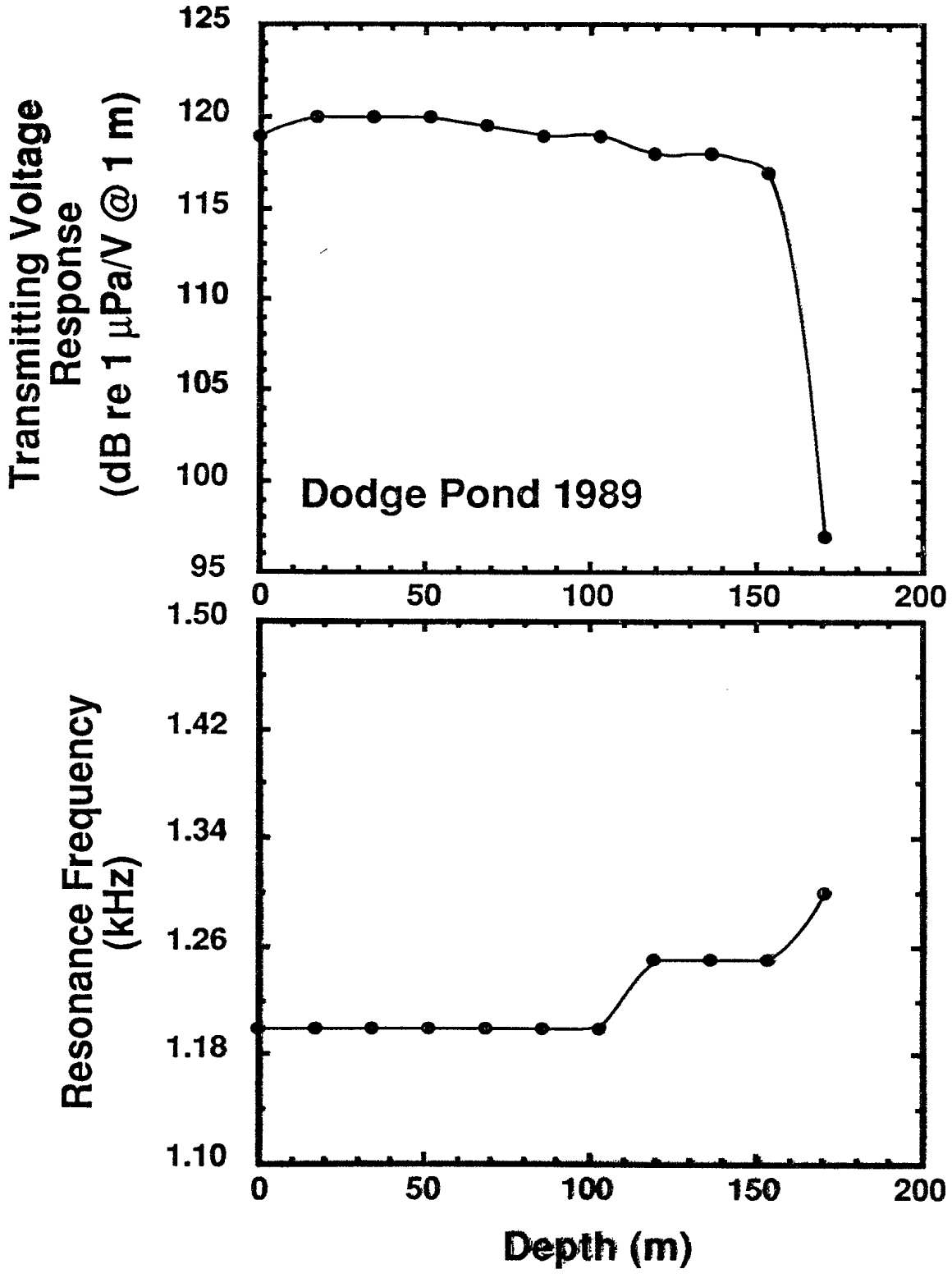
LARGE BARREL-STAVE PROJECTOR
(NUWC's Seneca Lake Facility 1992)



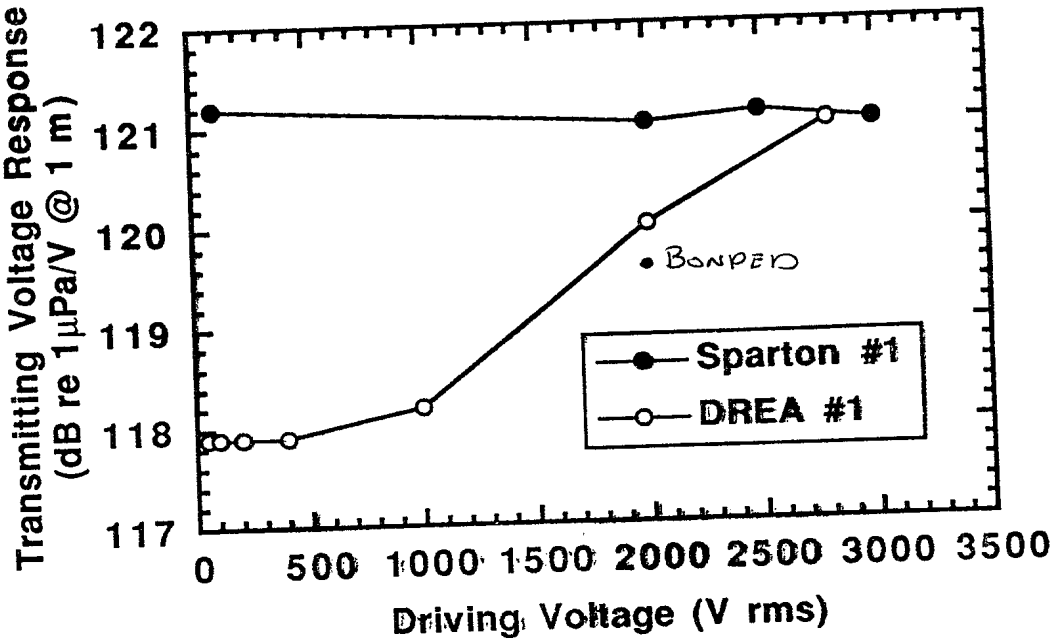
LARGE BARREL-STAVE PROJECTOR
(NUWC's Seneca Lake Facility 1992)

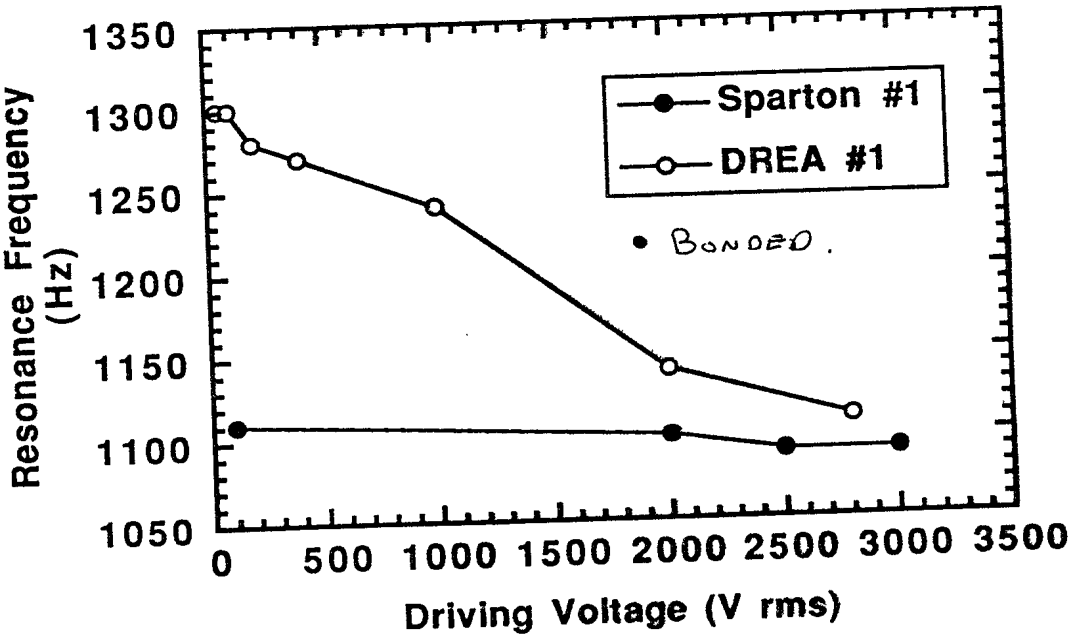


Small Barrel-Stave Projector #8



Bonded vs Unbonded Boots





Summary

Obtained a source level of 204 dB for an input driving voltage of 5.5 kV rms (4 kV/cm or 10 V/mil) at 790 Hz, 80 % efficiency, in 61 m (200 ft) of water.

Acoustic parameters vary with drive voltage and water depth. These non-linearities are thought to be boot related.

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