Chapter 1

GENERAL INFORMATION

INTRODUCTION

The purpose of this catalog is to assist activities engaged in underwater acoustic measurements to select and obtain transducers that will aid them in their measurements. Collectively these are referred to as reference transducers.

Data on each type of reference transducer is presented and information is given on how to obtain transducer services from the Underwater Sound Reference Detachment (USRD) of the Naval Research Laboratory. This catalog contains much of the information presented previously in NRL Report 7735, "Twenty Years of Electroacoustic Standards," published in 1974, and the USRD Transducer Catalogs of 1982 and 1991. The information has been revised, newer transducer types added, and obsolete transducers removed.

Because measurements of underwater sound are very vulnerable to error and inaccuracies, users of any USRD reference transducers are urged to read all of this introductory and other general information as well as any appendix that is referred to in the descriptions of the individual transducer types.

TRANSDUCER CHARACTERISTICS

The primary objective of the USRD's reference transducer program has been the design of transducers whose characteristics are stable and predictable. Sensor elements have been kept as simple as possible. Where feasible, pressure-release materials such as corprene, air-cell rubber, and other materials whose acoustic characteristics change markedly as a function of temperature and pressure have been avoided.

In general, sensor materials such as piezoelectric crystals or ceramics usually are more consistent and predictable than are the mechanical mountings, housings, potting compounds, and elastomers used in transducer construction; it is the latter that accounts for most of the deviations from average or typical performance. In addition, deliberate changes in electronic components, housing materials, and cable types and lengths of newly built transducers will affect sensitivities and responses that deviate from older typical data.

The USRD continues to use lithium sulfate crystals for some of its reference transducers because the piezoelectric constants of this crystal are very stable under varying temperatures and hydrostatic pressures. Also, it does not require that some surfaces be acoustically masked with pressure-release materials when used in simple configurations such as disks or blocks. Lead metaniobate piezoceramic also has this advantage, but PZT does not. It is for this reason that PZT is used in more complex configurations (e.g., capped cylinders). References 1-3 provide more information on this subject.

Electrodynamic or moving coil transducers constitute a small minority of underwater electroacoustic transducers, but they also serve as the only practical wideband sound sources for audio and infrasonic frequencies. They are much different in design and construction from piezoelectric types and have their own set of problems (see the section on J-series transducers for more details).

MEASUREMENTS

All calibration measurements at the USRD are made in compliance with American National Standards. Theory and practice are described in Refs. 5 and 6. The standard practice for transducer orientation is given in Appendix A. A variety of information and data are provided herein for each type. However, the key information is usually the sensitivity or response together with the frequency range. Comments about these parameters follows.

Free-Field Voltage Sensitivity (FFVS)

The FFVS is the primary parameter for standard hydrophones and for the basic measurement of sound pressures. It provides the ratio of the hydrophone output voltage to the input free-field sound pressure at the point where the acoustic center of the hydrophone is placed. Note that the free-field sound pressure is that existing at the point *before* the hydrophone is put in place. If the hydrophone is not omnidirectional (e.g., Type H52) the acoustic axis must be facing toward the sound source. Of particular importance is the measurement requirement that the output voltage be measured as the "open-circuit" voltage! In practice this means that the first amplifier, oscilloscope, or other instrument in the receiving system must have an input impedance well into the megohm range. An ideal theoretical FFVS for a small piezoelectric hydrophone is shown in Fig. 1a along with perturbations in practical cases.

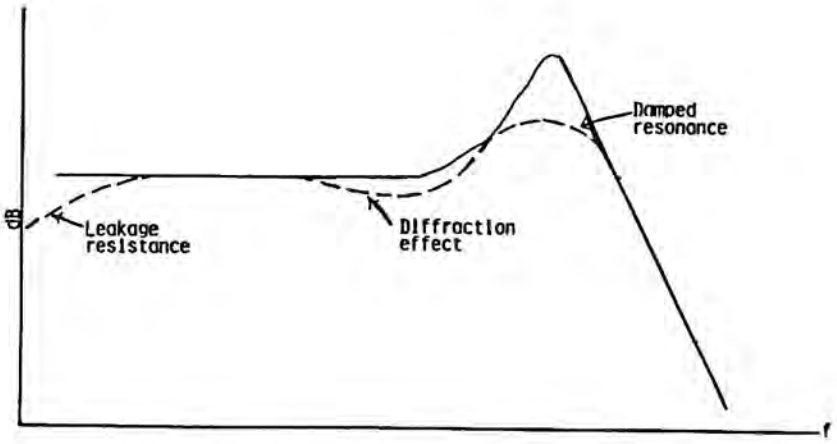

Fig. 1a - Theoretical (solid line) and practical (dashed line) receiving sensitivity of a small piezoelectric hydrophone (Types A and H).

Transmitting Current Response (TCR)

The TCR is the parameter that has a reciprocal relationship with the FFVS. See section 2.3 of Ref. 4 for more about reciprocity. The USRD discourages the use of any transmitting response to produce a known sound pressure. Such a method is vulnerable to error due to the always imperfect free-field and far-field conditions. The TCR is useful in providing only approximate sound levels and for monitoring or troubleshooting purposes. For the special case of electrodynamic transducers (or J series) the TCR is more useful than the transmitting voltage response (TVR) because a constant current produces an approximately constant sound pressure at frequencies above the basic resonance, which is

always at the low end of the frequency range. Figure 1b shows an ideal TCR for an electrodynamic transducer along with the affect of a typical damped resonance.

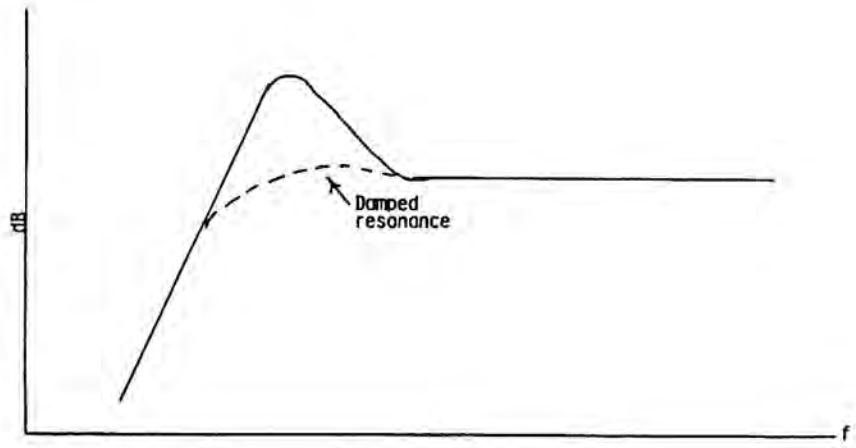

Fig. 1b - Transmitting current response (TCR) of an electrodynamic (or moving coil) transducer.

Transmitting Voltage Response (TVR)

The TVR is usually used with piezoelectric transducers because voltage is a more commonly and easily used parameter than is current. It is related to the TCR via the transducer impedance and Ohm's law. Figure 1c shows an ideal theoretical TVR for a piezoelectric transducer.

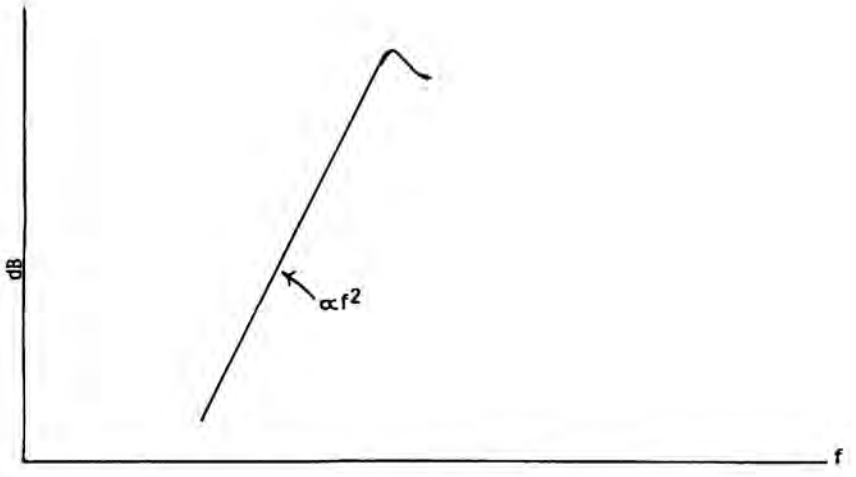

Fig. 1c - Transmitting voltage response (TVR) of a piezoelectric transducer (Types E, F, and G).

Voltage Coupling Loss

Formerly the voltage coupling loss was a measurement made with any hydrophone with a preamplifier. With the now widespread use of reliable solid state circuits the USRD considers this

measurement to be obsolete, even though some of its hydrophones still have the circuitry for this measurement. All USRD standard hydrophone calibrations are now made with reference to end-of-cable voltage measurements. Other users of these hydrophones who still use voltage coupling loss measurements for calibration, troubleshooting, or monitoring purposes are referred to Appendix B for details and precautions about this measurement.

Cable Lengths

The cable length can have a significant effect on the response and sensitivity of reversible piezoelectric transducers. For hydrophones with preamplifiers and reversible electrodynamic transducers the effect will be minor and usually negligible. With few exceptions the standard cable length for USRD reference transducer is 30 m. Other cable lengths are available at special request and with additional costs. The additional cost depends on (a) the labor cost for any cable change, (b) the cost of extra cable if longer lengths are requested, and (c) the cost of a new calibration if one is requested.

UNITS

The USRD uses all SI units. However, in recognition of the slow adoption of these units in some areas of engineering and commerce, a conversion table for units of pressure and length is given in Appendix C and page 11 of Ref. 5 (both metric and English units are given in some parts of this catalog).

MODEL DESIGNATIONS

Transducers developed at the USRD have been designated in the same manner for about 40 years. The letter prefix indicates the general type and the digits denote the model number within that type. The general types are given below

PREFIX	TYPE
A	Probe hydrophones
E	High-frequency transducers (above 150 kHz)
F	Reversible piezoelectric transducers for high-audio and low-ultrasonic frequencies
G	Miscellaneous or unconventional
H	Hydrophones with preamplifiers
J	Electrodynamic (or moving coil) projectors

SERVICES INFORMATION

Eligible Users

USRD transducers are available to

1. Naval activities upon direct request to the USRD.
2. Contractors when a valid DoD contract is cited and the contractor's request is endorsed by the administrative

contracting officer and forwarded directly to the USRD.

3. Other federal and state government activities when providing requested services will not interfere with Navy work.
4. Other private activities when providing requested services will not interfere with Navy work, and with a surcharge of 10 to 20%.

Cost

A per-annum service fee is charged to the user in an amount that varies among the transducer types and is periodically changed. The amount can be learned by calling the appropriate telephone number shown at the beginning of the catalog. Services are performed on a cost-reimbursable basis, and all fiscal policies are subject to change without notice. The service fee covers the cost of calibration, repair, and maintenance of the transducer. Use for periods shorter than one year still requires the full per-annum fee to be paid since the fee is based on costs that are generally not time related. A replacement is provided if the transducer fails or is damaged during the service period. Transducers are normally returned to the USRD after one year, even if continued use is requested, for preventive maintenance and recalibration.

An exception is made to the above cost policy for a few of the very large and expensive J-series transducers where service is based on three- or six-month periods to maximize use and minimize costs.

Selection Information

The staff at the USRD can assist in selecting the appropriate transducer if you provide such relevant information as frequency range, intended use, directivity, environmental conditions, etc., when you call. Figure 2 is an aid for selecting transducers. The specific type requested will be furnished, if available.

An individual calibration is furnished with each standard hydrophone. For this practice, the E-series transducers are considered to be standard hydrophones. A typical calibration is furnished with each reversible transducer. However, if the user intends to use a reversible transducer as a standard hydrophone an individual calibration is available upon request and at extra cost.

An instruction book is also furnished with each transducer or portable calibrator.

Delivery

Generally, an off-the-shelf transducer should be requested three to four weeks before a required delivery date. Special requests, as for additional cable, require longer lead times.

Specialized Transducers

When a measurement transducer is needed with special design features that are not available in the regular USRD inventory, the USRD will (as an added service) develop, design, and build such transducers given sufficient time.

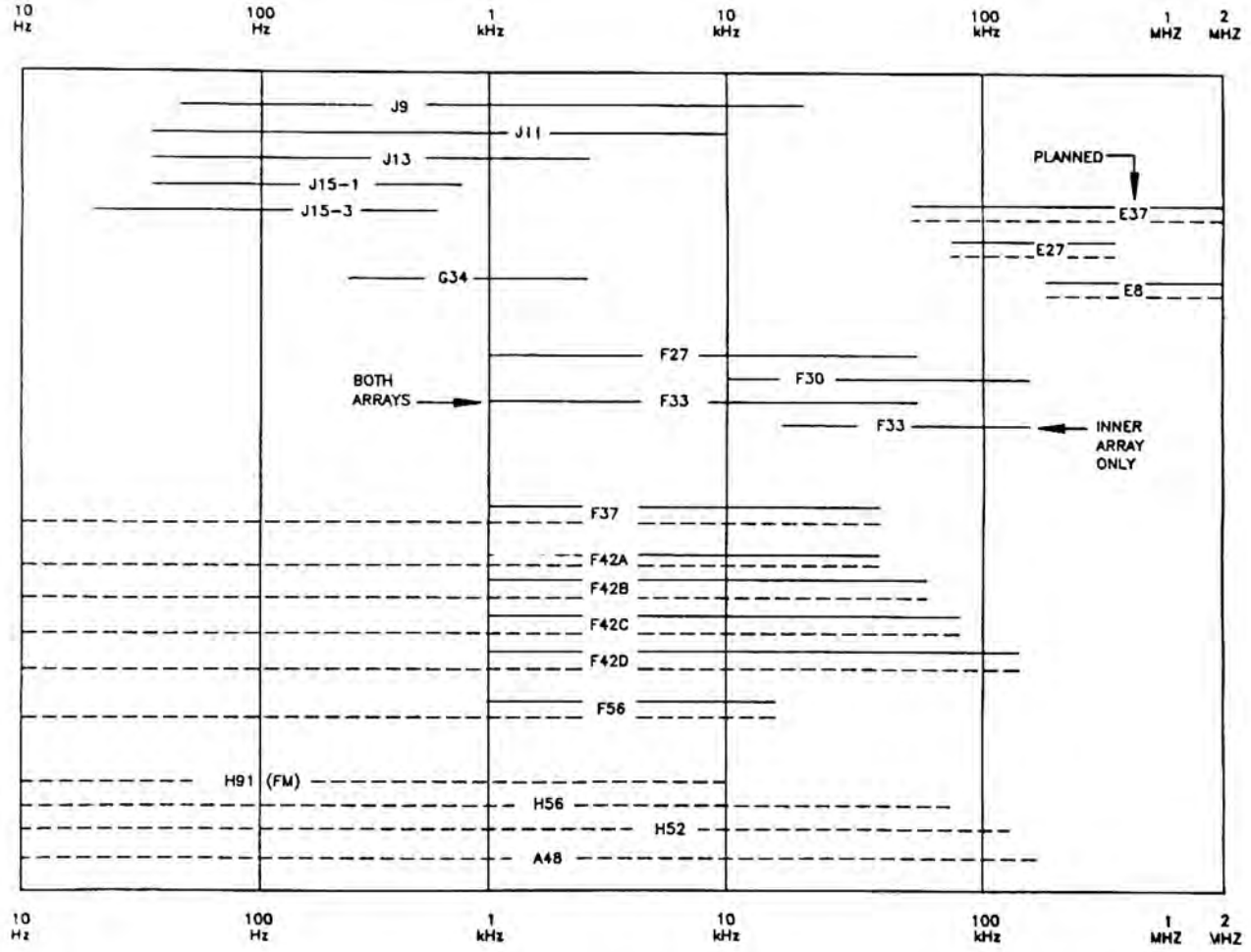

Fig. 2 - Frequency ranges of reference transducers available from the USRD.
Solid line: frequency range as source. Dashed line: frequency range as receiver.