

	SURFACE VEHICLE INFORMATION REPORT	
	SAE	J1782 MAY2013
	Issued 1981-11 Reaffirmed 2013-05 Superseding J1782 NOV2006	
Ship Systems and Equipment - Hydraulic Systems - Noise Control		

RATIONALE

J1782 has been reaffirmed to comply with the SAE five-year review policy.

1. Scope—Hydraulic systems are used on marine vehicles for steering, vehicle control, and utility services. System components that generate and transmit noise are of concern. This SAE Information Report (a) addresses noise requirements which may apply to the hydraulic systems of ships and submersibles, and (b) identifies noise sources and techniques which may be used to reduce system noise. Noise of power sources (e.g., electric motors) and end items (e.g., steering linkages) is beyond the scope of this document.

1.1 Purpose—The purpose of this document is to summarize design information on how to reduce noise of on-board hydraulic systems.

1.2 Application—This document is applicable to the marine vehicles using hydraulic systems. This document does not apply to recreational watercraft.

1.3 Rationale—This document has been reaffirmed to comply with the SAE 5-Year Review policy.

2. References

2.1 Applicable Publications—The latest issue of the referenced documents should be used. Nothing in this document supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 INDUSTRY PUBLICATIONS—Industry publications that have been adopted by the Department of Defense (DoD) can be ordered by DoD activities only from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-2179, <http://assist.daps.mil> or <http://stinet.dtic.mil>.

2.1.1.1 SAE Publications—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

SAE J1778—Ship Systems and Equipment—Recommended Practice for Hydraulic Fluid Selection
 SAE AS5440—Hydraulic Systems, Aircraft, Design and Installation Requirements for

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SAE reviews each technical report at least every five years at which time it may be revised, reaffirmed, stabilized, or cancelled. SAE invites your written comments and suggestions.

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- 2.1.1.2 *ASA Publications*—Available from the Acoustical Society of America, Standards and Publications Fulfillment Center, P.O. Box 1020, Sewickley, PA 15143-9998, <http://asa.aip.org>.

ASA 38—Guide for the Evaluation of Human Exposure to Whole-Body Vibration (ANSI S3.18)
ASA 47—Specification for Sound Level Meters (ANSI S1.4)
ASA 65—Specification for Octave, Half-Octave and Third-Octave Band Filter Sets (ANSI S1.11)
ASA 107—Guidelines for the Specification of Noise of New Machinery (ANSI S12.16)
ASA 111—Acoustical Terminology (ANSI S1.1)

- 2.1.1.3 *IMO Publication*—Available from International Maritime Organization, 4 Albert Embankment, London SE1 7SR, United Kingdom, Tel: +44-0-20-7735-7611, www.imo.org.

IMO Resolution A.468(XII)—Code on Noise Levels on Board Ships (part of Publication IMO-814E)

- 2.1.1.4 *ISO Publications*—Available from ANSI, 25 West 43rd Street, New York, NY 10036-8002, Tel: 212-642-4900, www.ansi.org.

ISO 4412-1—Hydraulic fluid power—Test code for determination of airborne noise levels—Part 1: Pumps
ISO 4412-2—Hydraulic fluid power—Test code for determination of airborne noise levels—Part 2: Motors
ISO 4412-3—Hydraulic fluid power—Test code for determination of airborne noise levels—Part 3: Pumps—Method using a parallelepiped microphone array
ISO 10767-1—Hydraulic fluid power—Determination of pressure ripple levels generated in systems and components—Part 1: Precision method for pumps
ISO 10767-2—Hydraulic fluid power—Determination of pressure ripple levels generated in systems and components—Part 2: Simplified method for pumps
ISO/TR 11688-1—Acoustics—Recommended practice for the design of low-noise machinery and equipment—Part 1: Planning
ISO/TR 11688-2—Acoustics—Recommended practice for the design of low-noise machinery and equipment—Part 2: Introduction to the physics of low-noise design

- 2.1.1.5 *NFPA Publication*—Available from the National Fluid Power Association, 3333 North Mayfair Road, Suite 211, Milwaukee, WI 53222-3219, Tel: 414-778-3344, www.nfpa.com.

NFPA/T2.7.2—Hydraulic Fluid Power—Pumps—Determination of Fluid Pressure Fluctuation Characteristics (to be replaced with ISO 10767-2)

- 2.1.1.6 *SNAME Publication*—Available from the Society of Naval Architects and Marine Engineers, Publication Sales, 601 Pavonia Avenue, Jersey City, NJ 07306, Tel: 201-798-4800, www.sname.org.

SNAME TRB 3-37—"Design Guide for Shipboard Airborne Noise Control," SNAME Technical and Research Bulletin 3-37

2.1.2 U.S. GOVERNMENT PUBLICATIONS

- 2.1.2.1 *Military Specifications and Standards*—Available from DODSSP, Customer Service, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-2179, <http://assist.daps.mil> or <http://stinet.dtic.mil>.

MIL-STD-740-2—Structureborne Vibratory Acceleration Measurements and Acceptance Criteria of Shipboard Equipment
MIL-STD-1474—Noise Limits
MIL-M-24476—Mounts, Resilient: Pipe Support, Types 7M50, 6M150, 6M450, 6M900, and 5M3500

2.1.2.2 Other U.S. Government Publications

- 2.1.2.2.1 CFR Publication—Available from internet site <http://www.osha.gov> or from U.S. Government Printing Office, Superintendent of Documents, Mail Stop: SSOP, Washington, DC 20402-9328.
- 29 CFR 1910.95—Occupational Safety and Health Act, 29 CFR 1910.95, "Occupational Noise Exposure"
- 2.1.2.2.2 OPNAVINST Publications—Available from internet site <http://neds.nebt.daps.mil>.
- OPNAVINST 5100.19—Navy Occupational Safety and Health (NAVOSH) Program Manual for Forces Afloat, Vol. 1 - NAVOSH and Major Hazards - Specific Programs, CH B4 Noise Preservation
- OPNAVINST 9640.1—Shipboard Habitability Program
- 2.1.2.2.3 NAVSEA Publications—Available from NAVICP, 700 Robbins Avenue, Attention: Customer Service, Code 0862, Philadelphia, PA 19111, with approval from NAVSEA 05L3, 2531 Jefferson Davis Highway, Arlington, VA 22242-5160.
- NAVSEA S9073-A2-HBK-010—Navy Resilient Mount Handbook: A Users Guide of Design, Installation, and Inspection Information (NSN 0910-LP-000-5250)
- NAVSEA S9078-AA-HBK-010/DIM—Navy Distributed Isolation Material (DIM) Mount Design Handbook (NSN 0910-LP-049-7200)

2.1.3 OTHER APPLICABLE REFERENCES

- Harris, C.M., "Handbook of Noise Control," 3rd Edition, McGraw-Hill, Inc., 1991
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- Shorin, V.P., "The Correction of Dynamic Characteristics of Hydraulic and Gas Lines of Automatic Systems," Fluid Power Transmission and Control—Proceedings of the 2nd International Conference, International Academic Publishers (PRC)/Pergamon Press (outside PRC), 1989
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- Smith, S.E., "FPRC Experimental Survey of Fluid Power Pump Sound Levels," Fluid Power Research Center BFPR Annual Report No. 8, Paper No. P74-5, Oct. 1974
- Taylor, R., "The Effects of Fluid Viscosity and Bulk Modulus on the Flow Ripple Produced by an Axial Piston Pump," Fluid Power Research Center 4th Annual Fire Resistant Hydraulics Conference Papers, 1984, 4:33-38
- Vickers, Inc., "Noise Control in Hydraulic Systems," Vickers Document No. 510, August 1991, Vickers, Inc., P.O. Box 101, Jackson, MS 39206
- Yeaple, F.D., "Fluid Power Design Handbook," 3rd Edition, Marcel Dekker, 1996

3. **Definitions**—For definitions of other terms, see ASA 111.

List of Symbols:

B	bulk modulus of fluid
c	speed of sound
C	capacitance
f	frequency of oscillations
I	intensity of sound power
L	length of tubing
P	pressure of fluid
Q	flow rate
t	time of valve closure
v	velocity of fluid
V	volume of fluid
λ	wave length
ρ	density of fluid
dB	decibel

3.1 **Sound**—Sound is a disturbance which propagates through an elastic medium of bulk modulus (B) and density (ρ) at a speed (c) characteristic of the medium. See Equation 1.

$$c = \sqrt{B/\rho} \quad (\text{Eq. 1})$$

The disturbance consists of a variation in pressure (ΔP) and associated fluid particle displacement, at a velocity (Δv). The variation in pressure and the rate of change in momentum across the disturbance are in dynamic balance. See Equation 2.

$$\Delta P = \rho c \Delta v \quad (\text{Eq. 2})$$

It follows that (see Equation 3)

$$\Delta P / \Delta v = \rho c \quad (\text{Eq. 3})$$

The product ρc is called the characteristic impedance of the fluid.

Table 1 lists typical values in engineering units.

TABLE 1—FLUID CHARACTERISTICS

	c (m/s)	ρ (kg/m ³)	ρc (Pa/(m/s))
Air, 20 °C, Sea Level	343	1.2	412
Typical aircraft petroleum-base fluid	1360	860	1.16×10^6
Water-glycol fluid	1358	1060	1.44×10^6
Sea Water, 15 °C	1507	1027	1.55×10^6

NOTE—The speed of propagation can be reduced by the elasticity of the tubing as much as 10%. SAE J1778 provides additional information for numerous hydraulic fluids.

3.2 **Sound Intensity**—Sound power transmitted per unit area. See Equation 4.

$$I = \Delta P \Delta v = \Delta P^2 / (\rho c) \quad (\text{Eq. 4})$$

In SI units, I is measured in watt per square meter (W/m^2). At the threshold of hearing (see Equation 5):

$$I_0 = 10^{-12} \text{ W/m}^2. \quad (\text{Eq. 5})$$

3.3 Sound Pressure—Sound pressure (ΔP) is measured directly. In air, the threshold of hearing is (see Equation 6):

$$\Delta P_0 = 20 \mu\text{Pa}, \text{ that is } 0.0002 \text{ dyne/cm}^2. \quad (\text{Eq. 6})$$

Since Δv is proportional to ΔP , the product $\Delta P \Delta v$ is proportional to ΔP^2 (see Equation 7):

$$I_0 = (\Delta P / \Delta P_0)^2 \quad (\text{Eq. 7})$$

3.4 Decibel—A logarithmic scale for sound intensity levels is defined by Equation 8:

$$\text{dB} = 10 \log(I / I_0) \quad (\text{Eq. 8})$$

When adding noises from different sources, it is their sound intensities that are added. The combined dB is then calculated.

In terms of sound pressure (see Equation 9):

$$\text{dB} = 20 \log(\Delta P / \Delta P_0) \quad (\text{Eq. 9})$$

Table 2 illustrates typical values of the decibel scale.

TABLE 2—DECIBEL SCALE

dB	60dB	80dB	100dB	120dB
I	10^{-6} W/m^2	10^{-4} W/m^2	10^{-2} W/m^2	1.0 W/m^2
P	0.02 Pa	0.2 Pa	2 Pa	20 Pa

3.5 Sound Power—Total sound power radiated from a source is determined by measurement of the sound intensity at a specified radial distance. For example, ISO 4412-1 specifies a radial distance of 1 m for hydraulic pump noise rating.

3.6 Octave Bands—An octave is a range or “band” of frequencies such that the upper frequency limit is two times the lower limit. ASA 65 defines standard octaves. One-third octave band noise measurement is standard where higher frequency resolution is required. Figure 1 shows the noise contribution of a hydraulic pump with a fundamental frequency of 500 Hz. The sources of noise can often be identified by their fundamental and harmonic frequencies.

One-third octave band data are shown in Figure 1 by squares and standard octave band data by hexagons. Sound intensity of each standard octave band is the sum of the intensities of the component one-third octave bands.