



GUIDE FOR THE CLASSIFICATION NOTATION

UNDERWATER NOISE

JULY 2018

**American Bureau of Shipping
Incorporated by Act of Legislature of
the State of New York 1862**

**© 2018 American Bureau of Shipping. All rights reserved.
ABS Plaza
16855 Northchase Drive
Houston, TX 77060 USA**

Foreword

This Guide sets forth requirements for the optional underwater noise notation **UWN (Type)** and **UWN+ (Type)**. It is applicable to self-propelled commercial and research vessels. This Guide outlines the process and criteria to obtain the notation. It also provides requirements on acoustic instrumentation, test site conditions, measurement procedures for the underwater noise measurement, as well as a description of the post-processing activities to be carried out for the resulting data sets collected from the measurement.

Both IMO and the European Union (EU) have made efforts to support the reduction of underwater radiated noise (IMO MEPC.1/Circ.833 Guidelines for the Reduction of Underwater Noise from Commercial Shipping to Address Adverse Impacts on Marine Life and EU Marine Strategic Framework Directive, 2008/56/EC) to address concerns about the underwater noise pollution affecting marine life and habitats.

The guidelines contained in IMO MEPC.1/Circ.833 are technical advice/guidance for designers, shipbuilders, and ship operators on the reduction of underwater noise due to commercial shipping. ABS recognized the need for continuing work to develop optional notations to establish the baseline underwater noise levels for vessels and quantify the relationship between individual ship noise levels and the regional ambient noise level reductions. It is anticipated that there will be future development work by the MEPC on this issue.

The EU Marine Strategic Framework Directive (MSFD), 2008/56/EC, which entered into force on 15 July 2008, addresses the protection of the marine environment. It requires EU Member States to achieve a Good Environmental Status (GES) in all the EU waters by 2020. It sets out 11 high-level environmental Descriptors for achieving the GES [EC 2010], and the 11th Descriptor includes underwater noise. With this Directive being enforced, underwater noise from ships is an issue of great relevance, and all Member States are obliged to provide an evaluation of the GES of their marine waters based on the descriptors and targets.

In response to the above regulatory initiatives and the growing interest in the quantification and minimization of underwater radiated noise from commercial shipping in the current marine industry, ABS recognizes the need for the development of this *ABS Guide for the Classification Notation Underwater Noise* with the objective to assist vessel operators to address the underwater noise control aspect.

This Guide becomes effective on the first day of the month of publication.

Users are advised to check periodically on the ABS website www.eagle.org to verify that this version of this Guide is the most current.

We welcome your feedback. Comments or suggestions can be sent electronically by email to rsd@eagle.org.



GUIDE FOR THE CLASSIFICATION NOTATION UNDERWATER NOISE

CONTENTS

SECTION 1	General	1
1	Introduction	1
3	Application	1
5	Scope	2
7	Basis and Process of Obtaining a Notation	2
7.1	Basis	2
7.3	Process for Obtaining a Notation.....	2
9	Alternatives	3
11	Major Modifications	3
13	Definitions	4
15	Abbreviations	6
FIGURE 1 Flow Diagram for Obtaining ABS Underwater Noise Notation UWN (Type) or UWN+ (Type).....		3
SECTION 2	Documentation and Engineering Review	7
1	Plans and Documentation for Information	7
3	Engineering Review	7
TABLE 1 Underwater Noise Measurement Plan		8
TABLE 2 Underwater Noise Measurement Report		9
SECTION 3	Underwater Noise Requirements	10
1	General	10
3	Underwater Noise (UWN) Requirements for Commercial Vessels.....	10
5	Underwater Noise (UWN) Requirements for Research Vessels	11
7	Underwater Noise Plus (UWN+) Requirements for Commercial Vessels.....	12
TABLE 1 UWN Limits for Commercial Vessels.....		11
TABLE 2 UWN Limits for Research Vessels.....		11
TABLE 3 UWN+ Limits for Commercial Vessels.....		12

FIGURE 1	Allowable UWN Limits for Commercial Vessels	10
FIGURE 2	Allowable UWN Limits for Research Vessels	11
FIGURE 3	Allowable UWN+ Limits for Commercial Vessels	12
SECTION 4	Instrumentation for Measurement.....	13
1	Introduction	13
3	Hydrophones and Signal Conditioning	13
3.1	Required Characteristics of a Hydrophone	13
3.3	Deployment of Hydrophones	14
3.5	Hydrophone(s) Array Deployment Geometry.....	16
3.7	Signal Conditioning.....	16
5	Data Acquisition and Recording	17
7	Sound Data Processing and Display System	17
TABLE 1	Performance Requirements of Hydrophones	13
FIGURE 1	Deployment Using a Support Vessel	14
FIGURE 2	Deployment Using a Surface Buoy with an Independent Recorder	15
FIGURE 3	Deployment using Bottom Mounted System (Anchor with Sub Surface Buoy)	15
FIGURE 4	Hydrophone Array Deployment with Respect to Vessel under Test	16
SECTION 5	Underwater Noise Measurement and Survey.....	18
1	General	18
1.1	Measurement Protocols	18
1.3	Measurement Plan.....	18
1.5	Background Noise Measurement.....	19
1.7	Distance Measurement.....	19
1.9	Performance of Underwater Noise Measurement.....	19
1.11	Other Auxiliary Measurements and Data	19
3	ABS Recognized External Specialist for Underwater Noise Measurement	20
5	Survey	20
7	Test Site Requirements	20
7.1	Depth of the Water.....	21
7.3	Weather/Sea Surface Conditions.....	21
9	Test Conditions of Vessel	21
9.1	Operation Condition.....	21
9.3	Loading Condition.....	21
9.5	Test Course	21
11	Measurement Test Sequence.....	21
11.1	General.....	21
11.3	Sea Trial Procedure.....	22
11.5	Underwater Noise Measurement Test Sequence	23

13	Processing and Analysis of Measured Data	23
13.1	Background Noise Correction.....	24
13.3	Bottom Effect Correction	24
13.5	Sensitivity Adjustment	25
13.7	Distance Correction.....	25
13.9	Power-averaged of the Sound Source Level from all Hydrophones	26
13.11	Arithmetic Average of the Sound Source Level of the Four Runs under the Same Operation Condition	26
15	Measurement Report	26
TABLE 1	Current Underwater Noise Measurement Standards and Other Related Measurement Standards	18
TABLE 2	Signal-Plus-Noise-to-Noise Ratio Conditions	24
FIGURE 1	Underwater Noise Measurement Configuration – Beam Aspect Test Course	22
APPENDIX 1	Underwater Noise Control	27
1	Introduction	27
3	Propeller Noise Control.....	27
5	Machinery Equipment Noise Control	27
APPENDIX 2	Underwater Noise Measurements Data Sheet	28
APPENDIX 3	References	31

This Page Intentionally Left Blank



SECTION 1 General

1 Introduction

The impact of underwater ship noise on marine life in deep oceans as a result of the global increase of vessel numbers, vessel size, and propulsion power has recently become an emerging issue in the marine industry. Ships generate underwater noise over a broad range of low frequencies, particularly from the propeller, machinery, and hull movements. The radiated underwater noise poses a potential threat to marine mammal behavior and/or induces stress responses as it may interfere with their hearing of natural signals for communication, feeding, socializing, prey detection, and orientation in the water.

Historically, underwater radiated noise from commercial vessels was not a key area of consideration in ship design and construction. However, with the increased attention and efforts made by international regulatory bodies such as IMO and the EU to minimize the adverse effect of underwater radiated noise from commercial vessels on marine mammals (see, for instance, IMO MEPC.1/Circ.833; EU MSFD 2008/56/EC), ABS recognized the need for developing this Guide. The intent of this Guide is to provide the ship owners with optional notations to help address underwater radiated noise.

This Guide has been developed with the objective of promoting an environmentally-friendly ship design, assisting the specific vessel to operate in a “quieter” condition with the aim of reducing the radiated underwater noise.

3 Application

This *ABS Guide for the Classification Notation Underwater Noise* is applicable to vessels for which one or multiple optional underwater noise notations listed below has been requested.

UWN (Type) For the vessel that has met the underwater noise criteria specified in this Guide. See Subsections 3/3 and 3/5.

UWN+ (Type) For the vessel that has met the more stringent underwater noise criteria specified in this Guide. See Subsection 3/7.

Type denotes the type of underwater noise criteria. The following **Type** notations may be assigned:

T Underwater noise criteria for Transit condition. See Subsections 3/3 and 3/7.

Q Underwater noise criteria for Quiet Operation condition. See Subsections 3/3 and 3/7.

R Underwater noise criteria for Research Vessels. See Subsection 3/5.

A commercial vessel may carry multiple underwater noise notations. The notation **UWN (T)** and/or **UWN (Q)** can be assigned provided the vessel can meet the underwater noise criteria under Transit condition for normal operation and/or Quiet Operation condition for low speed operation in environmentally-sensitive areas. The minimum vessel speed in the test for the Quiet Operation condition is specified in 5/9.1. When the vessel can meet more stringent underwater noise criteria, notation **UWN+ (T)** and/or **UWN+ (Q)** can be assigned.

For research vessels, there is only one notation applicable, **UWN (R)**.

The Guide is applicable to self-propelled commercial vessels and research vessels that are equipped with ship acoustic design technologies in their design and construction to perform specific operations.

This Guide does not apply to vessels such as offshore support vessels/workboats, tugboats, towboats, dredges, drillships, or any other vessels providing service to offshore oil and gas exploration and production.

The notation only focuses on the noise aspect generated during normal/routine ship activities. Other marine activities, such as seismic surveys or pile driving, which result in loud and short duration noise, are not covered in the scope of this Guide.

5 Scope

This Guide outlines the process and criteria to obtain the notation. It provides requirements on acoustic instrumentation, test site conditions, measurement procedures for the underwater noise measurement. It also provides a description of the post-processing activities to be carried out for the resulting data sets collected from the measurement.

7 Basis and Process of Obtaining a Notation

7.1 Basis

The measurement requirements and criteria in this Guide are based on a combination of the available international regulations and standards, as referenced in Section 5, Table 1, and reviews of research regarding the effects of underwater radiated noise on marine aquatic life from commercial and research shipping.

7.3 Process for Obtaining a Notation

The flowchart in Section 1, Figure 1 depicts the process for obtaining a **UWN (Type)** notation or a **UWN+ (Type)** notation where more stringent requirements are introduced.

The Underwater Noise Measurement Plan, which includes the relevant information and drawings as shown in Section 2, Table 1, is to be submitted to ABS for review before scheduling the underwater noise measurement. The intent of this measurement plan is to serve as a primary means of verification that all the necessary requirements and conditions for carrying out the actual underwater noise measurement during sea trials are satisfied before carrying out the actual measurement. This includes identifying the ABS Recognized External Specialists for Underwater Noise Measurement, who are companies recognized by ABS that are qualified to do underwater noise measurements for the **UWN (Type)** or **UWN+ (Type)** notation.

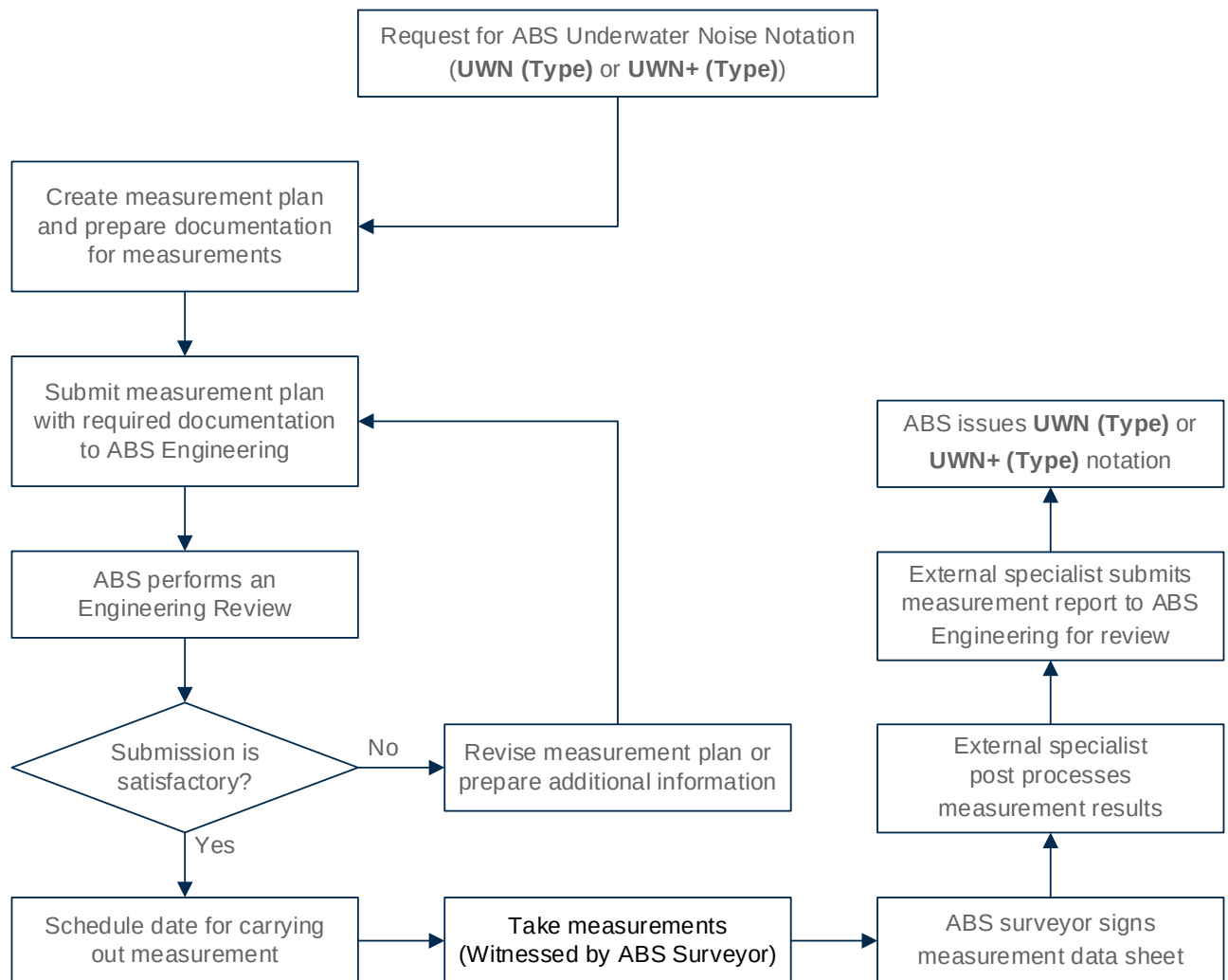
The underwater noise measurement and the data collection process are to be executed by an ABS Recognized Underwater Sound Specialist and witnessed by an ABS Surveyor.

The ABS Recognized External Specialist will post-process the collected measurement data and include the processed results in the final measurement report. The other contents that the measurement report is to include are indicated in Section 2, Table 2. The final measurement report is to be submitted to ABS Engineering for review.

The **UWN (Type)** or **UWN+ (Type)** notation may be issued provided that:

- The underwater noise measurement has been carried out according to the measurement plan approved by ABS and the procedures as specified in Section 5
- The resulting signature noise source level from the measurement is within the maximum allowable underwater noise level criteria limits as per Section 3.

FIGURE 1
Flow Diagram for Obtaining ABS Underwater Noise Notation
UWN (Type) or UWN+ (Type)



9 Alternatives

ABS is prepared to consider alternative procedures, methods or arrangements that are based on internationally recognized codes/standards. When alternate codes and/or standards are proposed, comparative analyses are to be provided to demonstrate equivalency to the criteria that is referred to in this Guide.

11 Major Modifications

ABS is to be notified of any modifications made to major components on the vessel, such as changes to the hull form, the main machinery (including propulsion and large auxiliary equipment) and propellers, which contributes to the underwater radiated noise.

ABS will review the scope of the modification and advise the shipyard/owner of the necessity for a new set of measurements to be carried out in accordance to Section 5 of this Guide in order to maintain the existing class notation.

13 Definitions

Acoustic Center. The position on the vessel where it is assumed that all the noise sources are co-located as a single point source. In this Guide, it is assumed to be located halfway between the center of the engine room and the propeller for all test conditions.

Attenuation. The opposite of amplification, which is necessary when voltages to be digitized are beyond the analog-to-digital converter (ADC) range. This form of signal conditioning decreases the input signal amplitude so that the conditioned signal is within the ADC range. Attenuation is typically necessary when measuring voltages that are more than 10 volts.

Background Noise. Noise from all sources (biotic and abiotic) other than the vessel being tested and measured.

Beam Aspect. The direction to either side of the vessel under side.

Broadband. In the context of this Guide, “broadband” refers to sound energy over the one-third octave frequency band. In order to compare broadband measurements, the underwater acoustics community generally report broadband levels in one-third octave frequency bands.

Cavitation Inception Speed: Vessel speed at which a propeller starts to cavitate.

Closest Point of Approach (CPA). The point during a test run where the horizontal distance from the acoustic center of the vessel under test is the closest to the hydrophone(s). This position on the straight line course is referred as the CPA point. The distance at the closest point of approach is defined by the symbol d_{CPA} . See Section 5, Figure 1.

Data Window Length (DWL). The distance between the start data point and the end data point, given as $2 \times d_{CPA} \times \tan(30)$. See Section 5, Figure 1.

Data Window Period (DWP). The time window the test vessel to travel the data window length (DWL) at a specified test speed (v) given by $DWP = DWL/v$.

Decibel (dB). A relative unit for the intensity of a sound wave to a reference intensity. In underwater sound, it is expressed using the logarithmic decibel scale referenced to 1 micro-Pascal, as dB re 1 μPa (1.45×10^{-10} psi).

Effective Sound Pressure. The root mean square of the sound pressure of the source over a given interval of time or space.

End Data Point. The position where the data recording is ended when the acoustic center of the test vessel passed this point. It is typically at a distance half DWL past the CPA point. This point is also known as the “Stern CPA”. See Section 5, Figure 1.

Ending Point of Test Range. The ending location of a test run at a distance twice the data window length (DWL) after the CPA point. See Section 5, Figure 1.

Far Field. A region in free space, away from the sound source. In this region, the sound pressure is in phase with the sound particle velocity. In the far field, the direct field radiated by most machinery sources will decay at the rate of 6 dB each time the distance from the source is doubled.

Free Field. A sound field region where sound may propagate freely without any form of obstruction. In practice, a free field can be said to exist if the direct sound is 6 dB, or preferably 10 dB, greater than the reverberant or reflected sound.

Hydrophone. A transducer that produces electric signals in response to water borne acoustic signals. For the purpose of this Guide, “hydrophone” could also refer to the underwater microphone or electro-acoustic transducer.

Narrow Band. The entire frequency range is divided into subsections with equal bandwidth. The bandwidth is usually 1 Hz.

Near Field. A part in the sound field region which is close to a source where the sound pressure is not in phase with the sound particle velocity. In this region, the sound field does not decrease by 6 dB each time the distance from the source is increased (as it does in the far field). The near field is limited to a distance from the source equal to about a wavelength of sound or equal to three times the largest dimension of the sound source (whichever is the larger).

Omni-directional Hydrophone. Underwater sound pressure transducer that responds equally to sound from all directions.

One-third Octave Band. The logarithmic frequency band whose upper limit is $2^{1/3}$ (1.26) times the lower limit, and the center frequency is the geometric mean of the upper and lower frequency limits. In underwater sound applications, the sound source spectrums are usually represented in the one-third octave bands. The standard one-third octave band center frequencies are defined as: 10, 12.5, 16, 20, 25, 31.5, 40, 50, 63, 80 Hz, and factors of 10 times and 100 times of this list of frequencies, and so on.

Pistonphone. An apparatus having a rigid piston which can be given a reciprocating motion of a known frequency and amplitude, so as to permit the establishment of a known sound pressure in a closed chamber of small dimensions (Ref: IEC 60565). Also, an acoustical calibrator (sound source) that uses a closed coupling volume to generate a precise sound pressure for the calibration of measurement microphones. It is to be calibrated using a calibrated microphone if the results are to be traceable.

Quiet Operation Condition: A low-speed operation condition for a vessel operating in environmentally-sensitive areas. The minimum vessel speed in the test for the Quiet Operation is specified in 5/9.1.

Radiated Noise. A vessel's radiated noise is the acoustic energy radiated into the sea by sources originating at or within the vessel, from machinery transmitted to the hull/water interface, machinery and flow noise through sea-connected piping systems, and hydrodynamic noise caused by the interaction of the ship hull.

Sheet Cavitation: Sheet cavitation is a kind of propeller cavitation. It is generated due to large suction pressures build up near the leading edge of the blades when the blade sections are working at non-shock-free angles of incidence.

Sound Pressure Level (SPL) (or Sound Level (L_p)). A logarithm measure of the effective sound pressure of a sound relative a reference value. It is measured in decibels (dB) above a standard reference level where p_{rms} is the root-mean-square sound pressure measured and p_{ref} is the reference sound pressure. In water, a reference level of one μPa (1.45×10^{-10} psi) is used.

$$L_p = 10 \log \left(\frac{p_{rms}^2}{p_{ref}^2} \right) = 20 \log \left(\frac{p_{rms}}{p_{ref}} \right)$$

Source Level. The apparent strength of a sound source at a nominal reference distance of one meter (3.28 feet) from the source and expressed in dB re $1 \mu\text{Pa}$ (1.45×10^{-10} psi) in underwater acoustics.

Start Data Point. The position where the data recording is started when the acoustic center reaches this point. It is typically at a distance half DWL ahead of the CPA point. This point is also known as the "Bow CPA". See Section 5, Figure 1.

Starting Point of Test Range. The starting location of a test run at a distance twice the data window length (DWL) ahead of the CPA point. See Section 5, Figure 1.

Tip Vortex Cavitation: Tip vortex cavitation is a kind of propeller cavitation generated from the low-pressure core of the shed vortices. It usually occurs at the blade tips.

Transmission Loss (TL). A measure of the rate of loss in intensity or pressure of the acoustic field strength as sound propagates from a source to a receptor and is generally defined as:

$$TL = 20 \log \left(\frac{p_0}{p_R} \right)$$

where p_0 is the pressure at a point one meter (one foot) away from the source and p_R is the pressure at range R meters (3.28R feet) from the source, or

$$TL = N \log R + \alpha R$$

where N is the coefficient of geometric spreading, R is the range from the source, and α [in dB/m (dB/3.28 ft)] is a factor for the absorption of sound in water.

15 Abbreviations

ADC	Analog-to-digital converter
CPA	Closest point of approach
DAS	Data acquisition system
DWL	Data window length
DWP	Data window period
EU	European Union
GES	Good Environmental Status
GPS	Global positioning system
ICES	International Council for the Exploration of the Sea
IMO	International Maritime Organization
MCR	Maximum continuous rating
MEPC	Marine Environmental Protection Committee
MSFD	Marine Strategic Framework Directive