MEASUREMENT PROCEDURES FOR UNDERWATER SOUND SOURCES ASSOCIATED WITH OIL AND GAS EXPLORATION AND PRODUCTION ACTIVITIES

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IOGP promotes the use of standard procedures for underwater sound measurements for activities related to offshore oil and gas E&P.

Under its Sound and Marine Life Joint Industry Programme (http://www.soundandmarinelife.org/), a consortium consisting of TNO (Netherlands), CSA (USA), UNH (USA) and JASCO (Canada) and independent consultant Darlene Ketten produced a series of reports describing standard procedures for:

- Terminology - report TNO 2016 R11076
- Data processing - report TNO 2017 R10022
- Reporting - report TNO 2016 R11188
- Measurement procedures for underwater sound sources - report TNO 2021 R11210
OBJECTIVE & SCOPE

The aim was to provide the oil- and gas industry with standardized procedures for measuring underwater sound radiated by relevant sources in the operational area, with limited hindrance on operations.

The results of these measurements should allow for characterization of the sources in a clear manner, comparable between independently carried out measurements, and suitable as input for environmental impact assessments.

Measurement procedures for selected source types

Sound pressure measurement only.

Separate IOGP project: guidelines for measuring sound particle motion

SOURCE TYPES

Type A sources: used for geophysical exploration surveys (“seismic acquisition”)
- e.g. airgun arrays, water guns, sparkers, boomers, some sub-bottom profilers, marine vibrators
- typically have most acoustic energy at frequencies below 1 kHz and a repetition rate below 1 Hz.

Type B sources: used for high resolution geophysical (HRG) surveys
- e.g. multi-beam echo-sounders, side scan sonars, some sub-bottom profilers
- typically have most acoustic energy at frequencies above 1 kHz and a repetition rate above 10 Hz.

Type C sources: associated with production platform activities
- typically stationary sources that produce underwater sound as an unintended by-product of their activity, such as pumping and drilling
Source level

\[ L_S = 10 \log_{10} \left( \frac{p^2(r) r^2}{1 \, \mu \text{Pa}^2 \, \text{m}^2} \right) \, \text{dB} \]

- \( r \) = distance from the acoustic centre of a source
- \( p^2(r) \) = mean-square sound pressure at distance \( r \)
  - *in the acoustic far field, in a specified direction*
  - *in a hypothetical infinite uniform lossless medium* of the same density and sound speed as the real medium at the location of the source, with identical motion of all acoustically active surfaces as the true source in the true medium

Measurement procedures for underwater sound sources associated with oil and gas exploration and production activities
Environment (propagation) affects received sound
Source level measurement is necessarily indirect:

\[ L_S = L_p(r) + N_{PL}(r) \]

- \( r \) = distance from the acoustic centre of a source
- \( L_p(r) \) = mean-square sound pressure level at distance \( r \)
  - \emph{in the acoustic far field, at a specified location}
- \( N_{PL}(r) \) = propagation loss
  - \emph{in the real environment}
**APPROACH**

- WP1: Review and selection of procedures
  - IOGP–PSG review and approval

**CONCLUSIONS:**
- Fairly high degree of commonality in the reported measurements of type A sources
- Some commonality in reported measurements of type B sources
- Very limited commonality in reported measurements of type C sources
- Very few papers/reports include all relevant parameters

- WP2-4: Development of measurement procedures for type A, B and C sources
  - Lots of interaction to come to conclusions:
    - ~ 30 Teams sessions (1.5-2 hours each) between October 2019 and October 2020
  - IOGP–PSG review and approval
OVERVIEW OF REPORT CONTENTS

1. Introduction  
   (Background, Objective & Scope)

2. Terms and definitions  
   (Sound source types, Guidance on characterizing sound source signals, SL, SPL, PL)

3. Instrumentation  
   (Selection of hydrophones, preamplifiers, filters, ADC, recording system, calibration)

4. Sensor deployment  
   (Mooring geometries, flow noise suppression, etc.)

5. Measurement procedures
   - General considerations & requirements
   - Procedure for measuring type A and B sources (geophysical exploration surveys)
   - Procedure for measuring type C sources (production activities)
   - Required auxiliary measurements

6. Data processing (received sound metrics)

7. Calculation of source output metrics

8. Uncertainties

9. Reporting

Measurement procedures for underwater sound sources associated with oil and gas exploration and production activities
EXAMPLE OF THE PROCESS:
SELECTION OF GEOMETRY FOR TYPE A SOURCE MEASUREMENTS

› Towed source: airgun array
› ‘Pulse’ signals (duration < 125 ms; inter-pulse interval > 1 s)
› Directional in horizontal and vertical plane
⇒ Defined observation aspects:
  › ‘Port and Starboard Abeam’, ‘Keel’ and ‘Endfire’
› Procedures for deep and shallow water

› Example:
  › *abeam aspect measurements in deep water*
ABEAM ASPECT GEOMETRY IN DEEP WATER

- Based on ISO 17208-1 for ship RNL measurements

- Vertical observation angles (at CPA)
  - 15, 30 and 45 degrees

- Horizontal observation angles (around CPA)
  - ±30 degrees

- Analyse pulse signals in ‘measurement zone’

Measurement procedures for underwater sound sources associated with oil and gas exploration and production activities
Calculate sound exposure level ($L_{E,p}$) per pulse

- TOW per pulse
- Multiple pulses in TAW (‘measurement zone’)

Required frequency range:
- 10 Hz to 50 kHz decidecade bands

Optional metrics:
- $L_{p,rms}$ with specified averaging time (e.g. $T_{90}$, or 100 ms)
- $L_{p,pk}$
- $L_{E,p,w}$
CONCLUSION

› Reports describing standard procedures are available online

› NOTE:

› Caution: in the event that procedures cannot be precisely followed, it is imperative that all deviations from the standard be thoroughly documented and reported. The importance of following the standard is the provision of comparability between studies and results.

› We are looking forward to feedback from users

› We are open to providing future updates, incorporating lessons learned

› We advised IOGP to consider regular maintenance of the standards

› (ISO standards are reviewed every 5 years)
THANK YOU FOR YOUR ATTENTION