



PC19 LAKE PUKAKI  
WATERCRAFT NOISE - DESKTOP ASSESSMENT

Rp 001 20181231 | 31 October 2018

**Project:** PC19 LAKE PUKAKI

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## EXECUTIVE SUMMARY

In order to assist the hearing panel considering and deciding on submissions to Plan Change 19, Marshall Day Acoustics has been engaged by Mackenzie District Council to perform an acoustic assessment that will inform the possibility of choosing an area within Lake Pukaki where motorised craft could operate and be inaudible at key locations.

An assessment of visual effects has been prepared by *Jeremy Head Landscape Architect Ltd (JHLA)* and this has recommended and identified an area where motorised watercraft may be more appropriate.

In developing suitable inaudibility criteria, we have adopted the following methodology:

- We have limited our assessment to the audibility of motorised watercraft to the *formed scenic viewing areas* identified by JHLA. We have labelled these as 1 to 7 in Figure 1.
- In the absence of any universally accepted inaudibility criterion, we have adopted the approach that the maximum motorised watercraft noise level ( $L_{AFmax}$ ) shall be 10 decibels below the ambient background sound ( $L_{A90}$ ) at the scenic viewing location;
- We have estimated background sound levels ( $L_{A90}$ ) at scenic viewing locations on the assumption they will be most commonly in use between 0800 and 1800 hrs. Ambient noise levels are likely to be lower outside these times, increasing the possibility of watercraft sounds being audible;
- Background sound levels will be highly variable depending on meteorological conditions in the area and should ideally be established through long term noise monitoring. In the absence of this data, we have assessed the most conservative (quietest) situation that will typically be experienced on clear and calm days.
- To be inaudible, we propose that motorised watercraft noise should not exceed 20 dB  $L_{AFmax}$  at scenic viewing locations 1, 2 and 7, and 30 dB  $L_{AFmax}$  at scenic viewing locations 3, 4, 5 and 6.

On this basis, our findings are summarised as follows:

- Vessels complying with the existing Rule 2.3.4 in Section 14 of the Mackenzie District Plan (i.e. 90 dB  $L_{AE}$  at 25 metres) will not comply with the inaudibility criteria at any location on Lake Pukaki. Based on previous measurements, 90 dB  $L_{AE}$  approximately corresponds to a maximum noise level of 80 dB  $L_{AFmax}$ . We note that the parameter Sound Exposure Level,  $L_{AE}$ , is unsuitable for an assessment of inaudibility and we have adopted  $L_{AFmax}$  for our analysis;
- In Figure 2, we have provided three potential inaudibility zones for motorised watercraft that can comply with suggested alternative watercraft criteria of 65, 70 or 75 dB  $L_{AFmax}$  at a distance of 25 metres. However, we do not have sufficient data to confirm how many motorised watercraft that will potentially use the lake, are capable of complying with these noise limits. Further noise level investigation will be required.
- Should one of the proposed limits be adopted, an appropriate rule should be developed to describe the measurement and certification of vessels wishing to use Lake Pukaki. As a starting point, an example of a suitable methodology is contained within Rule 36.8 of the Queenstown Lakes District Plan (noting that numerical noise limits should be modified).
- We note that if the assessment criterion were to be relaxed from inaudibility to one where the motor craft maximum noise level is equal to the background ambient sound level (i.e. vessel  $L_{AFmax} \leq$  background  $L_{A90}$ ), vessels complying with Rule 2.3.4 in Section 14 of the Mackenzie District Plan would be able to use an area of the Lake equivalent to furthest right image in Figure 2 (i.e. 65 dB  $L_{AFmax}$  at 25m).

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## 1.0 INTRODUCTION

Mackenzie District Council has received several formal submissions in relation to Proposed Plan Change 19 that both support the proposed prohibitive approach outlined in the Plan Change in relation to motorised boating on Lake Pukaki, and those that oppose the proposed prohibited status.

To assist the hearing panel considering and deciding on submissions to Plan Change 19, Marshall Day Acoustics has been engaged by Mackenzie District Council to perform a desktop acoustic assessment that will inform the possibility of choosing an area within Lake Pukaki where motorised craft could operate and be inaudible at key scenic viewing locations.

An assessment of visual effects has been prepared by *Jeremy Head Landscape Architect Ltd (JHLA)* and this has identified an area where motorised watercraft will be acceptable. This area is identified in Figure 1 and is the starting point for the noise assessment outlined below.

This report provides:

- A discussion of the existing ambient noise environment;
- Development of an appropriate inaudibility criterion;
- Predicted sound levels from motorised watercraft using the lake; and
- A summary of our assessment and findings.

A glossary of terminology used in this report is provided in Appendix A.

## 2.0 EXISTING AMBIENT NOISE ENVIRONMENT

Motorised watercraft will most likely be audible at scenic viewing areas when visitors are outside their vehicles. Therefore, our assessment has focused on the period between 0800 and 1800 hrs which is when viewing areas will be most often in use.

Formed scenic viewing areas are identified in Figure 1 as locations 1 to 7; unformed viewing areas are identified with blue dots.

The existing ambient noise environment at the viewing areas will be dominated by natural environmental sounds such as wind noise in vegetation and, at some locations, wave lapping noise from the lake. Wind speed and rain are responsible for the greatest variation in ambient noise level on a day-to-day basis.

Ambient noise measurements in the general area show that noise from wind alone can be in the order of 55 dB  $L_{Aeq}$  during the day, reducing to low 30's dB  $L_{Aeq}$  during periods of calm.

Several of the viewing locations, most notably 3, 4, 5 and 6 in Figure 1, are adjacent to State Highway 8 and are subject to significant traffic noise. NZ Transport Agency traffic data from 2017 shows this road carried approximately 2900 vehicles per day (AADT) with 13% of movements being commercial vehicles (i.e. trucks and coaches).

On average, this will translate to approximately two to three vehicles passing each viewing area every minute between 0800 and 1800 hrs. Locations 3, 4, 5 and 6 will receive traffic noise levels of around 60 to 65 dB  $L_{Aeq(1hr)}$  during this time. There will be brief periods of relative quiet between vehicle passes.

Viewing locations 1 and 2 are adjacent to State Highway 80 and, in 2015, carried 1100 vehicles per day (AADT) with 7% being heavy vehicles. Between 0800 and 1800 hrs, an average of around four vehicles will pass these locations every five minutes which means there is likely to be significant periods of relative quiet without any traffic noise. Traffic noise will contribute around 50 to 55 dB  $L_{Aeq(1hr)}$  at these locations between 0800 and 1800 hrs.

Traffic data is not available for Hayman Road which runs past viewing location 7. We estimate that this viewing area will have significant periods of time when vehicles are not passing directly, and the ambient noise will be dominated by natural sounds.

In order to perform a rigorous assessment of the variation in ambient sound levels at the viewing location, noise monitoring would be required over extended periods of time during various weather conditions.

In the absence of this background noise data, we estimate that the lowest ambient daytime noise levels at positions 1, 2 and 7 are in the order of 35 dB  $L_{Aeq}$  and 30 dB  $L_{A90}$ . At positions 3, 4, 5 and 6 we anticipate that lowest noise levels will be 50 dB  $L_{Aeq}$  and 40 dB  $L_{A90}$ .

**Figure 1: JHLA Appendix 1 showing viewing locations and potential motorised craft area**



### 3.0 INAUDIBILITY CRITERION

As noted in the introduction, our brief for assessing motorised watercraft noise is that it should be inaudible. Within International published guidance and research, there is no commonly accepted objective definition of inaudibility. However, the fundamental mechanisms that contribute to inaudibility are:

1. The level and character of the **specific sound**;
2. The level and character of the **background sound**.

For example, a specific sound (e.g. boat engine) will be less audible in a high level of background noise than it will be in an area with low background noise.

To be generally inaudible, we propose that the maximum level ( $L_{Amax}$ ) of the specific sound should be 10 decibels below the background sound level ( $L_{A90}$ ) at the viewing location.

From the discussion in Section 2.0, the level and character of the background sound at the viewing locations will vary considerably with both the weather conditions and with distance from State Highway. The variation in background sound, and hence the audibility of noise from motor craft, should ideally be established through long term noise monitoring. For the purposes of this study we have assumed the most conservative situation of a calm day with a low background sound environment.

We have assumed a background sound level of 30 dB  $L_{A90}$  at viewing locations 1, 2 and 7. **Therefore, the maximum motorised watercraft noise should not be greater than 20 dB  $L_{Amax}$  at viewing locations 1, 2 and 7.**

At viewing locations 3, 4, 5 and 6, we have assumed a background sound level of 40 dB  $L_{A90}$ . **Therefore, the maximum motorised watercraft noise level should not be greater than 30 dB  $L_{Amax}$  at viewing locations 3, 4, 5 and 6.**

We note that this inaudibility criterion is based on our best estimate and further testing will be required to validate the criterion.

### 4.0 MOTORISED WATERCRAFT NOISE

Motorised watercraft can generate a wide variety of noise levels and therefore, it is difficult to generalise about the type of watercraft that may be used on the lake and their potential noise emissions.

As a starting point, Rule 2.3.4 in Section 14 of the Mackenzie District Plan provides a maximum permitted watercraft noise level which can give some context to the current assessment. Rule 2.3.4 is provided in full in Appendix B. The part of the rule most relevant to this study states:

*Provided no moving craft shall emit noise in excess of Sound Exposure Level of 90 dBA in any single driveby measured at any notional point more than 25m from the line of travel of the craft.*

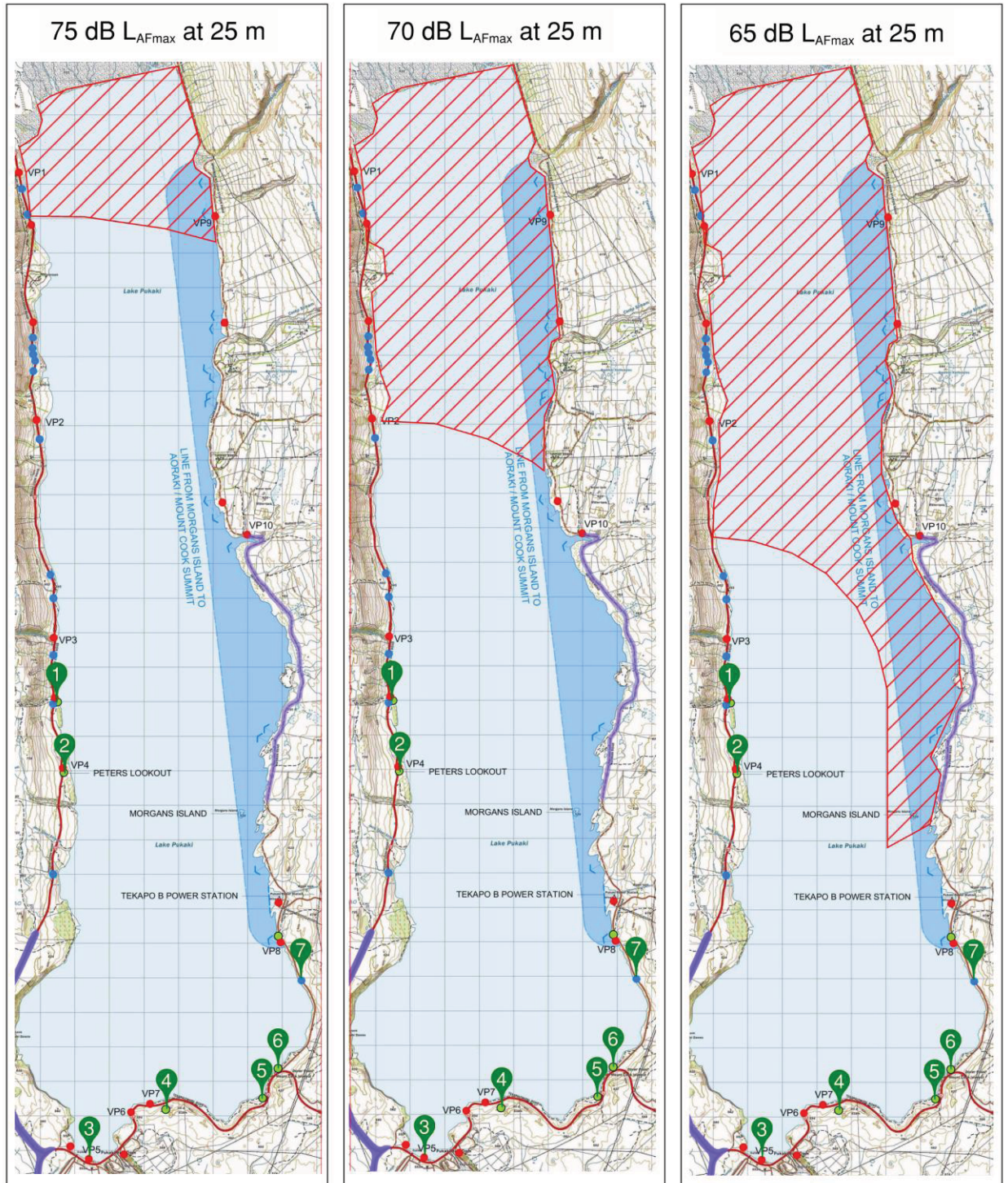
Whilst Sound Exposure Level is the metric used for this rule the District Plan, it is not have any established relationship to the perception of noise in the environment. For an assessment of audibility, we consider  $L_{Amax}$  to be more appropriate. Based on our database of motorised vessel data, a Sound Exposure Level of 90 dB  $L_{AE}$  is approximately equivalent to a maximum noise level of 80 dB  $L_{AFmax}$ . Our analysis shows that no vessels generating this noise level could use Lake Pukaki and comply with the proposed inaudibility criterion at formed scenic viewing areas.

Figure 2 presents potential operational areas for vessels with a reduced noise level outputs of 75, 70 and 65 dB  $L_{AFmax}$  at a distance of 25 metres. The more stringent (i.e. lower) the noise level control that is placed on vessels, the greater the useable area of the lake.

However, we do not have sufficient data to confirm how many motorised watercraft that will potentially be used on the lake, are capable of complying with these alternative suggested noise limits. Further noise level investigation will be required.

In practice, the lowest noise limits of 65 and 70 dB  $L_{AFmax}$  are likely to mean that watercraft will require effective engine noise control or be required to travel at lower speeds.

**Figure 2: Potential motorised watercraft areas (red hatching) for stated watercraft maximum noise level**





## 5.0 DISTRICT PLAN PROVISIONS

Should any of the noise limits discussed in Section 4.0 be adopted, an appropriate rule should be developed to describe the measurement and certification of vessels wishing to be operated on Lake Pukaki. We recommend that Sound Exposure Level  $L_{AE}$  is not used. An example of a suitable methodology is contained within Rule 36.8 of the Queenstown Lakes District Plan (noting that numerical noise limits should be modified). We have provided this rule for reference as Appendix C.

**APPENDIX A GLOSSARY OF TERMINOLOGY**

<b>Frequency</b>	The number of pressure fluctuation cycles per second of a sound wave. Measured in units of Hertz (Hz).
<b>Hertz (Hz)</b>	Hertz is the unit of frequency. One hertz is one cycle per second. One thousand hertz is a kilohertz (kHz).
<b>Noise</b>	A sound that is unwanted by, or distracting to, the receiver.
<b>Masking Noise</b>	Intentional background noise that is not disturbing, but due to its presence causes other unwanted noises to be less intelligible, noticeable and distracting.
<b>Ambient</b>	The ambient noise level is the noise level measured in the absence of the intrusive noise or the noise requiring control. Ambient noise levels are frequently measured to determine the situation prior to the addition of a new noise source.
<b>dB</b>	<u>Decibel</u> The unit of sound level.  Expressed as a logarithmic ratio of sound pressure P relative to a reference pressure of $P_r=20 \mu\text{Pa}$ i.e. $\text{dB} = 20 \times \log(P/P_r)$
<b>dB(A)</b>	The unit of sound level which has its frequency characteristics modified by a filter (A-weighted) so as to more closely approximate the frequency bias of the human ear.
<b>A-weighting</b>	The process by which noise levels are corrected to account for the non-linear frequency response of the human ear.
<b><math>L_{Aeq}(t)</math></b>	The equivalent continuous (time-averaged) A-weighted sound level. This is commonly referred to as the average noise level.  The suffix "t" represents the time period to which the noise level relates, e.g. (8 h) would represent a period of 8 hours, (15 min) would represent a period of 15 minutes and (2200-0700) would represent a measurement time between 10 pm and 7 am.
<b><math>L_{A90}(t)</math></b>	The A-weighted noise level equalled or exceeded for 90% of the measurement period. This is commonly referred to as the background noise level.  The suffix "t" represents the time period to which the noise level relates, e.g. (8 h) would represent a period of 8 hours, (15 min) would represent a period of 15 minutes and (2200-0700) would represent a measurement time between 10 pm and 7 am.
<b><math>L_{AFmax}</math></b>	The A-weighted maximum noise level using fast time averaging. The highest noise level which occurs during the measurement period.
<b>SEL or <math>L_{AE}</math></b>	<u>Sound Exposure Level</u> The sound level of one second duration which has the same amount of energy as the actual noise event measured.  Usually used to measure the sound energy of a particular event, such as a train pass-by or an aircraft flyover

**APPENDIX B MACKENZIE DISTRICT PLAN RULE 2.3.4**

The Mackenzie District Plan contains the following noise limits in Section 14:

**2.3.4 Watercraft Noise**

- i Powered watercraft shall be fitted with effective mufflers during all movement on water and shall not exceed the following noise limits at any point within the notional boundary of any residential dwelling:*

*On any day*

*7:00 am to 9:00 pm Sound Exposure Level (SEL) 85 dBA*

*9:00 pm to 7:00 am the following day Sound Exposure Level (SEL) 78 dBA*

*Provided no moving craft shall emit noise in excess of Sound Exposure Level of 90 dBA in any single drive-by measured at any notional point more than 25 m from the line of travel of the craft.*

- ii Sound exposure levels shall be measured in accordance with the provisions of NZS 6801:1991 Measure of sound [sic] (or its successors)*

*Provided further that on four occasions in any 12 month period, the noise limit may be unrestricted for any portion of water for the purpose of an approved special event.*

Note that the latest version of New Zealand noise assessment standard NZS 6802:2008 “Acoustics - Environmental Noise” uses  $L_{AE}$  to denote the sound exposure level (SEL).  $L_{AE}$  and SEL are the same metric.

As the hovercraft is only proposed to be used during daytime hours, the relevant noise limits are:

- 85 dB  $L_{AE}$  within the notional boundary of any residential dwelling; and
- 90 dB  $L_{AE}$  at 25 m from a straight-line pass.

**APPENDIX C RULE 36.8 FROM QLDC DSITRICT PLAN**

## 36.8 Acoustic Measurement and Assessment

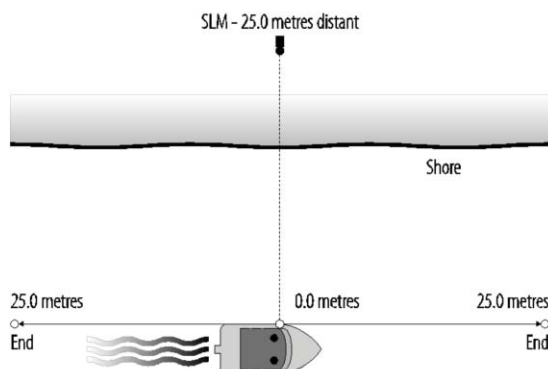
### 36.8.1 Acoustic Measurement and Assessment of Motorised Craft on the Surface of Rivers and Lakes

Noise limits should be modified

- 36.8.1.1** All motorised craft operating on the surface of lakes and rivers within the District must have and display a current acoustic certificate of fitness. Testing shall be undertaken on a strictly controlled "test" day, and shall be conducted by an enforcement officer appointed pursuant to the Act.
- 36.8.1.2** The measured sound pressure level shall not exceed a maximum A weighted level:
- 77 dB LASmax for vessels to be operated between the hours of 0800 to 2000;
  - 67 dB LASmax for vessels to be operated between the hours of 2000 to 0800.
- 36.8.1.3** Retesting will be undertaken at not more than 12 monthly intervals. Additional monitoring measurements shall be performed in order to check that the noise of the craft remains within the prescribed limits and no noticeable changes have occurred since the previous testing of the craft and/or allowing modification to the same.
- 36.8.1.4** All sound measuring equipment and methods used shall be in compliance with the standards stated in the above references.
- 36.8.1.5** The following test conditions shall be complied with as closely as possible, but if unavoidable variations have to be made, these must be stated in the test report. In no instance shall the integrity of the test be compromised.
- 36.8.1.6** The noise emitted by warning devices and the like are excluded, however ancillary noise generated or associated with the operation of the craft, other than the motive device, may be measured separately or in conjunction with the test.

### 36.8.2 Test Conditions

- 36.8.2.1** The following instrument shall be used:
- A class 1 sound level meter and an acceptable wind screen.
  - A sound level calibrator.
  - A wind speed anemometer.
  - An engine speed tachometer.
- 36.8.2.2** Measured Quantities - "A" weighted, slow response sound level, expressed in decibels (dB).
- 36.8.2.3** Acoustic Environment - The test site shall be such that sufficient free field sound propagation exists, (ie 30m clearance from reflective surfaces).
- 36.8.2.4** There shall be no obstacles between the craft and the microphone and the area between shall be open and free from sound absorbing materials. Meteorological conditions shall be within standard acceptable limits and the wind velocity shall not exceed 5m/sec.
- 36.8.2.5** Test Course - The depth of water must be sufficient for the normal operation of the craft.
- Craft shall run either against the stress or current or in slack water.
  - A set straight line course shall be used to ascertain the acoustic measurements, as detailed:



- 36.8.2.6** Operating Conditions - The test run shall commence at sufficient distance downstream to obtain stabilised engine conditions when the craft passes the microphone. The craft shall be driven by a competent person who is mutually acceptable to the operator of the craft and the enforcement officer. The loading condition of the craft shall be stated in the report. All openings and hatches shall be set and located in their normal operational condition and the craft's engine system shall be at normal operating temperature.
- 36.8.2.7** The boat shall pass all three markers on a straight course at wide-open throttle with the engine operating at the midpoint of the manufacturer's recommended full throttle rpm range.
- 36.8.2.8** The engine speed tolerance shall be +/- 100rpm if this falls within the full throttle speed range. If a single top speed rpm is recommended, the tolerance shall be +0, -100rpm.
- 36.8.2.9** Boats which are sold with the power units installed (for example, outboards and stern drives) shall be tested in this combination. Outboard motorboats shall be tested with a motor or motors for which the boat is rated, since sound level is dependent upon boat design and construction.
- 36.8.2.10** The boat shall pass within 0.5m to 1.0m on the far side of all three markers.
- 36.8.2.11** Test Procedure - Principally that the maximum A – weighted sound pressure level indicated during the passage of the craft be retained. The sound level will be accumulated as the craft passes at right angles to the microphone and will be measured until the craft has travelled a distance of 25 m. The meter shall be set for slow response.

Two passes shall be made and the mean value of the measurements rounded to the nearest integral decibel shall be obtained. If the sound intensity is louder along one side of the craft, then the measurements shall be conducted at this side. The background noise level shall be recorded and shall be at least 10dBA lower than measured level for the boat being tested.

All craft may not be able to be recorded according to the above method and any deviation shall be in compliance with ISO 2922:2000 or ISO 14509-1:2008. Other statistical and accumulated sound levels may also be recorded and retained for evaluation.

### 36.8.3 Test Report

- 36.8.3.1** The test report shall include a reference to the Standards and all relevant details concerning:
- The nature of the tests.
  - The craft design or make, operator, engine and exhaust system.
  - The test site locality, water conditions, meteorological conditions, for example temperature, and wind velocity, if relevant.
  - The measurement equipment.
  - The background noise level.
  - The loading of the craft.
  - The A-weighted sound pressure levels.
  - The presence of pure tones or noise of an impulsive character.
  - A conclusion, evaluating the test results and considerations.
- 36.8.3.2** The craft shall, upon compliance and following testing exhibit a current acoustic certificate label in a prominent place, which will be issued by the enforcement officer.
- 36.8.3.3** All craft shall be retested, should any modification be made to the craft or engine componentry that could alter the acoustic integrity and another certificate, upon compliance, will be issued.

REFERENCES: IEC 61672-1:2002, IEC 60942:2003, ISO 2922:2000, ISO 14509-1:2008