Edinburgh, Scotland
EURONOISE 2009
October 26-28

Noise evaluation of sound sources related to port activities

Johannes Hyrynen
Panu Maijala
VTT, Technical Research Centre of Finland

Velipekka Mellin
Sandvik Mining and Construction

ABSTRACT

Port activities generate sound that is propagated to the environment. In some cases the people affected by the noise are very close to the port and are highly disturbed by the activities. There is a large number of sound sources in the port area and the nature of noise generated can vary a lot depending on the source. The sound sources very often depend on the operating mode of the machine and one piece of machinery can include various sound sources located apart from each other. The sound emitted can be either continuous or intermittent.

This study deals with sound power measurements and results of typical sound sources in the port area. The sound sources include operation of various mobile machinery, reefers, container handling and ship loading events and sound sources related to berthing ships.
The results are presented as sound power levels and a ranking of the sources has been made. In addition, the Unbiased Annoyance indicators are presented for some of the sources.

1. INTRODUCTION

Port areas have numerous sound sources that contribute to the noise emitted to the nearby residents. The sources are located around the area. Therefore their effect is not equal to the residents or receivers. In order to predict the sound percept by the inhabitants, noise prediction software can be used. It is essential to use good quality sound source data for the models. The data can be obtained from the manufacturers of equipment, databases or measured. Additional annoyance information on the sound source can be given using calculated psychoacoustic descriptors. The descriptors give more information on the frequency and temporal content of the sound signal.

Noise measurements were carried out for several sources in two ports. A great number of sources were measured at different locations around the port areas. In addition to the operation of equipment also the noise emitted from the work process of the equipment was measured. The noise sources measured included a berthing vessel including auxiliary engine exhaust funnel, ventilation fans and hydraulics. Other sources measured in the port area were reach-stackers and straddle carriers including both by-pass noise and container handling, several RTGs (Rubber Tyred Gantries) including their sub-sources, such as power unit, exhaust and alarm, RoRo loading ramps with trucks and terminal tractors, reefer units and container cranes including the power units and container handling events. Some of the equipment has been measured at different operation modes. For instance the sound power of an RTG power unit can vary significantly depending on its operation such as idling or lifting modes. Some of the sources are presented in Figure 1. Significant differences were also detected between some equipment depending on the type or manufacturer.

The results are presented as linear and A-weighted sound power levels. In addition, annoyance related indicators:, Unbiased Annoyance, Sensory pleasantness, and Loudness 10% have been calculated for the sources. However in this paper only the Unbiased Annoyance indices have been presented. 1/3 octave band sound power levels are presented in order to give a picture on the nature of the sound sources in terms of frequency content.

The test ports were selected from among the partners of the EU consortium EFFORTS, which had particular interest in present or future noise issues. The ports selected were the Port of Turku, Finland and the Port of Dublin, Ireland. It was assumed that a further analysis of the noise in terms of sound quality could be beneficial in evaluating the noise perceived by the nearby inhabitants. Therefore sound samples were taken and analyzed for each source type. After further processing they will be used for listening tests in order to develop psychoacoustic descriptors for port related sound sources.

Figure 1: Common equipment and noise sources of ports.

2. MEASUREMENT METHODS AND CONDITIONS

The sound power measurements were carried out according to standard ISO 3744 [1]. As the sources under investigation in this study are in some cases hard to reach, are in motion or are very large, some simplifications were allowed. The determination of the measurement surfaces in some cases was challenging and the number of microphone positions was therefore reduced to a practically applicable number, 1 to 6 microphone positions normally. Examples of the measurement setups are presented in Figures 2 and 3.

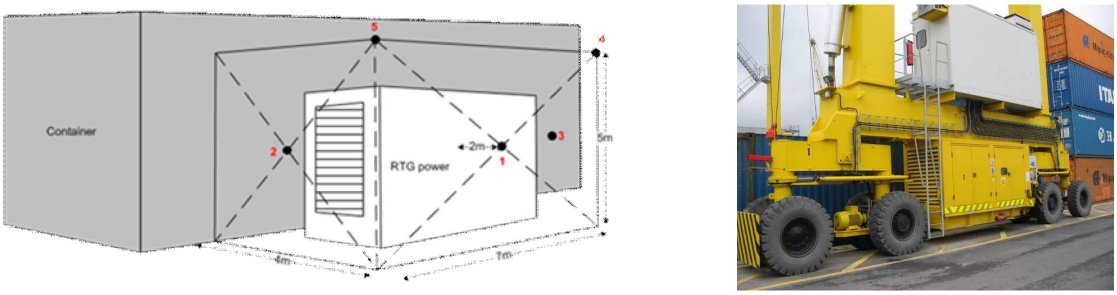

Figure 2: Measurement set up of an RTG power unit.

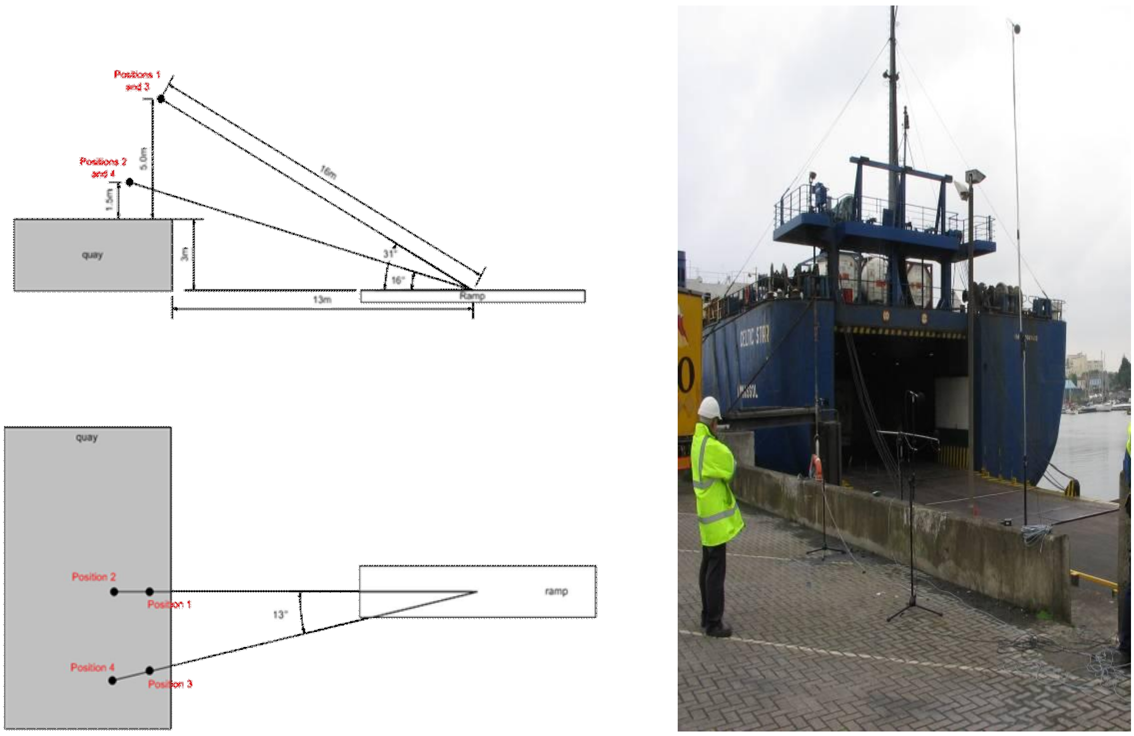

Figure 3: Measurement set up of a RoRo ramp.

The measurements were carried out in good weather conditions. The temperature varied between 12-20°C and the wind speed conditions were below 5 m/s.
The measurement and signal analyzing time for the instationary sound sources like container handling were adjusted according to the durance of the events.

3. RESULTS

The results are presented as linear and A-weighted sound power levels and 1/3 octave band levels. For some of the sources the most common psychoacoustic descriptors have been calculated from the sound samples. The 1/3 octave band results are presented for each source type in the following chapters. The total sound power levels of all sources are presented in Chapter 4 *Ranking of the sources*. The Unbiased Annoyance values have been presented to continuous sound sources in the same chapter.

A. Vessel sound sources

The sources of a RoRo vessel measured were the engine room ventilation, hydraulics room ventilation, bow cable hydraulics, exhaust funnel and exhaust stack ventilation. The 1/3 octave band sound power levels are presented in Figure 4. Special attention should be paid to the high low frequency content of the auxiliary engine exhaust pipe.

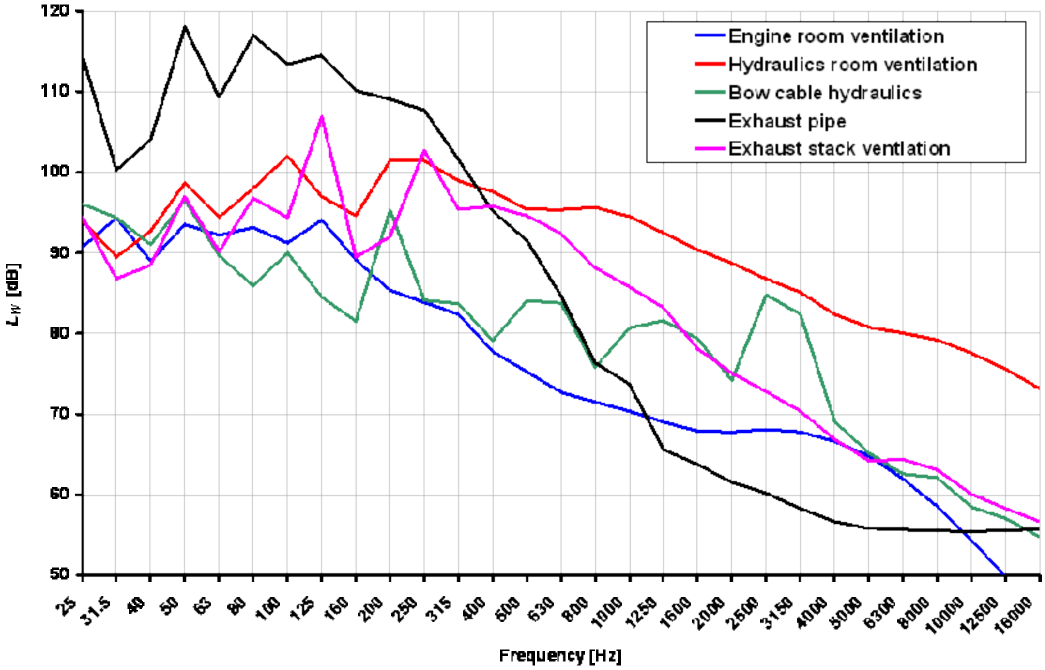

Figure 4: 1/3 octave band sound power levels of the vessel sound sources.

B. Container Handling Equipment

Several container handling equipment were measured. The sound properties of RTGs were measured in the port at two separate locations. Three sources of the RTG were measured; the power unit, exhaust pipe and alarm beacon. Both of the RTGs were measured at two operating conditions; idling and lifting. In the lifting mode the engine is run at high rpm under load. The power unit is located near the ground, but the exhaust pipe is at a height of approximately 20 m above ground level. Also by-pass measurements were carried out for reach-stackers and straddle carriers. Some measurements were also made for a ship to shore gantry crane. The 1/3 octave band sound power levels of the RTGs are presented in Figure 5. The pass-by sound power levels are presented in Figure 6.

The results show that there are significant differences between different RTGs. With the more silent RTG also a clear difference is seen in the sound power levels of different operating modes. During the lift mode, the sound power level increases by 3-4 dB.

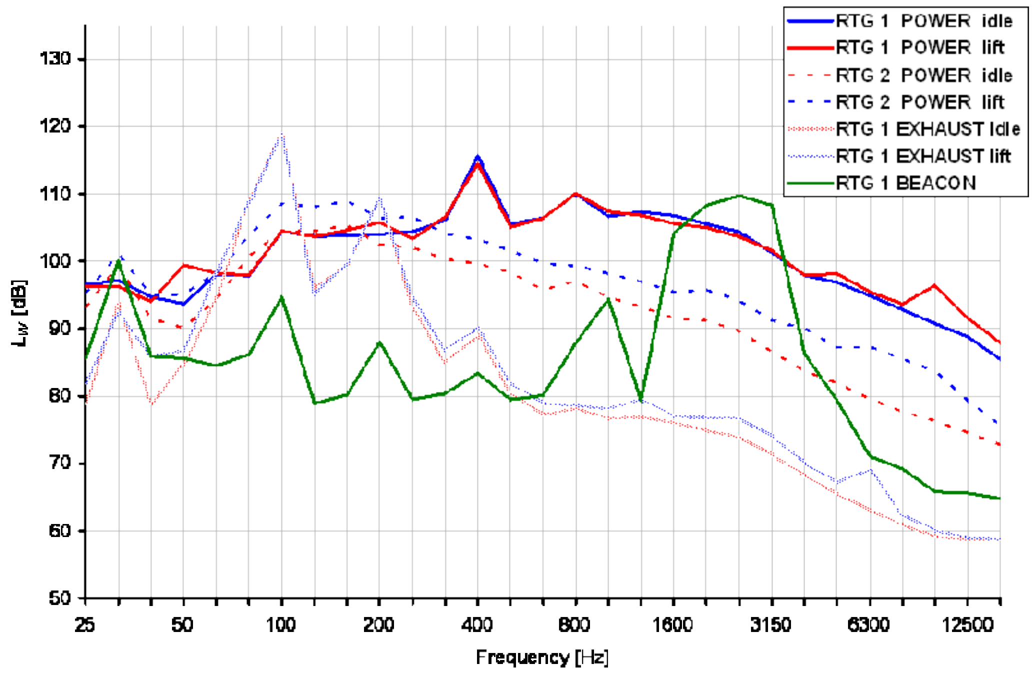

Figure 5: Separate 1/3 octave band sound power levels of the RTGs.

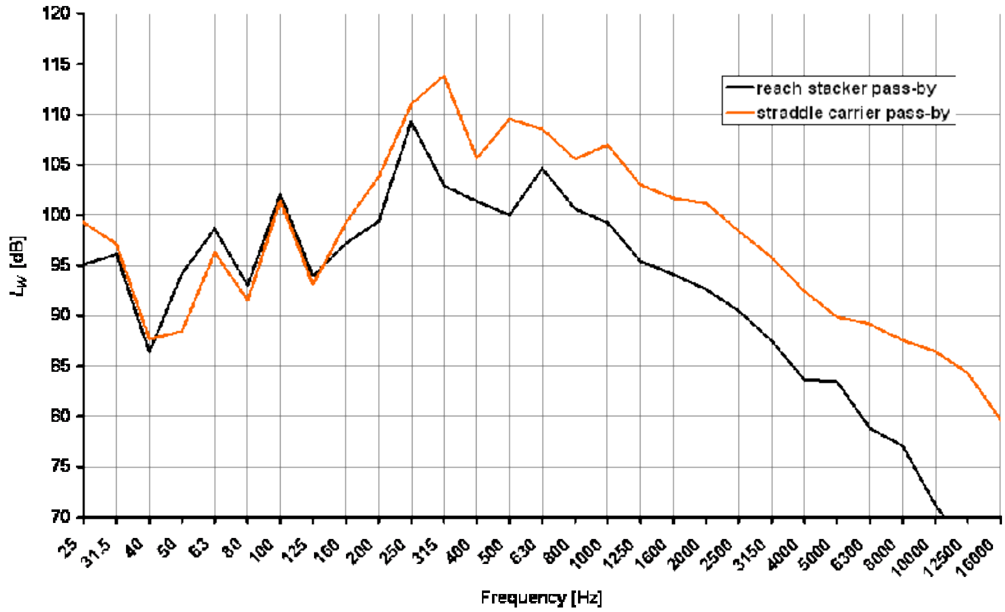

Figure 6: 1/3 octave band sound power levels of the reach stacker and straddle carrier pass-by events.

C. Reefers

The reefers measured were plug-in reefers. Several makes were measured and the results compared with each other. The 1/3 octave band sound power levels are presented in Figure 7. There were not very great differences between the different reefer types. The sound power levels were all within 3 dB.

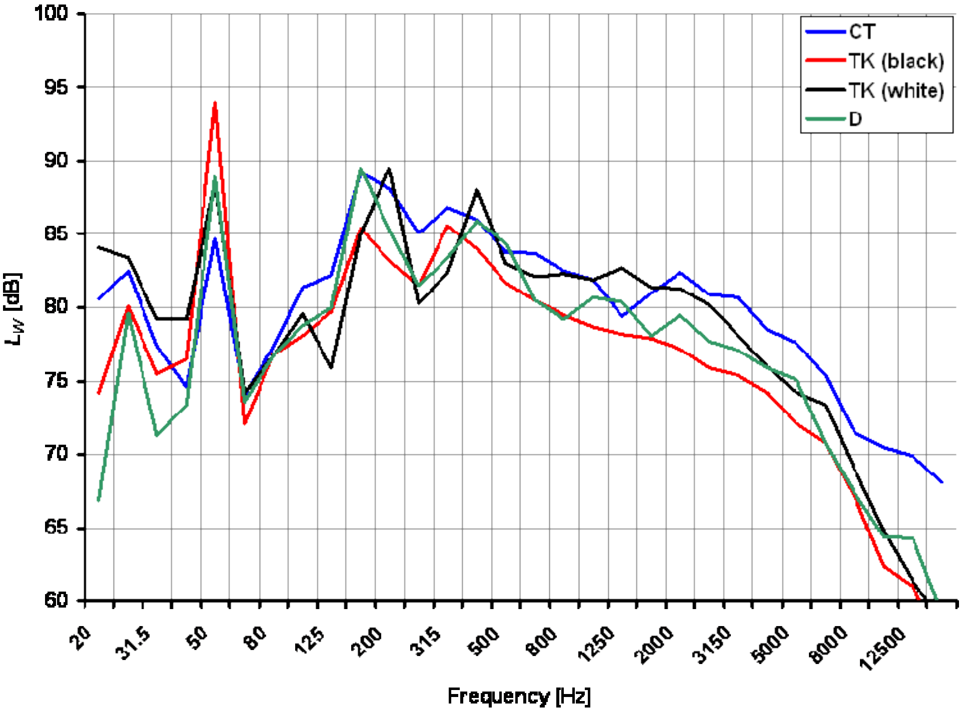

Figure 7: 1/3 octave band sound power levels of the reefers.

D RoRo Ramps

RoRo ramp noise here is considered to be caused by the bangs generated when trucks drive over the connections of the ship ramp to the quay. Therefore the measurement set ups are located near the ramp connections and the events are chosen at times when the trucks pass the measurement area. Measurements of RoRo ramps were carried out in both test ports. The measurements were carried out during the unloading and loading of RoRo vessels.

Two ramps were measured using four microphone positions at the side of the ramp on the quay, where the bang caused by terminal tractors and trucks driving over the joint of the ramp is located. A photograph of the measurement location is presented in Figure 3. The measurements included 32 different events for ramp 1 and 9 events for ramp 2. The results are presented in Figure 8. At the other port 10 and 7 events were recorder. The former events represent cases of terminal tractors with a trailer and the latter without a trailer. The results are presented in Figure 9. The error bars represent 95% confidence intervals for normal distribution.

It is seen from the results that the results vary a lot depending not only the type of ramp but also the type of vehicle driving over the ramp. Also the speed of the vehicle has an effect.

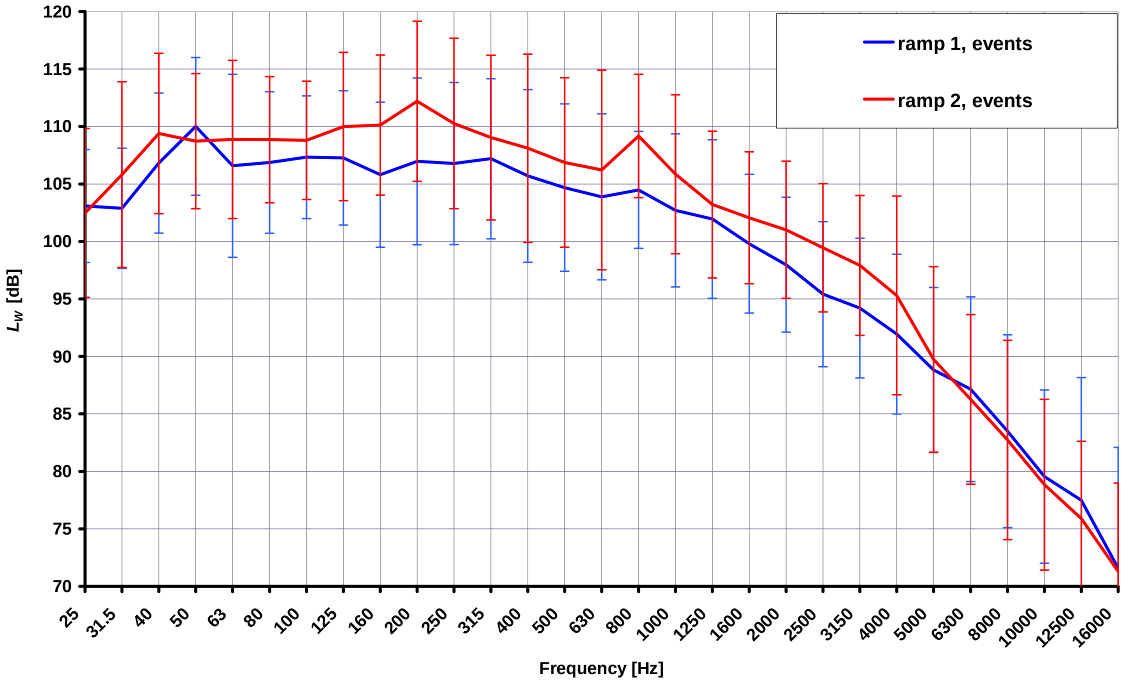

Figure 8: 1/3 octave band sound power levels of RoRo ramp noise, various vehicles.

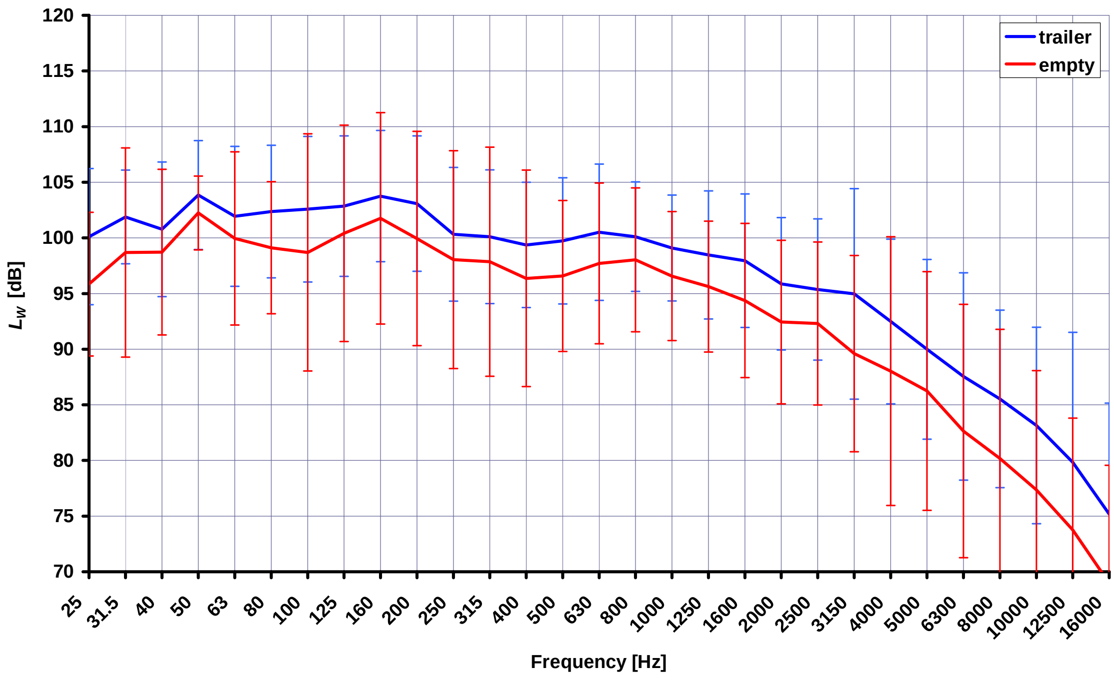

Figure 9: 1/3 octave band sound power levels of RoRo ramp noise, terminal tractors with and without trailer.

E Container Handling Events

Several container handling events were measured. The events included ship unloading, moving containers around on the ship, picking up and laying down containers. The used equipment were ship to shore gantries, reach-stackers and straddle carriers. The 1/3 octave band results are presented in Figure 10. Again the variation between different events is high.

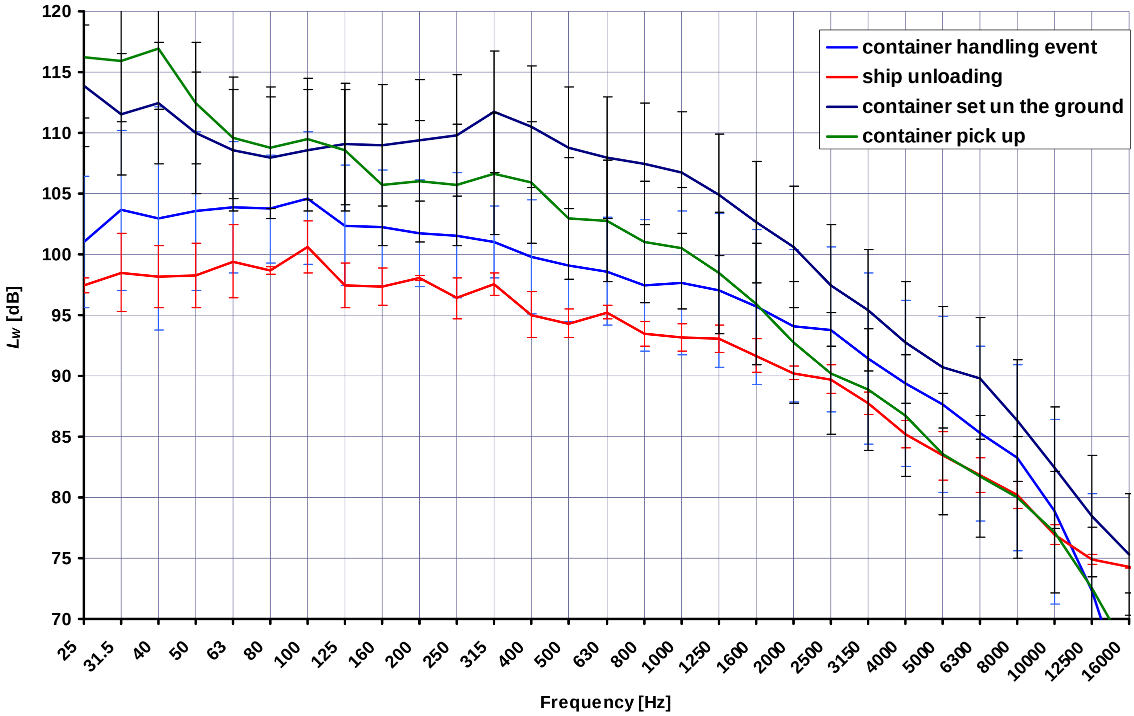

Figure 10: 1/3 octave band sound power levels of container handling.

4. RANKING OF THE SOURCES

The ranking of the measured sources is done by sorting the different sources in an order using the A- weighted sound power levels and Unbiased Annoyance as criteria. The results of the ranking have been presented in figures 11 and 12. According to the ranking carried out by A-weighted sound power levels the highest sound power levels are RTG power units, straddle carrier pass by, container handling in some cases and alarm sound. The lowest levels are generated by ventilation and reefers. If the linear sound power levels are considered, the ranking order is somewhat different. The highest levels are produced, in addition to the previously mentioned, by ship auxiliary engine exhaust, RTG exhaust and gantry crane power unit. By ranking the sources according to the Unbiased Annoyance Indicator the most annoying sources are alarm sounds, RTG engine sound and exhaust stack ventilation.

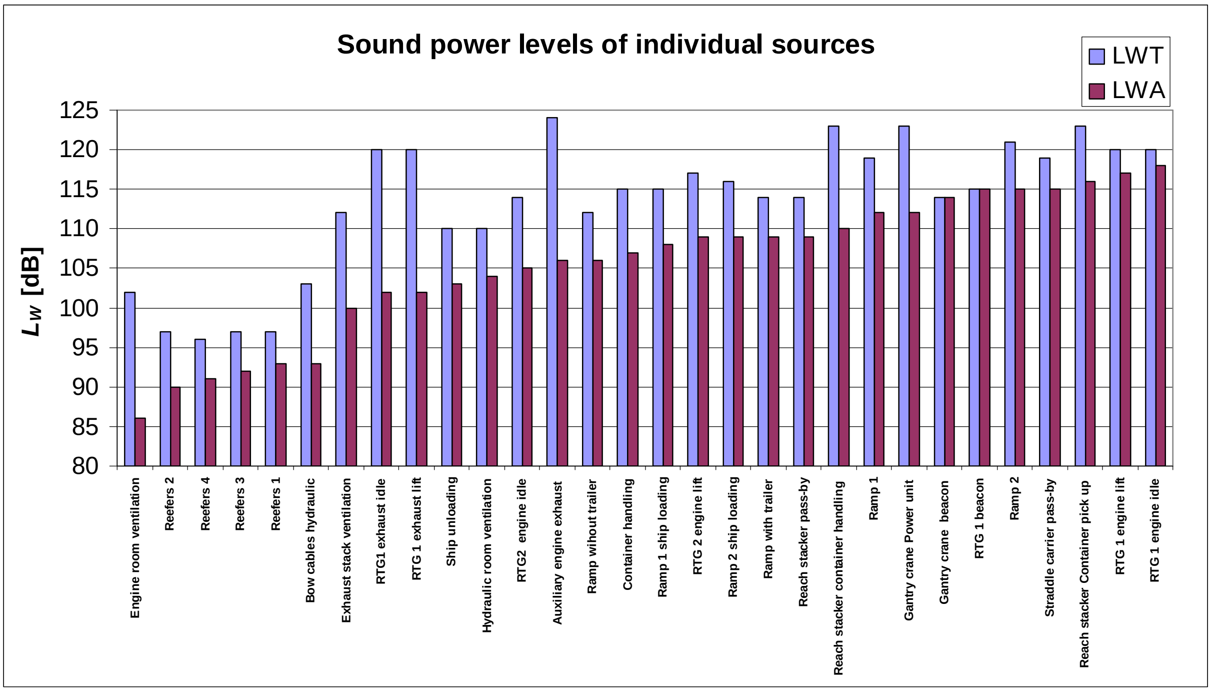

Figure 11: Linear and A-weighted sound power levels for individual sound sources ranked according to the A-weighted sound power levels.

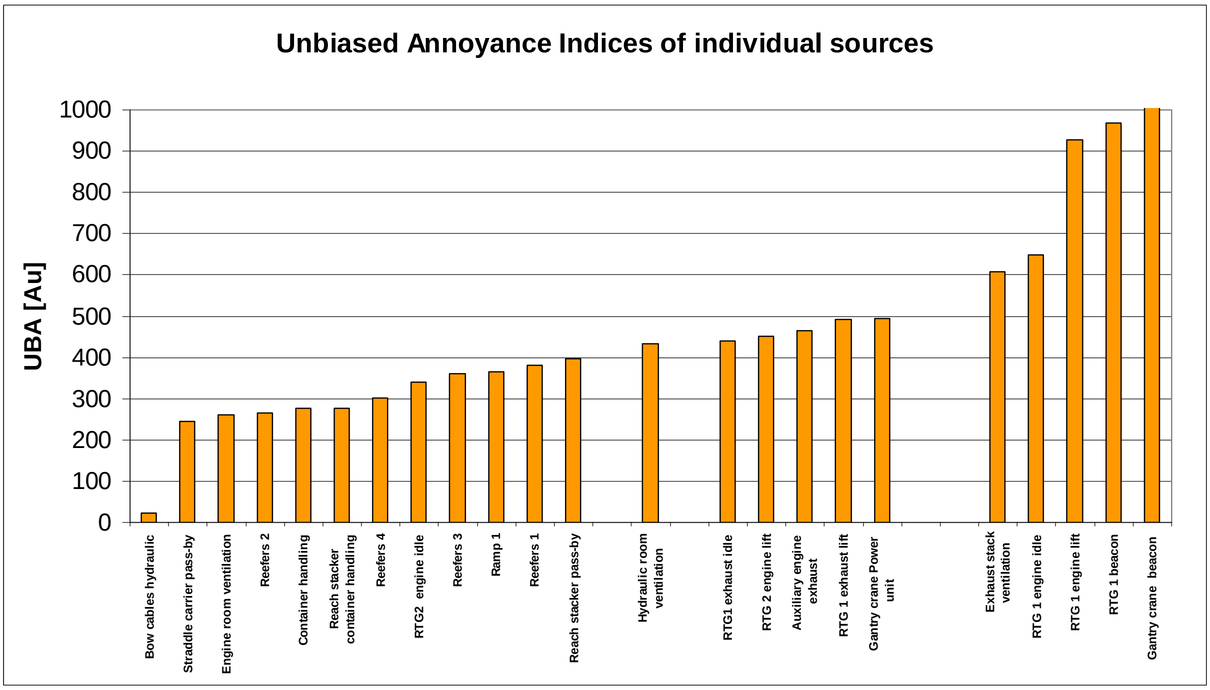

Figure 12: Individual sound sources ranked according to the Unbiased Annoyance Indices.

5. CONCLUSIONS

Several sound sources have been measured for sound power levels. In order to evaluate the annoyance caused by them, sound samples have been recorded and some psychoacoustic descriptors calculated.

The results are presented for individual sources. And the variation of the different A-weighted sound power levels is between 85 and 118 dB. It, however, has to be pointed out that also the amount of noise sources operating in the area will affect the total sound power level of the sources and therefore the annoyance of the sources. The Unbiased Annoyance values have been calculated from the data measured near the sources. The attenuation of sound over longer distance will also affect the annoyance of the sources. The ranking of the sources, however will give some indication on the annoyance of different sources of ports. The next step of the work is to further process the sound samples in order to evaluate the annoyance at certain distances from the source.

ACKNOWLEDGMENTS

The authors are grateful to the personnel of the ports of Turku and Dublin for their assistance in carrying out the measurements. The authors also express their gratitude to the EU funded project Efforts for enabling the financing this work.

REFERENCES

1. ISO 3744 Acoustics - Determination of sound power levels of noise sources using sound pressure - Engineering method in an essentially free field over a reflecting plane