Edinburgh, Scotland
EURONOISE 2009
October 26-28

Exposure to noise in ports

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ABSTRACT

There are many noise sources and various combinations of them that characterize the noise exposure of workers in ports. In this paper, with reference to methodologies and case studies, developed in ports of Italian cities, the authors present a draft of classification paper for source systems corresponding to general activities, considering standard and non-standard procedures for measurement of noise and calculation of risk assessment connected to them.
More in general, the main aspects of evaluation and reduction of noise in ports' working places are investigated, starting from the minimum requirements for the protection of workers against the risks resulting from exposure to noise, fixed by 2003/10/EC Directive and other European disposals and guidelines. Also problems and possible common solutions connected to the increased risk depending on concurrent exposure to vibrations are considered.

1. INTRODUCTION

In the frame of the precolloquium "Noise challenges in ports and industrialized areas", a satellite symposium of NAG-DAGA's congress (Rotterdam, March 2009), some first element of specific knowledge about methods for the correct evaluation of entity and effect of noise exposure for workers in port areas where given by the authors, referring to the Italian regulation and to a couple of Italian experiences.
One of the final results of the Rotterdam symposium was the engagement of all the involved experts and paper presenters to work at a development of their specific field of expertise, collecting more data and experiences and taking into account the other complementary aspects of the problem pointed out in the precolloquim, for a up-to-date contribution to be given at Euronoise 2009 strucured session on ports.
In the past five months, the authors have acquired a deeper knowledge of noise sources in ports and their activities, as single units or complex systems in a worker-oriented approach, considering their impacts on the port's area as a boundary condition and not as a primary one.
The assessment of noise exposure of workers in ports requires a complex analysis of a large number of procedures performed by personnel working with different tasks. It is particularly complex for those works where, if necessary, it is required the double work shift over the 24 hours: in this paper different methods for the evaluation of this subject are considered, basing on the worker's noise exposure document made by TDT Terminal in Leghorn and LSCT Terminal in La Spezia.
Actions for noise mitigation applied in LSCT Terminal and other innovative solutions to reduce emissions and noise pollution of ships in port are also described, with a brief report on vibration exposure risk for port workers.

2. ACTIVITIES AND PORT QUAY ORGANIZATION IN TDT TERMINAL (LEGHORN) AND LSTC TERMINAL (LA SPEZIA)

A goods terminal is a place where a company, with appropriate resources, equipment and personnel, performs the operations of handling goods from one means of transport arriving at the terminal to another departing. It is set up with of several parts:

• the quay, link between the sea and the land, which have a linear development (up to many kilometers long) to allow simultaneous work on different ships by cranes and portal;

• the machineries for container handling, both for loading and unloading operations and for transport and storage in specific areas;

• the warehouse and storage areas organized according to operating cycles and types of goods handled.

The activity of the terminal is performed following the so called "operational cycles" defined as "all the operations performed by the container terminal to execute the transfer of container from one carrier to another through standardized processes and sorted according to particular sequences of operations".

The operating cycles involved with a terminal activity are:

• operating cycle "import": concerns containers coming by sea that must be landed and keep on their journey overland;

• operating cycle "export": concerns the overland containers, arrived at the terminal by terrestrial carriers, which must be loaded onto the ship.

• operating cycle "transhipment": concerns containers arriving at the terminal by ship and later embarked again on another ship to arrive at destination.

The primary activity (read it as "not decomposable") which a cycle operation can be divided in are called "operations". Considering the no-stop and subsequential prerogative of these activities, an intermediate subdivision between cycle and operation are considered:

• "Landing" collect from board + quay transport + dock placement;

• "Boarding": collect from dock+ quay transport + board placement;

• "Discharging": discharge from trucks + dock placement;

• "Reloading": collect from dock+ charge on trucks (leaving).

Then the three cycles can be summarized as follows:

• Cycle Import = landing + reloading

• Cycle export = discharging + boarding

• Cycle transhipment = landing + boarding

The various operations described before can be performed using different means of transportation with different logistic organization.

In this paper two terminals, Terminal Darsena Toscana (TDT) and La Spezia Container Terminal (LSCT) have been investigated. Goods handling in these two terminals is performed using the means of transportation and the procedures described below.

The cycle of containers landing and boarding is performed by portainers, large mobile crane placed near the pier with large jib protruding from the quay to enable the removal of containers from the ship deck (LO-LO system).

Once the container has been picked up, it scrolls along the crane jib binaries, and then lowered and placed on trailers attached to truck tractor (multitrailer or a fifth wheel tractor) carrying the units from the quay to the storage yard. Here containers are moved with lift truck (reach staker, front loader and fork lift) for movements within the storage yard. Alternatively, multitrailers are parked next to the RTG (Rubber Tire Gantry crane), which are used for stacking the containers on different rows side by side, for a total height of 4-5 units.

The staff involved in these operations perform inside the cabin of mechanical means (cranes, lift truck etc.) or on the outside, for the logistic operations of boarding / landing (Deckman) and for the goods control at the dock (Checker).
Apart from the workers involved in goods handling, others are involved in the organization and in the management of the activity, who carry out their duties in the offices.

3. NOISE EXPOSURE OF WORKERS AT PORTS: EXPOSURE LEVELS OF THE ACTIVITIES AND METHODOLOGIES FOR EXPOSURE CALCULATION.

A. Organization of the port and tasks

A port terminal is a very extensive working place in where many different workers operate.
A classic port terminal is divided in various areas for goods movement listed below:
• Ship: mobile work area, with all its nautical qualities and characteristics, which guarantees the overall performance of landing / boarding activities and the goods storage in the various cycles of work;
• Quay: ground clutter-free area equipped with mooring bollard and mobile cranes on tracks, with an extension commensurate within the range of on-board and land cranes;
• Uncovered areas: flat surfaces, paved or not and properly lighted, equipped and organized for storage and / or handling of goods, used for the transit of lifting mechanical vehicles and road / rail transport;
• Covered areas: protected structures with closed perimeter and checked access, with paved or not floors, used for storage, warehousing and goods care, suitable for lifting vehicles operation connected with discharging / reloading areas;
• Offices: buildings used for administrative and business tasks, organized with equipment and communication systems.

B. Noise exposure reduction through the working shift

The main distinction among the different workers in a port company is between the administrative staff, with a daily 8-hours activity, and the operating staff, characterized by a continuous turnover over the 24 hours.
The investigation of noise exposure for the administrative staff is not of primary interest because noise levels present in working areas are low, and the duration of the working day is fixed.
The analysis for the operational staff are more complex and interesting since it involves different activities (in areas with different noise exposure levels) but especially because, in the case of overtime, the worker may have to manage two shifts over 24 hours: in this case, to assess the daily noise exposure, it is necessary to consider all the different scenarios that may arise by combining appropriate activities carried out in two shifts, condensing the worker's sound energy exposure over the 24 hours to the reference standard period of 8 hours.
The activity of an operating worker is usually performed in a flexible manner; the worker has several skills for driving goods handling machines and for container checking activities. In case of double shifts, the worker may have to carry out the first shift driving a means of transport (reach staker, front loader, fork lift etc) and the second shift in the quay to check the flow of containers, or even both shifts driving the same vehicle, or different vehicles: it is clear that noise exposure levels of a worker during the 24 hours are diversified, and it is therefore interesting to note that situations of overexposure to noise can sometimes be reduced simply with different combinations of working rounds.
Referring to investigations conducted at TDT Terminal in Leghorn, a typical example is given by the activity of the shift-worker employee assigned at operative documentation support.

Considering the doubling of the turn, he works an average of one shift (half of his working day) completely in offices, exposed to a level of 73.8 Leq dB (A), and a shift in contact with other departments (in quay, workshops etc..) exposed to an average level of 80.5 dB (A).
Determining the Lex, 8h (which, it useful to remember, is referred to a standard 8 hours working daytime) we obtain a level of 80.1 dB (A), higher than the lower exposure action value. Otherwise, if his activity in the noisy shift is shared with another operator who usually works entirely into offices, both worker's noise exposure values lie below the limit of action, and it would not be necessary to proceed with further operations.
This example shows that in some cases it is possible to eliminate situations of overexposure to noise through the simple organization and redistribution of duties (in the case of double shift).

3. SYSTEMS FOR NOISE EXPOSURE REDUCTION WHITIN THE PORT AREA

A. Noise exposure reduction through the use source reduction systems.

It is obvious that it's possible to reduce workers' noise exposure by acting directly on the source. Furthermore, this solution also permit the global noise reduction from the port. This approach is particularly useful for port areas placed next to house settlements, when port noise exceed limits in the facade of the buildings.
A typical example is the port of La Spezia (see figure 1), many residential buildings are placed very close to port, and noise from port activities exceed noise-level limits.

Figure 1: The port of La Spezia

The main terminal in the port of La Spezia, LSCT, has therefore provided to equip means of transport and various facilities within the port area with noise mitigation systems which have contributed to reduce noise emissions produced during the work.
The major mitigation measures have been:
• Replacement of air vents and exhaust silencers of RTG (rubber tire gantry crane): noise produced by the RTG has been identified as a major contribution of the overall noise emission produced by the terminal, with significant power levels. The replacement of air vents and exhaust silencers with more efficient units has strongly reduced noise power emission (from 93 dB (A) to 80 dB (A)) (see figure 2).

Figure 2: RTG's air vents and exhaust silencer units

• The use of trailers equipped with "silent blocks". Another annoying source of noise occurs during containers handling for discharging and reloading operations. Shocks and frictions between container and trailers occur and generate strong impulsive noise. To reduce this phenomenon all the trailers in the terminal management have been equipped with "silent block", that is a resilient hard element installed on the contact surface between the trailer and container in order to limit the impulsive noise. The full effectiveness of this solution is obtained, however, with the contribution of the container handling operator, who have to try to be as soft as possible during loading and unloading operation, avoiding sudden movements of container (see figure 3).

Figure 3: Trailer equipped with "silent block"

• The use of new technology warnings: originally devices have been replaced with new horns with higher operating frequencies. New items operate on a frequency range of 2500-3000 Hz instead of 1200-1700 Hz. These new devices allow to get a sound diffusion concentrated near the source, with a significant reduction of levels away from it. At a distance of 70 meters, the level is no longer perceptible (see figure 4).

Figure 4: Horn for warnings

• Reach staker noise-reduction: many different solutions to reduce noise emissions have been tested, including reduction of maximum engine rev, and a special end on exhaust silencer (figure 5).

Figure 5: Silencer panels on the reach staker body

Apart from the solutions described above, it has become necessary to install noise barriers on the boundary of the terminal area, in order to reduce noise contribution of port activity along the source-receiver path.

B. Innovative systems for noise reduction at source: ships power supply whitin the port area

An innovative solution to reduce noise and environmental pollutants emissions coming from ship engines within the port area is represented by electricity network connecting systems for vessels berthing at the quay.

When a ship moors at the port quay for maintenance operations, a series of on-board and land generators are used to provide electricity to ship's devices and service systems. Generators represent a main source of noise and environmental pollution in general, which are used for very long time during manteinance operations.

A system to eliminate this annoying source lie in the set of quay and craft with a port power supply system: in substance, the ship is physically connected to a bundle (see figure below) and then has a system of silent power supply on-board.

Figure 6 and 7: Bundle of electric cables and its craft linking system

The final phase of a pilot project for the use of this technology within the port of Genoa has been completed. The project includes the installation of connecting systems in three macro-areas of the port: the dry docks, the ship's repairing area and the technique dock as shown in the picture below.

Figure 8: Genoa port with ships power supply areas (project)

Electrical transforming cabin have been placed away from distribution cabin, in order to free the quay from the encumbrance and of reducing noise exposure of workers. The converter device uses a static machine instead of a rotating one; this solution allows to a reduction encumbrances, management costs and noise emissions.

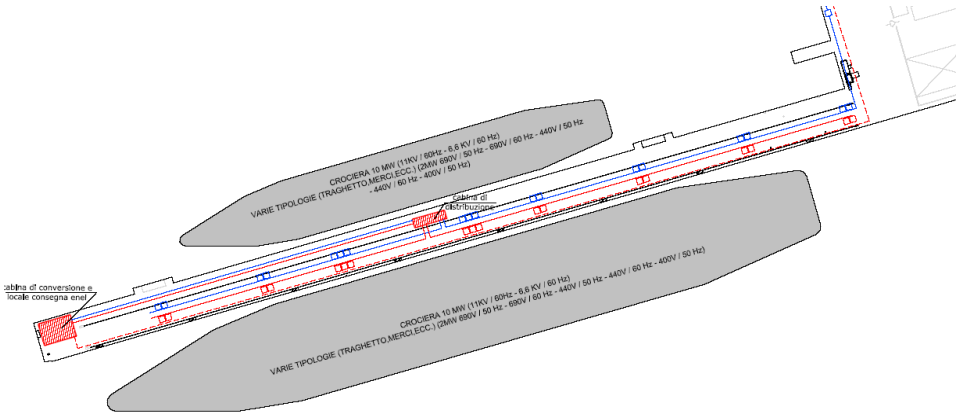

Figure 9: Plan of the distribution system for craft power supply

4. VIBRATION EXPOSURE OF WORKERS AT PORTS

In the investigated scenarios, the analysis of vibration exposure of port workers doesn't show hazardous situations for this type of physical risk.
Workers usually operate with vehicles as pointed out in the preceding paragraphs.
Daily exposure to vibration of the potentially most hazardous tasks has been therefore carried out by determining the levels of vibration in the cabin of container handling machines during its normal use.
In port work activities, vibrating facilities which can shake the hand-arm system are very hardly used. Moreover, it was found that vibrations on hand-arm system produced by the controls (steering wheel, joystick, lever etc..) are negligible compared to the action limits set by the European legislation. A risk assessment for hand-arm vibrations has not therefore taken into account. The results of investigations showed very low levels of vibration exposure, far from the limits laid down in legislation (limit daily exposure normalized to 8 hours of 5 m/s2, daily action value of 2.5 m/s2) as reported in table 1.

Table 1: *Vibration exposure values for workers at ports*

Mansione: Operatore piazzale		
Attrezzature	**h/d**	**A_{wmax} – m/s²**
gru Unloading 1	2,5	0,22
gru Unloading 3	2,5	0,22
gru Unloading 7	2,5	0,20
gru Stacking 4	2,5	0,16
gru Stacking 9	2,5	0,11
gru RTG 23	2,5	0,14
gru RTG 24	2,5	0,13
gru RTG 30	2,5	0,15
carrello per container 47	5	0,45
carrello per container 51	5	0,26
Nessuna	6	0
Totale	36	=
ESPOSIZIONE GIORNALIERA A(8) – m/s²		**0,22**

Mansione: Manutentore		
Attrezzature	**h/d**	**A_{wmax} – m/s²**
carrello a forche piccolo	2,5	0,84
carrello a forche grande	2,5	1,17
Nessuna	31	0
Totale	36	=
ESPOSIZIONE GIORNALIERA A(8) – m/s²		**0,36**

5. SUMMARY

This paper describes activities usually performed by workers in ports and some methods to reduce noise exposure. Some methodologies for the reduction of daily noise exposure of workers by means of changes in organizational and logistic activities are described. Technical provision and innovative technological solutions for reducing noise at source are reported too.
The reduction of noise at source is always to be preferred, and it is crucial in popolous settlements where port areas lie close to residential areas, because of the joint positive effect on port workers and residents.
A brief description on the assessing of workers vibration exposure has been carried out: the results showed rather low levels of vibration, below the limits provided by law.

The authors give a contribution on noise at work in ports at two levels: a general level moving from the evaluation methods and the other requirements for the protection of workers against the risks resulting from exposure to noise, fixed by 2003/10/EC Directive and other European disposals and from their transposition in Italian National Legislation (D.Lgs. 81/2008); a specific level, refererring to case studies, developed in ports of Italian cities, stressing the critical points present in the standard procedures for measurement of noise and risk assessment.

6. ACKNOWLEDGMENTS

The authors express their warmly thankfulness to Captain Pasquale Avino of TDT Terminal in Leghorn and to Mr. Ermanno Gianelli of La Spezia Container Terminal, for the their fundamental help given in the preparation of this paper.

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