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Technical Notes

Assessment of Exposure to Noise of Workers to a Reinforcing Bar Rod Mill ArcelorMittal Algeria

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This work is a contribution to a normative approach of noise assessment in the professional environment. It permits the identification of the affected workstations on the one hand and on the other hand it constitutes an important support to the preoccupations of the impact study on the environment in plants. It also informs us on the adequate preparation of the procedures required by the Environmental Management System (ISO 14001) being implemented in steel-making complex ArcelorMittal Algeria. It constitutes an answer to the recommended environmental politics.

The proposed calculation methods are verified according to the recognized sources (ISO 9612, 2009) and the results will be estimated in relation to the legal thresholds recommended by international bodies. The methodology for measuring the noise exposure levels has been done according to the following steps: work analysis; selection of measurement strategy; measurements; error handling and uncertainty evaluations; calculations; and presentation of results. This will lead us to an implementation of a corrective and preventive action plan intended to master this occupational risk carrying prejudice to the health of the workers.

Keywords: noise; workstation; measurement; assessment; occupational risk.

1. Introduction

Noise, particularly that derived from industrial activities is considered an important occupational risk. Moreover, the daily exposure of workers to elevated noise levels can cause hearing loss. This disease classified as an occupational disease, due to the industrial development takes statistically alarming proportions in the working environment (Rucay *et al.*, 2010; Martinez *et al.*, 2011). Also, the noise is not just an ineluctable banal phenomenon of industrialization. Considered by some authors as an aggravating factor of environmental stress (Hammoudi *et al.*, 2013; Taleb *et al.*, 2003; Gaudemaris, Madon, 1998; Fyhri, Aasvang, 2010), it is a part of the environmental and societal problems. The inclusion of noise as a factor of stress and occupational risk of hearing loss in the impact assessment study is now an unavoidable fact. Our contribution is an important manager' concerns in reinforcing bar rod mill industrial plant (ArcelorMittal Algeria). The commercial ambitions of this plant require an adaptation of its installation with the international standards. After having passed the steps of the management standards (ISO 9001) and security (ISO 18001) it agrees currently the environmental standards (ISO 14001). The main goals of this paper are constituting a first data bank on noise pollution and establishing an adequate program of prevention of the occupational risks related to noise. Also this contribution answers to the preoccupation of the reinforcing bar rod mill (LRB). Its attachment is to make an assessment of noise exposure level in different areas of the plant using the standard ISO 9612: 2009 (ISO, 2009).

2. Material and methods

2.1. Manufacturing process of reinforcing bar

The rolling mill reinforcing bar (LRB) is a train of reinforcing bars at the steel-making complex ArcelorMittal Algeria (ArcelorMittal, 2010), with a production capacity of 466 600 t/year (Superior Optime Institute, 2008), and a workforce of 151 workers (ArcelorMittal, 2011).

From billets supplied by the steelworks with oxygen no. 2 or by the electric steelworks, the LRB produces of the ribbed reinforcing bar, of diameter (10 to 32 mm) intended for the construction (ArcelorMittal, 2010).

The LRB is composed of an oven with mobile central girders of 80 T/h, a rolling mill of 16 mill stands, equipped with a roughing stand and a group of intermediate stands and finishing stands, a line of ribbed reinforcing bar (⌀ 10–32 mm) and round smooth (⌀ 14–50 mm) and a line of cooling "Thermex and big bed" (VAI POMINI, 2002).

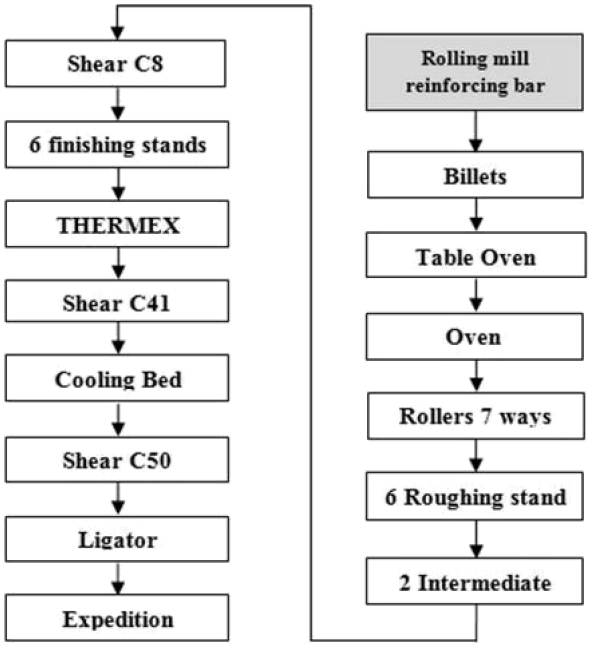

Fig. 1. Schematic representation of the manufacturing process (Serradj, Cheniti, 2010).

2.2. Equipment used for the measurements

To make all measurements of the noise levels, we used INTEGRATOR SONOMETER, Model: SOLO Class 1, calibrated[1], with a microphone typifies: MCE 212 and a preamplifier typifies: MEADOW 21S (Entreprise SOLO METRAVIB, 2005).

[1]The Laboratory of Calibration of Acoustic Instruments (LACAINAC), according to the standards IEC 651 and IEC 804 (Class 1) and equivalent UNE 20464:90 and UNE: 20493:92 (INERCO Prevention of the risks, 2011)

2.3. Methodology for measuring of the exposure levels to the noise

The measurements were realized according to the standard ISO 9612: 2009 (Acoustics – Determination of occupational noise exposure – Engineering method) (ISO, 2009). This international standard specifies an engineering method for measuring workers' exposure to noise in a working environment and calculating the noise exposure level (ISO, 2009). The chronological stages are the following ones: work analysis; selection of measurement strategy; measurements; error handling and uncertainty evaluations; calculations; presentation of results (ISO, 2009).

Stage 1: Work analysis and identification of the posts to be estimated (definition of homogeneous groups' exposure to noise)

According to the functional organization chart of the LRB Plant and the collected information, we grouped the workers in the Plant into groups called homogeneous noise exposure groups. These groups of workers do the same job and undergo similar noise exposures during the working day as shown in Table 1.

Stage 2: Selection of measurement strategy

Taking into account the configuration of the functional organization chart, it was recommended to envisage a representative number of 8 groups of homogeneous exposure for which an analysis based on the function (office) was made according to the standard (ISO, 2009).

Stage 3: Measurements

The measures mentioned in Table 2 are the average values that were obtained during all week (2-6/03/2014) they also permitted to get the relevant results that are based on the following evaluation criteria: the equivalent continuous A-weighted sound pressure level (L_{PAeqTe}), the number of staffs, the number of samples and the duration of exposure to the risk.

3. Results (Stage 4 and 5)

3.1. Treatment of the measures (according to the standard ISO 9612: 2009)

The calculates of the equivalent continuous A-weighted sound pressure level $L_{P,A,eqTe}$, the daily noise exposure level $L_{EX,8H}$ and the expanded uncertainty $U_{(L_{EX,8H})}$ were performed according to Eqs. (1), (2) and (3):

$$L_{PAeqTe} = 10\lg\left(\frac{1}{N}\sum_{n=1}^{N} 10^{0.1\times L_{PAeqT,n}}\right), \quad (1)$$

$$L_{EX,8H} = L_{PAeqTe} + 10\lg(Te/T_0), \quad (2)$$

$$U_{(L_{EX,8H})} = 1.65 \times u, \quad (3)$$

where $L_{P,A,eqTe}$ is the equivalent continuous A-weighted sound pressure level, $L_{PAeqT,n}$ is the equivalent

Table 1. The homogeneous noise exposure groups of LRB Plant.

Group	Zone	No. of staff	Professional staff
1	Direction	8	Divisional – Manager Operations – Responsible for working conditions – Leader technical office manufacturing – Main Calibrator – Main assistant manufacturing – Main assistant mill stand – Main assistant guide.
2	Oven	15	Crane conductor – File billets – Head oven – Operator oven.
3	Rolling (*Operations group*)	29	Chief operating post – Crane conductor – PC2 Operator – Rolling mill operator roughing stand – Rolling mill operator intermediate stands – Rolling mill operator.
	Rolling (*Maintenance group*)	25	Chief post maintenance – Mechanic – Electrician – Automaticien – Foreman – Technician hydraulics – hydraulicien – Lubricator.
4	Preparation	13	Foreman assembly mill stand – Editor mill stand – Turner CNC – Milling machine operator – Turner.
5	Expedition	30	Watching line – PC3 Operator – Leader of post – Shipping Agent – crane conductor – mechanical foreman – Technician mechanic – Mechanic – Welder.
6	Fluids	11	Chief fluid sector – fluid Operator (Day) – fluid Operator (3*8).
7	Electric intervention team	8	Chief electricity sector – regulation Engineer – Automaticien – Instrumentalist – Electrical engineer – Electrician.
8	Technical office	12	SAP (System Application and Product) Agent – Agent estate management – Draftsman archivist – Technician of oven zone – Technician of rolling zone – Technician of zone rolling, ligne, cool – Technician of zone arm, exp – Hydraulic, pneumatic – Technician of fluid zone – Technician of zone electricity, regulation.

Table 2. The measures of (2-6/03/2014).

Group	Zone		N	n	$L_{P,A,eqT,n}$ et $L_{p,Cpeak}$						
1	Direction		8	3	$L_{P,A,eqT,n}$	64.0	65.3	65.2			
					$L_{p,Cpeak}$	87.2	86.9	89.3			
2	Oven		15	6	$L_{P,A,eqT,n}$	88.4	88.1	87.2	88.7	84.9	101.2
					$L_{p,Cpeak}$	104.5	106.3	107.1	109.3	105.1	115.5
3	Rolling	*Operations group*	29	6	$L_{P,A,eqT,n}$	89.5	91.7	92.1	96.4	98.0	93.9
					$L_{p,Cpeak}$	105.4	107.3	112.4	110.9	111.6	109.7
		Maintenance group	25	6	$L_{P,A,eqT,n}$	88.7	89.8	91.3	88.7	87.6	87.4
					$L_{p,Cpeak}$	103.1	105.3	106.4	104.6	102.8	102.8
4	Preparation		13	6	$L_{P,A,eqT,n}$	88.0	87.6	85.7	85.4	79.6	84.7
					$L_{p,Cpeak}$	107.7	103.7	107.5	104.4	98.3	107.1
5	Expedition		30	6	$L_{P,A,eqT,n}$	90.1	89.8	96.3	93.3	86.8	87.3
					$L_{p,Cpeak}$	106.3	111.7	123.4	119.2	109.5	108.3
6	Fluids		11	6	$L_{P,A,eqT,n}$	77.9	68.2	91.8	88.3	88.1	86.6
					$L_{p,Cpeak}$	105.6	102.2	105.8	103.9	106.7	104.3
7	Electric intervention		8	3	$L_{P,A,eqT,n}$	74.9	79.5	72.9			
					$L_{p,Cpeak}$	96.0	101.7	98.3			
8	Technical office		12	3	$L_{P,A,eqT,n}$	73.8	63.7	68.1			
					$L_{p,Cpeak}$	102.9	91.1	100.0			

N – number of staffs,

n – number of samples,

$L_{P,A,eqT,n}$ – the equivalent continuous A-weighted sound pressure level of the n sample,

$L_{p,Cpeak}$ – C-weighted peak sound pressure level.

Table 3. Table of global results.

Group	Zone		N	L_{PAeqTe} [dB]	$L_{cpK\max}$ [dB]	$L_{EX,8H}$ [dB]	$U_{(L_{EX,8H})}$ [dB]	DE [h, mn]	ADE [h, mn]
1	Direction		8	64.87	89.3	64.58	3.31	7 h : 30 mn	8 h
2	Oven		15	94.28	115.5	93.99	3.71	7 h : 30 mn	1 h
3	Rolling	*Operations group*	29	94.55	112.4	94.26	3.05	7 h : 30 mn	1 h
		Maintenance group	25	89.13	106.4	88.84	2.24	7 h : 30 mn	4 h
4	Preparation		13	85.85	107.7	85.56	3.05	7 h : 30 mn	8 h
5	Expedition		30	91.94	123.4	91.65	3.05	7 h : 30 mn	2 h
6	Fluids		11	87.48	106.7	87.19	4.73	7 h : 30 mn	4 h
7	Electric intervention		8	76.67	101.7	76.38	5.49	7 h : 30 mn	8 h
8	Technical office		12	70.38	102.9	70.09	8.81	7 h : 30 mn	8 h

N – number of staffs,

$L_{P,A,eqTe}$ – the equivalent continuous A-weighted sound pressure level,

$L_{p,Cpeak}$ – C-weighted peak sound pressure level,

$L_{EX,8H}$ – daily noise exposure level dB,

DE – duration of exposure to the risk,

ADE – the authorized daily duration of exposure to the risk,

$U_{(L_{EX,8H})}$ – expanded uncertainty.

continuous A-weighted sound pressure level of the n sample, $L_{EX,8H}$ is daily noise exposure level, N is number of staffs, $U_{(L_{EX,8H})}$ is the expanded uncertainty, $u_{(L_{EX,8H})}$ is standard uncertainty composed for the daily noise exposure level. This parameter can be obtained from a table presented in ISO 9612 (ISO, 2009).

(**ADE**) The authorized daily duration of exposure to the risk was calculated according to the standard NF S 31-084 (AFNOR, 1987).

4. Discussion

After the application of Job-based measurement Strategy to determine noise exposure level (ISO, 2009), the final main outputs were the $L_{EX,8H}$ for each workplace and the corresponding expanded uncertainty (U) (Arezes *et al.*, 2012). The daily noise exposure levels are presented in the next graphic.

It is obvious that all workers of LRB plant are not exposed to the same intensity of noise. Figure 2 reproducing the workstations exposed to the noise shows three homogeneous exhibition zone requiring appropriate protective measures (Directive 2003/10/EC du Parlement européen et du Conseil, 2003; Canetto, 2006; Rucay *et al.*, 2010). The first zone (A) regroups the direction area, where the daily noise exposure level is lower than 85 dB due to the remoteness of equipment (30 m), mainly the rolling mill. In the second zone (B) the daily noise exposure level is above 85 dB, this zone includes a set of machines working

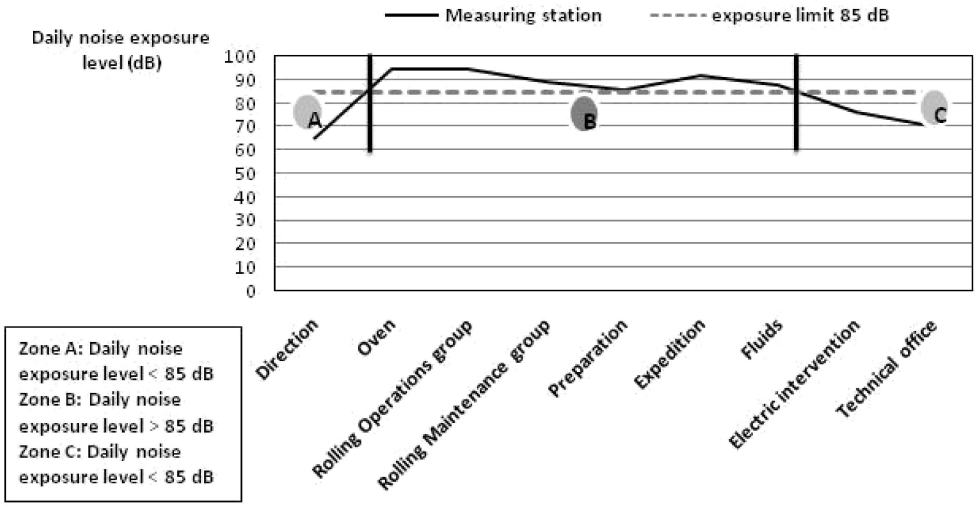

Fig. 2. Graphical representation of the noise of the LRB Plant.

simultaneously. The third zone (C) includes technical offices and the electrical room. In this zone the daily noise exposure level is not only less than 85 dB for the electrical room but decreases considerably for the technical office because of the sound isolation.

Taking corrective measures to reduce the impact of noise has become in the industrial world an imperious social necessity. The literature treating some impacts on workers' health is very verbose; the previous impacts could be handicapping. Also, the auditory impact comes in first position of the impacts on the auditory quality of the workers, it starts with the auditory fatigue and could reach until the hearing loss (Rucay *et al.*, 2010; Banerjee *et al.*, 2008; Çelik *et al.*, 1998; Osguthorpe, Klein, 1991; Hasan Beg, 1994; Yongbing, Martin, 2013). Then of the effects extra auditory (Banerjee *et al.*, 2008), also the effects of noise act on the nervous system (Chang *et al.*, 2012) that may provoke the most severe reactions in biological functions or physiological systems (Fyhri, Aasvang, 2010). Noise can accelerate cardiac and respiratory frequency (Stokholm *et al.*, 2014), increase the arterial pressure (Fyhri, Aasvang, 2010; Hammoudi *et al.*, 2013), decrease the intestinal transit, act on endocrine system (Chang *et al.*, 2012) and affect the quality of sleeping (Jiménez-Tejada *et al.*, 2012; Fyhri, Aasvang, 2010; Halperin, 2014). Thus, the works on relation between noise exposure and mental health have shown that the noise constituted a real factor of environmental stress (Taleb *et al.*, 2003; Gaudemaris, Madon, 1998; Fyhri Aasvang, 2010).

Taking into account the multiple and varied functions of the staff, it was observed during the analysis realized at the LRB that 18.54% of the workers of the plant are submitted to daily exposure levels below than 80 dB (lower exposure value triggering the action) (Directive 2003/10/EC du Parlement européen et du Conseil, 2003). Thus, in this situation it is necessary to mention the machine's noise level, where it exceeds 70 dB (A). In the case where the exposure level to the noise exceeds 80 dB, the employer must provide the workers with the individual protections against noise (earplugs or earmuffs), inform them about the problem of noise (risks caused by noise, measures and means of collective and individual prevention, the use of individual protections against noise) (INRS, 2009; Rucay *et al.*, 2010) and propose preventive audiometric exams (INRS, 2009).

While 15.90% of workers of the LRB undergo exposure levels between the superior exposure value triggering the action 85 dB and the limit value of exposure 87 dB (Directive 2003/10/EC du Parlement européen et du Conseil, 2003), in this case the employer must implement a program of technical measures to reduce the exposure to the noise, impose the port of individual protections, put a warning signs at the scene of work loud and limitation of access, and insure a reinforced medical surveillance of his employers (INRS, 2009).

The exposure limit values 87 dB cannot be exceeded in no circumstances. But, it is mentioned in Fig. 3 that 65.56% of the workers of LRB plant are submitted to exposure levels superior than 87 dB. In this situation the employer implements technical measures in order to reduce the exposure to the noise (INRS, 2009).

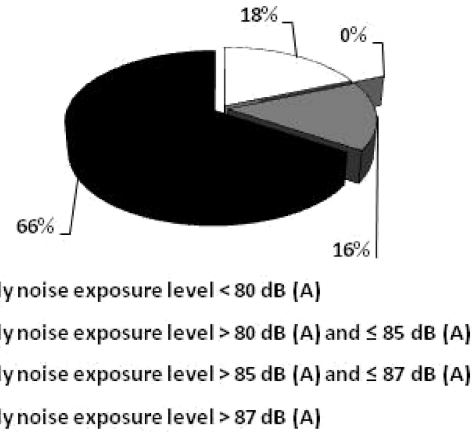

Fig. 3. Graphic representation of the percentages of noise exposure levels of the LRB plant.

5. Conclusion

This work will contribute to reducing the impact of noise pollution according to a chronological approach: assess risk, reduce noise at source and act on the propagation of noise (Gamba *et al.*, 1987; Pied, 2007). The data collected and the qualitative assessment of noise in the workshops will locate the most sensitive zones and identify the workstations that are exposed above the threshold provided by the standard (AFNOR, 1985).

The assessment of the risks by noise exposure of workers of a reinforcing bar rod mill – ArcelorMittal – Algeria has been done by taking of various measures. Calculations of exposure levels have been made in order to facilitate the development of a corrective and preventive action plan which derives the choice of the most appropriate actions to eliminate the noise. The measurements of noise levels became a necessity to assess the exposure of workers, but also to characterize the places of the different sources of emission in frequency and in intensity (AFNOR, 1987).

The found results should be completed by the respect of all the normative provisions.

References

1. AFNOR (1985), NF S 31-013: Acoustique. évaluation de l'exposition au bruit en milieu professionnel et estimation du déficit auditif, induit par le bruit, de populations exposées AFNOR.

2. AFNOR (1987) NF S 31-084: Acoustique. Méthode de mesurage des niveaux sonores en milieu de travail en vue de l'évaluation du niveau d'exposition sonore quotidienne des travailleurs, Paris.
3. ArcelorMittal (2011), *Functional organization chart of the zone of the products long PLG*, Adresse: BP 2055 Sidi Amar – El Hadjar – Annaba – Algérie / Site Web: http://www.arcelormittal.com: ArcelorMittal, Direction PLG.
4. ArcelorMittal (2010), *General presentation of the zone of the long products*, Adresse: BP 2055 Sidi Amar – El Hadjar – Annaba – Algérie / Site Web: http://www.arcelormittal.com, Algeria: ArcelorMittal.
5. Arezes P.M., Bernardo C.B., Mateus O.A. (2012), *Measurement strategies for occupational noise exposure assessment: A comparison study in different industrial environments*, International Journal of Industrial Ergonomics, **42**, 1, 172–177.
6. Banerjee D., Chakraborty S.K., Bhattacharyya S., Gangopadhyay A. (2008), *Modeling of road traffic noise in the industrial town of Asansol, India*, Transportation Research Part D, **13**, 8, 539–541.
7. Canetto P. (2006), *Une nouvelle réglementation sur le bruit au travail*, Dossier médico-technique 107 TC 110. Documents pour le médecin du travail, 297–307.
8. Chang T.Y., Liu C.S., Hsieh H.H., Bao B.Y., Lai J.S. (2012). *Effects of environmental noise exposure on 24-h ambulatory vascular properties in adults*, Environmental Research, **118**, 112–117.
9. Çelik O., Yalçın Ş., Öztürk A. (1998), *Hearing parameters in noise exposed industrial workers*, Auris Nasus Larynx, International Journal of ORL and HNS, **25**, 4, 369–375.
10. Directive 2003/10/EC du parlement européen et du conseil (2003), Les prescriptions minimales de sécurité relatives à l'exposition aux risques dus aux agent physiques (bruit).
11. Entreprise SOLO METRAVIB (2005), Manuel d'utilisation Sonomètre intégrateur à mémoire SOLO, Centre Technique TOULOUSE.
12. Fyhri A., Aasvang G.M. (2010) *Noise, sleep and poor health: Modeling the relationship between road traffic noise*, Science of the Total Environment, 4935–4942.
13. Gamba R., Josserand P., Paoli P. (1987), *Réduire le bruit au travail: une démarche*, Collection Outils et Méthodes pp. 147.
14. Gaudemaris R., Madon N. (1998), *Contrainte de l'environnement de travail et pathologie cardiovasculaire: bilan des études épidémiologiques et perspectives*, Rev. Med. Trav., 24–37.
15. Halperin D. (2014) *Environmental noise and sleep disturbances: A threat to health?*, Sleep Science, **7**, 4, 209–212.
16. Hammoudi N., Aoudi S., Tizi M., Larbi K., Bougherbal R. (2013), *Rôle du bruit dans le développement de l'hypertension artérielle en milieu aéroportuaire*, Annales de Cardiologie et d'Angéiologie, **62**, 3, 166–171.
17. Hasan S., Beg M.H.A. (1994), *Noise induced hearing loss in industrial workers of Karachi*, Pakistan Journal of Otolaryngology, Head and Neck Surgery, **10**, 200–205.
18. INERCO Prevention of the risks (2011), Report of the risks assessment by noise exhibition in the work stations of facilities of FERTIAL in ANNABA (ALGERIA). Annaba.
19. INRS (2009), Évaluer et mesurer l'exposition professionnelle au bruit, Paris.
20. ISO (2009), ISO 9612 (Acoustics – Determination of occupational noise exposure – Engineering method), France: ISO.
21. Jiménez-Tejada M.-P., Hódar J.A., González-García F. (2012), *Noise, what noise? Raising awareness of auditory health among future primary-school teachers*, Teaching and Teacher Education, **28**, 8, 1083–1090.
22. Martinez L., Bévilacqua D., Lanteaume A., Lehucher-Miche M.-P. (2011), *Reconnaissance des surdités professionnelles: il faudrait réduire le nombre de dossiers mal documentés soumis au Comité régional de reconnaissance des maladies professionnelles*, La Presse Médicale, **40**, 5, e286–e295.
23. Osguthorpe J.D., Klein A.J. (1991), *Occupational hearing conservation*, Otolaryngologic Clinics of North America, **24**, 2, 403–414.
24. Pied P.G. (2007), *Prévention entreprise* – No. 80.
25. Rucay P., Fusellier C., Garnier L., Moisan S., Ripault B., Penneau-Fontbonne D. (2010), *Le bruit dans un service de restauration collective hospitalière*, Archives des Maladies Professionnelles et de l'Environnement, **71**, 6, 882–887.
26. Serradj T., Cheniti H. (2010), *Evaluation de l'impact environnemental de deux laminoirs à chaud d'aciérie en Algérie,* Alexandrie, Egypte, Colloque Eau, Déchets et Développement Durable, 28–31 mars.
27. Stokholm Z.A., Hansen Å.M., Grynderup M.B., Bonde J.P., Christensen K.L., Frederiksen T.W., Lund S.P., Vestergaard J.M., Kolstad H.A. (2014). *Recent and long-term occupational noise exposure and salivary cortisol level*, Psychoneuroendocrinology, **39**, 21–32.
28. Superior Optime Institute (2008), *Environmental audit of the steel-making complex ArcelorMittal Annaba*, Annaba.
29. Taleb A., Brahim B.M., Benrezkallah L., Benkalfat F.Z. (2003), *Exposition au bruit, environnement psychosocial et hypertension artérielle en milieu de travail*, Archives des Maladies Professionnelles et de l'Environnement, **64**, 4, 246–252.
30. Yongbing S., Martin W.H. (2013), *Noise Induced Hearing Loss in China: a Potentially Costly Public Health Lssue*, Journal of Otology, **8**, 1, 51–56.
31. VAI POMINI (2002), *Technical specifications of a mill for rod and sections, Annaba, Algeria.*