NOISE POLLUTION IN THE UTILITIES INDUSTRIES IN SAUDI ARABIA

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***Abstract*— Noise presents health and social problems in industrial operations, and is mainly related to machinery used in the industries. The present study was conducted in the different utilities industries in Jeddah Industrial Estate (JIE), in order to assess the magnitude of the problem of industrial noise exposure there in an endeavor to propose remedial controls to the problem. Noise was measured in a random sample of 28 factories, representing 6 activities, at different day times. Results indicated that the noise levels vary, mostly, according to the type of industry and the size of the enterprise and the type and the number of the machinery used. The highest noise exposures exist in the cables, the concrete and the construction supplies, and the glass industries where, mostly, all the recorded dB(A) measurements (Leq, Max SPL and Min SPL) are higher than 85 dB(A), while the lowest exposures exist in the food processing and the dairy products and beverages industries, where all the average Leq dB(A) measurements are lower than 85 dB(A). It has been concluded that such noise pollution can present health problems to the workers, a situation which calls for a rapid planning of strategies for noise control and hearing conservation programs including:**

- **Measuring occupational noise exposure.**
- **Creating noise map of the factories.**
- **Controlling noise wherever is necessary.**
- **Pre-employment hearing tests.**
- **Periodical hearing test programs.**

***Keywords*— Industrial noise pollution; Electric appliances and supplies; Plastic and glass products; Food processing; Dairy products; Saudi Arabia**

I. INTRODUCTION

The preceding two papers of this series stressed the importance of the causal relationship between hearing loss and occupational exposure to noise, as well as described and discussed noise pollution in textile, paper and printing industries [1] and in metal and wood works industries [2]. This was executed in fulfillment of a plan to study in details the noise pollution in selected high risk Saudi industries.

Noise is an important factor that affects work environment, and consequently affects both workers' health and efficiency. The US Occupational Safety and Health Administration (OSHA)[3] specifies seven basic sources for health hazards, and noise is probably the most annoying factor. It can escalate the overall workload for a worker to highly fatiguing levels, and affects health both directly and indirectly. Direct effects include hearing impairments that may lead to a complete hearing loss [4]. Examples of indirect effects are backache, nervousness, annoyance, nausea, carelessness, and increased risk of accidents [5], [6]. Several field investigations for industry workers have established the strong association between high levels of exposure to noise and the risk of occupational accidents and injuries [6], [7], [8], [9].

The selection of the utilities industries for this study has been based on the conclusion derived from the National Institute for Occupational Safety and Health Studies (National Occupational Hazards Survey) NIOSH-NOHS, (1974, 1977, 1978)[10], [11], [12]; that utilities industries are among the top industries with greatest percentage of workers exposed to "unacceptable" levels of industrial noise[13]. Similar findings have been reported by the U.S. Occupational Safety and Health Administration (OSHA) – contracted noise survey (Balt Branek and Newzman Corp., 1976; Booz, Alen and Hamilton, 1983) [14], [15], consequently OSHA further acknowledged the criticality of assessing noise at workplace, and included it as requirement for a periodical job hazard report [16]. Furthermore other studies and reports related to the magnitude of the problem of noise exposure in the utilities industries include: Beaty, (1994) [17] and Food Information Sheet No.32 (FIS, 2004) [18] in USA; Holland and Ruggles, (1994) in Belgium [19]; Kuch, (1995) in Germany [20]; and Samules, (1994) in Australia [21].

The scope of this study includes electric appliances and supplies, tiles, marble and construction supplies, concrete products, plastic and glass products, food processing, dairy products and beverage industries in KSA. The specific objectives of study may be listed as:

- To map noise levels in selected industrial premises belonging to the utilities industries, and check their compliance with the standards of industrial noise exposure.
- To provide recommendations for noise reduction and health protection of employees.

II. METHODOLOGY

2.1 Selection of Factories:

A list of all the enterprises manufacturing and processing utilities in the city of Jeddah were obtained from Jeddah Chamber of Commerce and Industry (JCCI) including the following categories: (a) electrical appliances supplies, (b) tiles, marble and construction supplies, (c) concrete and concrete products, (d) plastic and glass products, (e) food processing (meat, bakery and pastry) and, (f) dairy products and beverages.

- A stratified random sample of 28 factories, representing about 20% of the above industries were selected, these include 4 of the electrical appliances supplies, 6 of the tiles, marble and construction supplies, 3 of the concrete products, 6 of the plastic and glass products, 5 of the food processing and 4 of the diary products and beverage industries.

2.2 Noise Measurement and Analysis

In individual factories, noise measurements were taken at strategic locations depending on the type, number and lay out of machineries. The noise measurements included Leq dBA and maximum and minimum SPLs at the individual octave bands. Other relevant data such as the operation, type and number of machineries, construction materials for roofs, floors, walls and ceiling, etc. were recorded.

Noise was measured at each location using the B&K sound level meter (SLM) type 1 model 2236. An omni directional microphone model 4188 was used with the SLM to include noises from all possible sources. Selection of measuring instruments has been based on OSHA Technical Manual (OTM) information which regulates the type of instruments and their calibration requirements [3]. It recommends using type 1 sound level meters to be used for field measurements for their accuracy, design, and cost effective controls. The calibration of the instrument was checked before and after each set of measurements as recommended by the SLM manufacturer [22] and ISO International Standards [23]. The measurements were performed over duration of 10 min. at each location at workers' head level.

The data were statistically analyzed using Excel. For each factory, frequency tables for Leq, Max and Min SPL levels were constructed. This was followed by computing the mean dBA of Leq, Max and Min SPLs, and also at different octave bands, for individual factories. The same analysis was done for each type of the industries by pooling the data of related factories.

The permissible limits for noise exposure of industrial workers are adopted for this study from OSHA recommendations [24]. Regulations limiting noise exposures for industrial workers have been also instituted by many countries and codes, e.g. ACGIH, TLV/BEL [25] and Directive 2003/10/EC of the European Parliament [26]. The general consensus in all regulations emphasize that working hours should be specified in relation to the sound pressure level (SPL) and that an SPL of 85-90 dBA is proposed as a limiting value for 8-hr exposure [23], [24], [25], [26].

III. RESULTS AND DISCUSSION

The studied plants vary considerably as related to their size, material of construction, and number and type of machinery. All the floors are concrete, while the walls are mostly of steel structure or from insulated panels except for plants where walls are of concrete blocks and the ceilings are all from steel structure. Such variation in the size and the material of construction of the studied enterprises, as well as the variation in the type and size of machinery, is anticipated to affect both the levels of the emitted noise and of the anticipated reverberant noise there. The means of noise levels of the Leq and of the maximum and minimum sound pressure levels (SPL) in the studied 28 factories are presented in Table 1 and graphically shown in figure 1. The highest noise exposures exist in the cables, the concrete and construction supplies and the glass industries where, mostly, all the recorded dB (A) measurements (Leq, Min SPL and Max SPL) are higher than 90 dB. This is mainly attributed to the high noise emitted from the machinery used, as well as from the fabricated materials. Meanwhile, the lowest exposures exist in the food processing and the diary products and beverages industries where all the average Leq dB (A) measurements are lower than 85 dB . Also, it is interesting to note that the most useful and possibly, the most meaningful parameter, the Leq has varying degree of variances, ranging from 1.9 dBA^2 (Jeddah cable, Saudi tile) to 5.6 dBA^2 (Saudi construction supplies). Factories with small variances of Leq could be treated with general noise control and reduction techniques. However, factories with high variations may have hot spots which would need individual noise control at the sources in addition to any general measures.

Figures 2 (a-b) show the mean Leq at the different frequencies of the pooled data for the factories belonging to each of the industries under study. The noise levels over 85 dBA occur at frequencies mostly below 1 KHz across all industries. This indicates that noise reduction techniques when applied should take special care of the frequencies below 1 KHz. Meanwhile, the reduction in noise at these frequencies ranges will considerably reduce noise interference with workers' speech, since much of the human speech ranges between 300 and 700 Hz and most vowels are below 1 KHz [27],[28].

IV. Conclusion and Recommendations

It may be concluded that industrial noise pollution can present health and social problems to the workers in the utilities industries. Levels of noise in most of the studied factories are higher than the acceptable industrial standards [24], [25], [26]. The situation in some of these factories calls for a rapid planning strategy for the control of industrial noise there.

Traditionally, there are three approaches to control workers' exposure to noise: source, environment, and receiver. ISO document 11690-1:1996 [29] presents recommended practices for the design of low noise work places. The most practical approach needs to be cost effective and suitable for the industry, and it is expected to differ from one industry to another. For example, in Metal fabrication [30] and in tractor driving [31], engineering methods that control the noise source were found to be more effective than administrative controls. However, in construction industry [32], [33], using personal hearing protective devices (receiver) were preferred over other noise control methods. A diversity of practices for efficient solution can be found in (Smith and Wellens(2007)) [34] that may be applicable for noise control in the utilities industries.

Based on the analysis, the following recommendations may be considered to improve the overall situation.

1- The first step consists of identifying and quantifying the noise exposure experienced by employees. It should be obvious that the risk of hearing loss will not only depend on the noise levels themselves but also on their duration. The employees usually experience time-varying noise exposure because noise varies unpredictably at their work location or because they move around the site in performing their job. Therefore it is essential to assess the total amount of noise to which the individual workers are exposed, i.e, the Noise Dose.

2- If the noise dose is greater than 100%, depending on the referred standard, noise control / reduction measures should be applied. It may be possible to reduce the noise; however, it may not be feasible to do so in practice due to the inordinate cost involved. The first few dB of noise reduction may cost nothing at all and may even save money in the long run. There comes a point, however, where further noise reduction involves appreciable investment.

3- The most important step in noise control is to use the first line of defense against hazardous industrial noise exposure that is the application of engineering control, such as replacing or modifying noisy machines, better installation and maintenance of machines, and where necessary, enclosing and / or isolating of every noise sources, etc. Many examples of noise control methods are described in the literature (HSE Information Sheet [18]; Holland and Ruggles, 1994[19]; Kush, 1995[20] and Bies and Hanson, 1985[35]).

4- The fourth step consists of making a scaled map of the particular factory or enterprise site showing all the noise resources. On this map lines can then be traced connecting points of equal noise levels. These noise contours or "Isobels" clearly define any hazardous areas and allow identifying locations where the most effective steps can be taken for noise reduction.

5- In situations where it is no longer possible to reduce the noise, it is necessary to ensure the protection of the people whose noise dosage was found to be above 100%. (after the application of engineering noise controls). This may be done, for example, by prescribing wearing of earplugs or ear muffles or rotation of personnel working at the most noisy posts with personnel in quieter areas.

6- Even at this point not all noise problems are entirely solved. The limit corresponding to a dosage of 100% will protect most of the workers, but not necessarily all. The means of protecting the individuals may not be perfect or are not used properly. The only way to obtain a guarantee of the success of any industrial hearing conservation program is to test the hearing ability of the employees periodically. The interest in these tests is two fold: firstly, they are a means of directly verifying the efficacy of the methods used to reduce the noise or to protect the personnel, and, secondly they allow hearing damage to be detected before the person being tested has difficulties in comprehending the normal speech. The periodical use of such tests is, therefore, an effective preventive method.

It may also be noted that the result of this study point to the need of further studies at the remaining factories belonging to these industries and the other industries as well.

References

[1] Noweir M.H. and Jamil, A.T.A. (2003) Noise pollution in textile, printing and publishing industries in Saudi Arabia. Environmental monitoring and assessment, Mar. 2003, 83(1): 103-116.

[2] Noweir, M.H., Jomoah, I.M. and Bafail, A.O. (2012) Noise Pollution in the metal and wood works industries in the Kingdom of Saudi Arabia. (Submitted for publication to the International Journal of Occupational safety and ergonomics).

[3] OSHA, (2008) OSHA technical manual (OTM) TED 01-00-015: Noise and hearing conservation. U.S. Department of Labor. www.osha.gov/dts/osta/otm.

[4] Parsons, K.C. (2000) Environmental ergonomics: a review of principles, methods, and models. Applied Ergonomics, 31: 581-594.

[5] Ekerbicer, H. and Saltik, A. (2008) The health consequences of industrial noise and methods for protection. TAF Preventive Medicine Bulletin, 7(3): 261-264.

[6] Ali, S.A. (2011) Industrial noise levels and annoyance in Egypt. Applied Acoustics, 72: 221-225.

[7] Eleftherou, P.C. (2002) Industrial noise and its effect on human hearing. ibid., 63: 35-42.

[8] Picar, M., Girard, S.A., Simard, M., Larocque, R., Leroux, T. and Turcotte, F. (2008) Association of work-related accidents with noise exposure in the workplace and noise-induced hearing loss based on the experience of some 240,000 person-year of observation. Accident Analysis and Prevention, 40: 1644-1652.

[9] Palmer, K.T., Harris, E.C. and Coggon, D. (2008) Chronic health problems and risk of accidental injury in the workplace: a systematic literature review. Occupational Environmental Medicine, 65(11): 757-64.

[10] NIOSH-NOHS (1974) National Occupational Hazards Survey. Department of Health and Human Services, National Institute for Occupational Safety and Health. Rockville, M.D., Publication No. (NIOSH) 77-127.

[11] NIOSH-NOHS (1977) National Occupational Hazards Survey. ibid (NIOSH) 77-213.

[12] NIOSH-NOHS (1978) National Occupational Hazards Survey. ibid (NIOSH) 78-114.

[13] NIOSH (1998) Health Hazard Evaluation: Noise and hearing loss 1988-1997. CDC; National Institute for Occupational Safety and Health, Pub. No. 99-106, Nov. 1998.

[14] Balt, Brank and Newzman Inc. (1976) Economic impact analysis of proposed control regulation, BBN Report 3246, U.S. Department of Labor, Washington, D.C.

[15] Booz, Alen and Hamilton, Inc. (1983) Technical and economic analysis of alternative noise standard. Prepared for the Office of Regulatory Analysis, Occupational Safety and Health Administration, U.S. Department of Labor, Washington, D.C.

[16] OSHA (2002) Job Hazard Analysis; OSHA 3071. U.S. Department of Labor; http://www.osha.gov/publications/osha3071.pdf.

[17] Beaty, K.L. (1994) Asphalt-rubber hot mix in road rehabilitation. Proceedings of the 3rd Materials Engineering Conference, San Diego, CA, USA, pp: 319-326.

[18] Health and Safety Executive (HSE) (2004) Reducing noise exposure in the food and drinks. HSE Information Sheet No. 32.

[19] Holland, P. and Ruggles, J. (1994) Quieten down, Highways. 62(8): 28-29.

[20] Kuch, H. (1995) Noise reduction in the production of concrete blocks. Betonwerk und Firtigtell-Technik, Concrete Precasting Plant, 61(April): 12-24.

[21] Samuels, S. (1994) Development of low noise surface textures for rigid pavements. Environmental and Planning Proceedings – Conference of the ARRB, 17(7) Australian Road Research Board Ltd., Nunawading, Aust. pp: 47-61.

[22] Hasall, J.R. and Zaveri, K. (1988) Acoustic Noise Measurements. Bruel & Kjaer, 5e, ISBN: 87 87 55 21 3.

[23] ISO (1997) International standards: acoustic-guidelines for the measurements and assessment of exposure to noise in a working environment. ISO 9612:1997.

[24] OSHA (1983) Occupational noise exposure: hearing conservation amendment. Federal register. Occupational Health and Safety Administration (OSHA), 48: 9738-9783.

[25] ACGIH TLV/BEI Resources (2011) American Conference of Governmental Industrial Hygienists OH, US, http://www.acgih.org/tlv.

[26] EU. Directive 2003/10/EC of the European parliament and of the council of 6 February 2003 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise). DOUE: February 2003.

[27] Kroemer, K.H.E and Grandjean, E. (1997) Fitting the Task to the human, Butter Inc., London.

[28] Sabanci, A. (1999) Ergonomics. Balki publishing Inc., Adna, publication No. 13.

[29] ISO (1996) International Standard: Acoustics – Recommended practice for the design of low-noise workplaces containing machinery, ISO 11690-1:1996.

[30] Mohammadi, G. (2008) Hearing conservation program in selected metal fabrication industries. Applied Acoustics, 69: 287-292.

[31] Aybek, Ali, Kamer, A.H. and Arslan, C. (2010) Personal noise exposure of operators of agricultural tractors. ibid., 41: 274-281.

[32] Fernandez, M.D., Quintana, S., Chavarria, N. and Ballesteros, J.A. (2009) Noise exposure of workers of the construction sector. ibid., 70: 753-760.

[33] Aubrit-Clochard, M. and Templier, D. (2007) Managing risks on construction site. First European forum on efficient solutions for managing occupational noise risks, Noise at work 2007. Paris, July; 2007.

[34] Smith A. and Wellens, B. (2007) Noise and Occupational health and safety. Noise at work, ibid. July 2007, Paris.

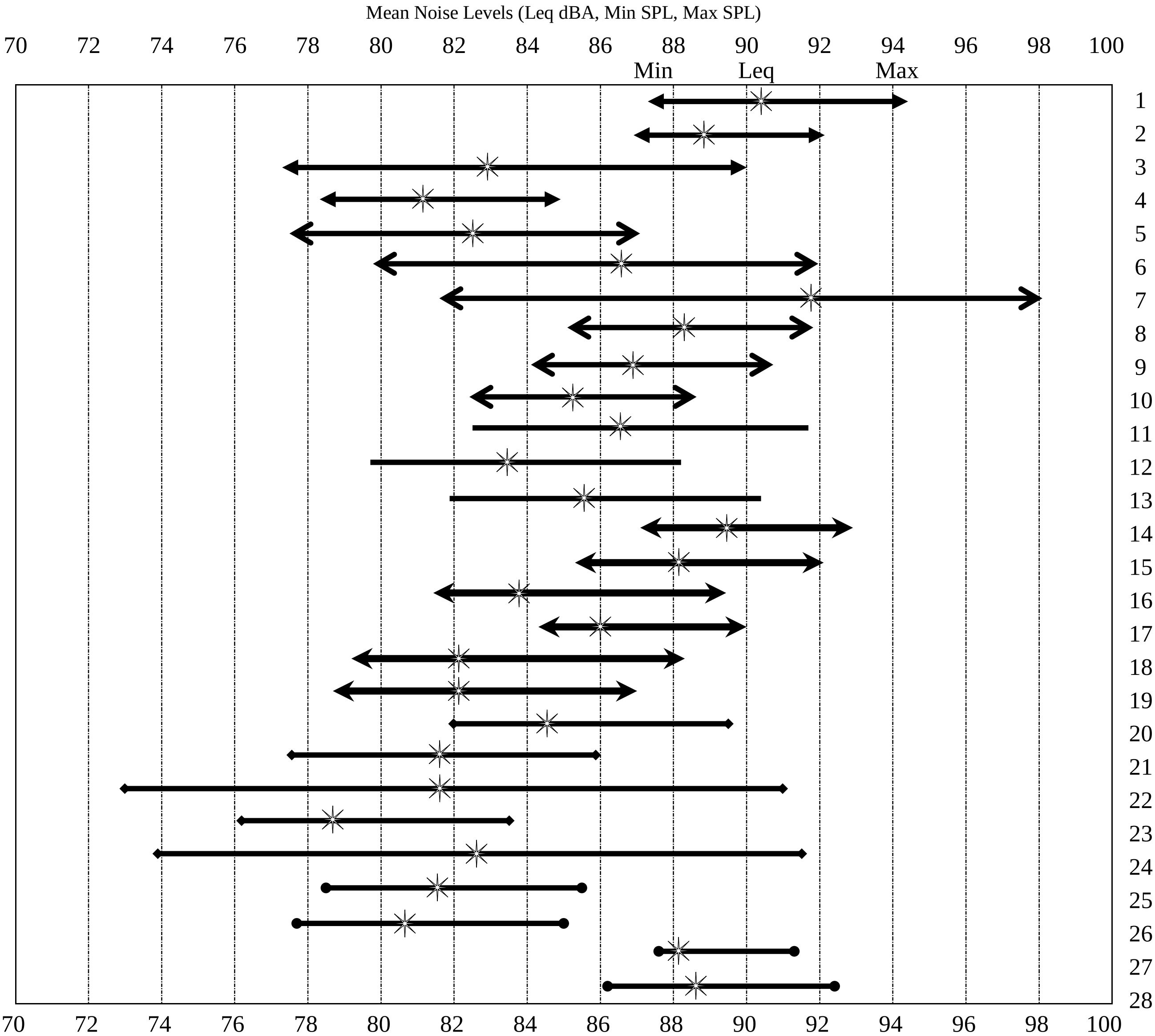
[35] Bies, D.A. and Hanson, C.H: (1995) Engineering Noise Control. Chapmant Hall, London.

TABLE I

MEANS OF LEQ AND THEIR STANDARD DEVIATIONS AND MEANS OF MAXIMUM SPL AND MINIMUM SPL IN THE STUDIED FACTORIES.

Industry	Factory name	N*	Leq mean (SD) (dBA)	Max. SPL mean (dBA)	Min. SPL mean (dBA)
Group: A Electrical Appliances & Supplies	1. Saudi Cable Company	10	90.3 (2.7)	94.4	87.3
	2. Jeddah Cable Company	10	88.4 (1.8)	92.1	86.9
	3. Saudi Air-Conditioning Factory (Al Juffali)	10	82.8 (4.7)	90.0	77.3
	4. Saudi Factory for Electric Appliances	10	80.6 (4.5)	84.9	78.3
Group: B Tiles, Marbles & Construction Supplies	5. Saudi Company for Building Materials	10	82.5 (5.6)	87.0	77.5
	6. Saudi Company for Sand Bricks	10	86.4 (4.3)	92.0	79.8
	7. International Factory for Cement Blocks (Baterji)	8	91.8 (2.7)	98.1	81.6
	8. Saudi Marble Company	10	88.2 (3.1)	91.8	85.1
	9. Ghamdi Marble Company	10	86.6 (3.3)	90.7	84.1
	10. Saudi Tiles Company	9	85.2 (1.8)	88.7	82.4
Group: C Concrete Industry	11. Sacop Concrete Factory	9	86.5 (1.8)	91.7	82.5
	12. Saudi Concrete Factory	10	83.4 (2.5)	88.2	79.7
	13. Saudi Factory for Transferred Concrete	10	85.5 (2.3)	90.5	81.9
Group: D Plastic & Glass Products	14. Saudi Arabian Glass Co. Ltd.	10	89.4 (3.3)	92.9	87.1
	15. Mangoor Fiber Glass Factory	10	88.1 (1.9)	92.1	85.3
	16. Nabro for Plastics	10	83.8 (2.2)	89.1	81.1
	17. Red Sea Plastics	10	86.0 (2.2)	90.0	84.3
	18. Al Sharq Company for Plastic Pipes	10	82.1 (4.2)	88.3	79.2
	19. Jeddah Plastic Factory	10	82.1 (2.6)	87.0	78.7
Group: E Food Processing (Meat, Bakery & Pastry)	20. Nashar Meat Factory	7	84.6 (2.8)	89.5	82.0
	21. Halwani Meat Factory	7	81.6 (2.4)	85.9	77.6
	22. Sunbula Co. for Food Stuffs	8	81.6 (7.3)	91.0	73.0
	23. National Company for Food Stuffs	10	78.8 (2.9)	83.5	76.2
	24. Saudi Bakeries Co.	8	82.7 (7.2)	91.5	73.9
Group: F Dairy Products & Beverages	25. Modern Dairy Co. Ltd. (Cortina)	10	81.5 (3.5)	85.5	78.5
	26. Jamjoom Foremost Co.	10	80.7 (3.8)	85.0	77.7
	27. Saudi Factory for Fruits & Beverages	10	88.1 (4.1)	91.3	87.6
	28. Al Amoudi Factory for Beverages	10	88.6 (2.3)	92.4	86.2

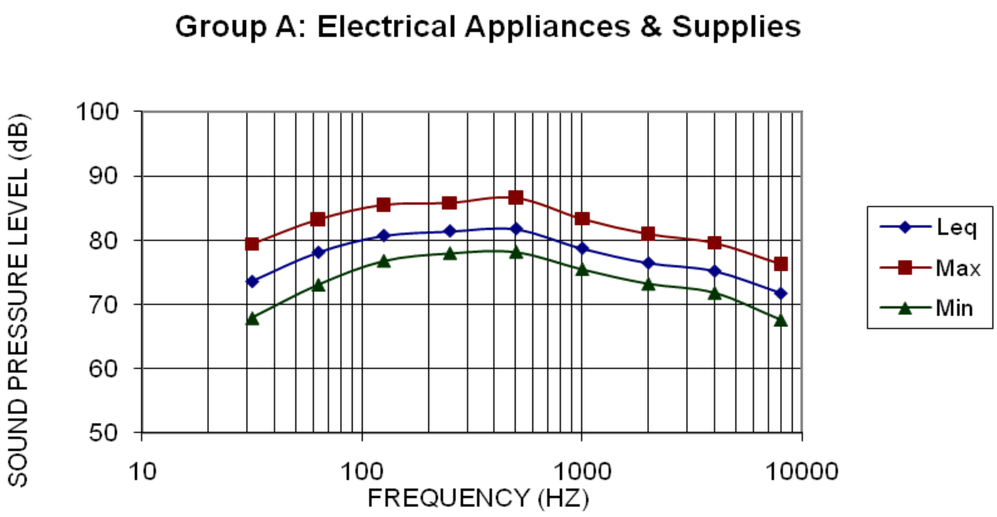
* N: NUMBER OF NOISE MEASUREMENTS.

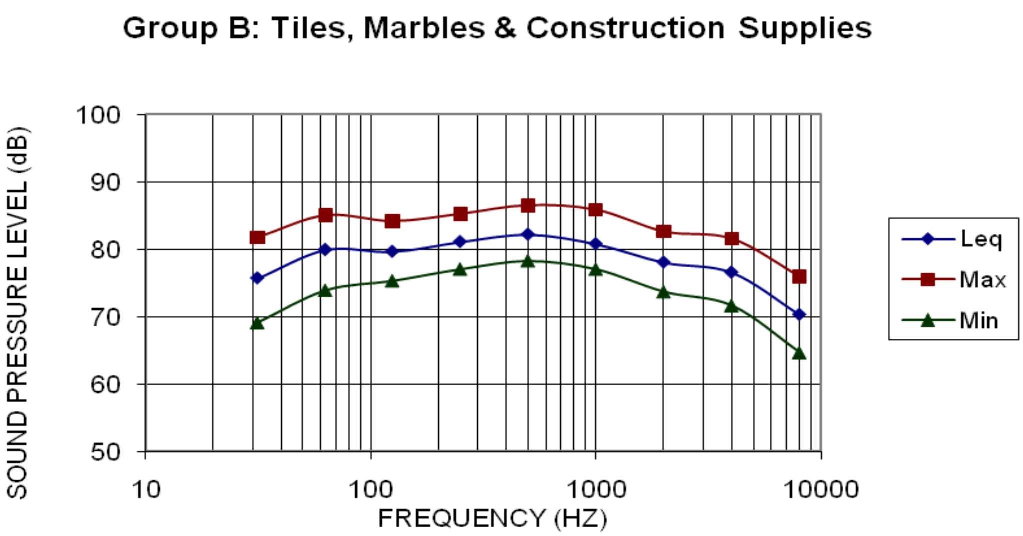


	Group A	Electrical Appliances & Supplies
	Group B	Tiles, Marbles & Construction Supplies
	Group C	Concrete Industry
	Group D	Plastic & Glass Products
	Group E	Food Processing
	Group F	Dairy Products & Beverages

1	Saudi Cable Co.	15	Mangoor Fiber Glass Factory
2	Jeddah Cable Co.	16	Nabro for Plastics
3	Saudi Airconditioning Factory (Juffali)	17	Red Sea Plastics
4	Saudi Factory for Electrical Appliances	18	Al Sharq Company for Plastics Pipes
5	Saudi Co. for Building Materials	19	Jeddah Plastic Factory
6	Saudi Co. for Sand Bricks	20	Nashar Meat Factory
7	Int'l Factory for Cement Blocks (Baterji)	21	Halwani Meat Factory
8	Saudi Marble Co.	22	Sunbula Co. for Food Stuffs
9	Ghamdi Marble Co.	23	National Co. for Food Stuffs
10	Saudi Tiles Co.	24	Saudi Bakeries Co.
11	SACOP Concrete Factory	25	Modern Diary Co. Ltd. (Cortina)
12	Saudi Concrete Factory	26	Jamjoom Foremost Co.
13	Saudi Factory for Transferred Concrete	27	Saudi Factory for Fruits & Beverages
14	Saudi Arabian Glass Co.	28	Amoudi Factory for Beverage Industry

Figure 1: Mean Noise Levels at Different Utilities Factories.





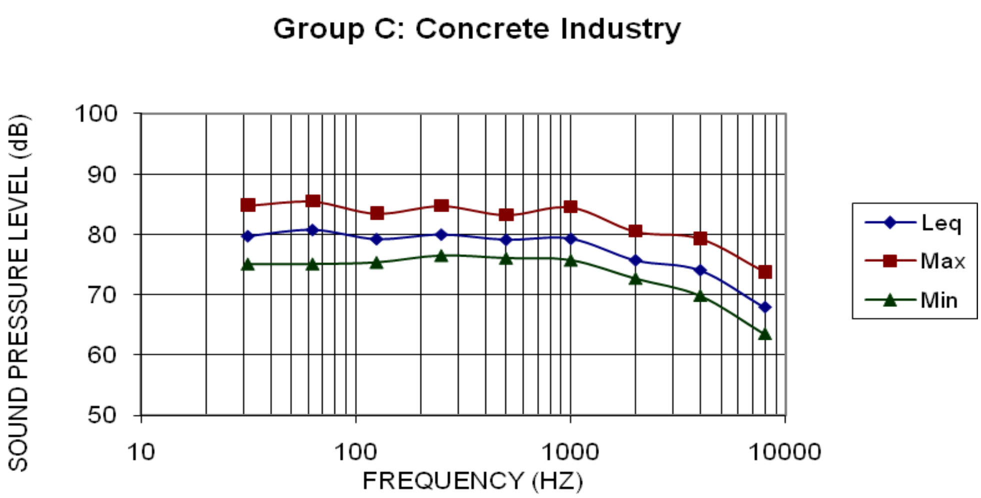
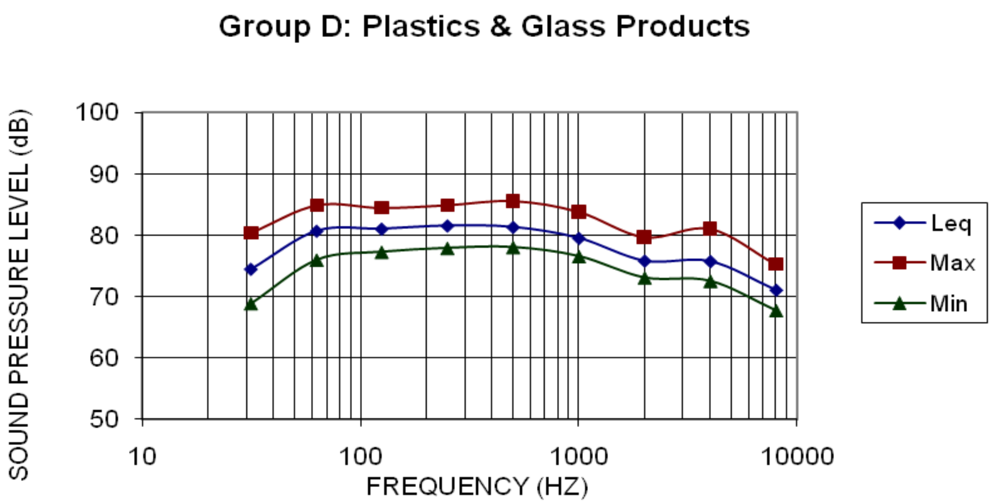
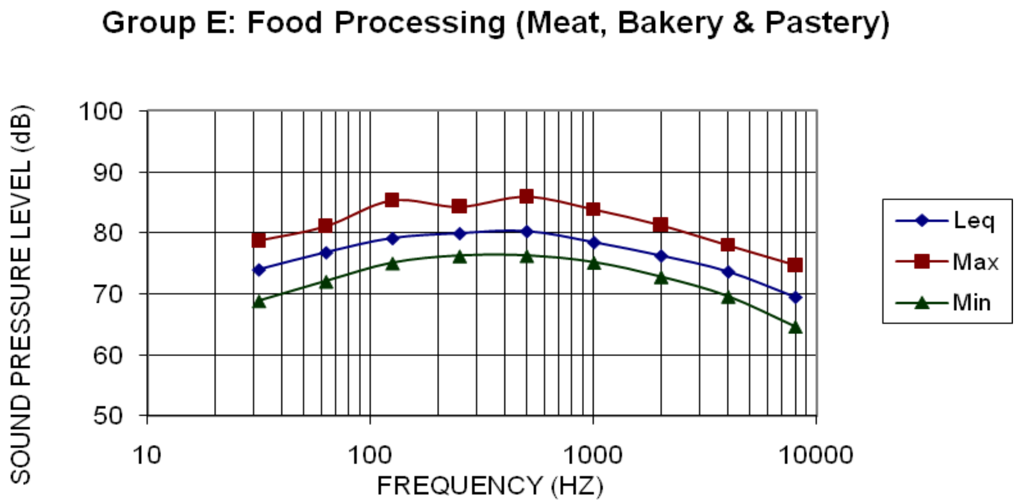


Figure 2a: Means of Leq, Max SPL and Min SPL at Different Octave Bands in the Studied Utilities Factories.





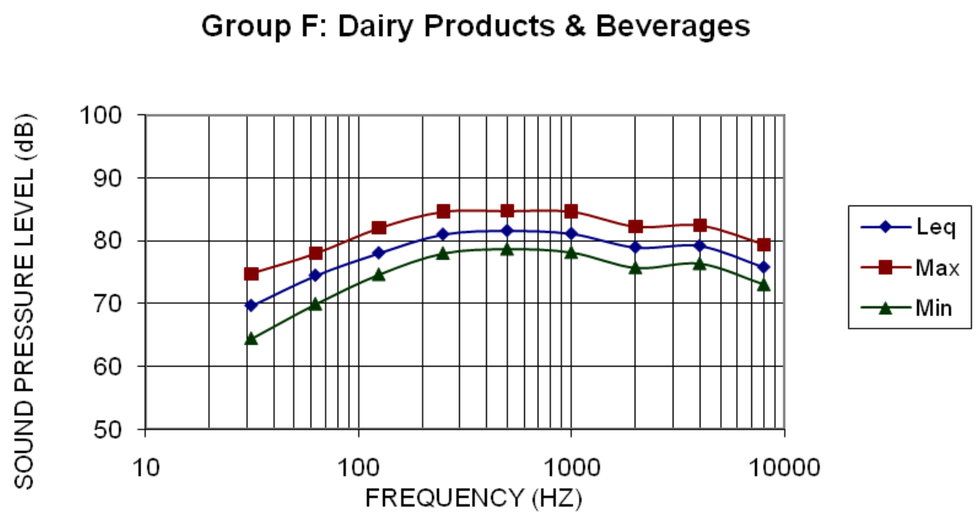


Figure 2b: Means of Leq, Max SPL and Min SPL at Different Octave Bands in the Studied Utilities Factories.