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قسمالصحة المهنية وتلوث الهواء
المعهد العالي للصحة العامة
وحدة بحوث ودراسات الصحة المهنية وتلوث الهواء

Study of Air Pollutants Levels Resulted from Stacks and Production Operation in Indoor and Outdoor Environment EGYPT LECICO COMPANY (KHORSHED)

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June 2016

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1. INTRODUCTION

Lecico Company requested the Occupational Health and Air Pollution Research Center – High Institute of Public Health (HIPH) – University of Alexandria to assess exposure of workers to physical factors and air pollutants levels at their workplaces in the company, to assess the air pollutant levels emitted from the company to the outdoor atmosphere and to evaluate the stack emissions from different departments in the company.

The highly developing awareness about environmental issues side by side with official seriousness concerning the restrict application of Egyptian Environmental Law No. 4 – 1994 and decision of Minister of Manpower and Immigration No 211-2003 make environmental assessment a necessity.

The Lisico Company has started the environmental assessment as early as its construction date. The management convince of the importance of environmental protection has made the company one of the pioneers in this aspect.

The research team of the Occupational Health and Air Pollution Research center makes this study during the period from31May to 2June 2016.

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1. Potential Hazards

A variety of health hazards to which workers in LecicoCompanyare exposed. These hazards include:

- Exposure to ***Total Suspended Particulates*** During handling and weighing of raw materials, and during mixing, grinding, and component preparation.
- Exposure to ***Heat***.
- Exposure to ***Noise***
- Exposure to ***Lighting***

1.1. Total and Respirable Particulates (TSP& PM10)

The term TSP refers to a wide range of finely divided solids or liquids dispersed into the air from combustion processes (heating, and power generation), industrial activities, and natural sources. Total suspended particulates range in size from 0.1 up to 10μm in diameter.

Exposure to TSP is through inhalation, in which dust particles are carried with air stream into the lungs and the majority of them being either exhaled or eliminated by means of the lung clearance mechanism. A small amount of these particles may be deposited in the lungs, depending on their size. Medical research has shown that particles of 1-5 μm can remain in the alveolar passages (respirable dust), while larger particles are retained by the mucous membrane of the nose, the throat, the trachea, and the bronchi, and are eliminated by the clearance mechanism. Smaller Particles (<0.1

μm) behave as colloids, of which a typical example is smoke. Smaller fractions of the particles are transported by lymphatic system after penetrating the interstitial tissue.

1.2. Heat Stress

The first response of exposure to heat is a sensation of discomfort. Inefficiency in the performance of physical and nonphysical tasks, an increased propensity to minor accidents and changes in the emotional tone of workers are found in association with these changes in sensation and body temperature.

If combination of workload and environmental heat is so great that thermal balance cannot be maintained, workers will become susceptible to heat exhaustion, rash, cramp, and stroke.

1.3. Equivalent Noise

Exposure to noise may lead to psychological and physiological effects. The psychological effects include annoyance, disruption of concentration, sleep or relaxation, and interference with communication that may lead to absenteeism, and accidents. The physiological effects are primarily noise induced hearing loss, aural pain, Nausea, and reduced muscular control.

1.4. Lighting

Exposure to unsuitable lighting leads to negative effects on vision, in addition to loss of concentration, chronic headache.

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2. SCOPE

Three different locations were assessed in this study:

1. Indoor work environment, the levels of which were compared with the TLV of the Egyptian Environmental Law No. 4-1994amended by law No 9-2009 and its executive law of the Prime minister No 1095-2011 and decision of the Minister of Manpower and Immigration No. 211 - 2003.

2. Stack emissions, the levels of which were compared with the source emission guidelines of the Egyptian Environmental Law No. 4-1994 amended by law No 9-2009 and its executive law of the Prime minister No. 710-2012.

3. Outdoor work environment, the levels of which were compared with the air quality guidelines of the Egyptian Environmental Law No. 4-1994 amended by law No 9-2009 and its executive law of the Prime minister No 1095-2011.

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3. WORK ENVIRONMENT EVALUATION

3.1. Indoor Sampling

3.1.1. Total and Respirable Suspended Particulates

Inside the LisicoCompany, different locations were selected for sampling of total and Respirable suspended particulates. The sampling procedures included stationary samples that are collected at fixed places representing all work conditions. The sampling train consists of pump, filter holder and in case of Respirable particulates a cycloneis added as illustrated in figure (1). The sampling train must then be calibrated using wet gas meter. The stationary sampling system was at height of about 1.5 meter to represent the breathing zone. Samples were collected for 2-3 hours using membrane filter. The concentration of TSP was determined gravimetrically in mg/m^3.

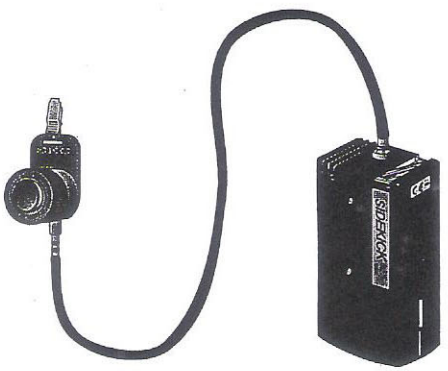

Fig. (1): Air sampling train of Total suspended Particulates

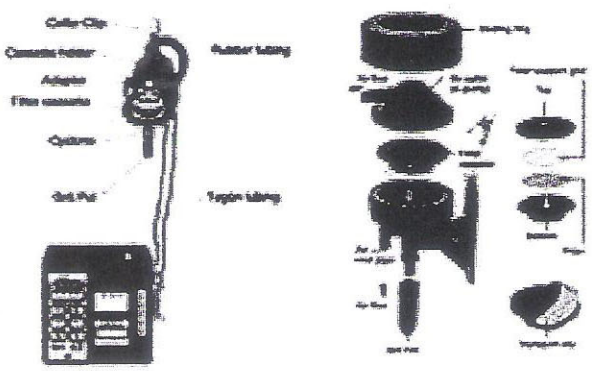

Fig. (2): Air sampling train of Respirable Particulate Matter

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3.1.2. Heat Stress

Heat stress index (Wet Bulb Globe Temperature WBGT) has been determined at different locations Using WBGT- Meter shown in figure (3).

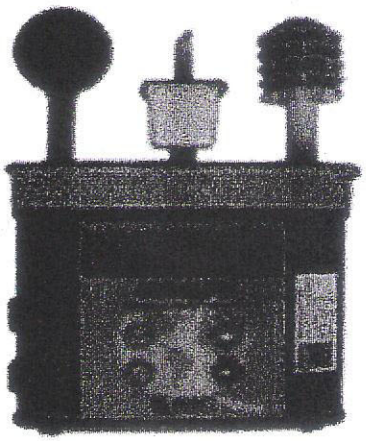

Figure (3): Wet Bulb Globe Thermometer

3.1.3. Equivalent Noise

Equivalent Noise levels were determined in Decibel dB(A) at different locations using pre-calibrated sound level meter at 114 dB(A) as indicated in figure (4).

Figure (4): Pre-Calibrated Sound Level Meter At 114 dB(A)

3.1.4. Lighting

The lighting in various departments is measured using Lux-meter shown in figure (5).

Figure (5): Luxmeter

3.2. Stack Emission Evaluation

Stack emissions were measured using Emission Gas Analyzer illustrated in figure(6)

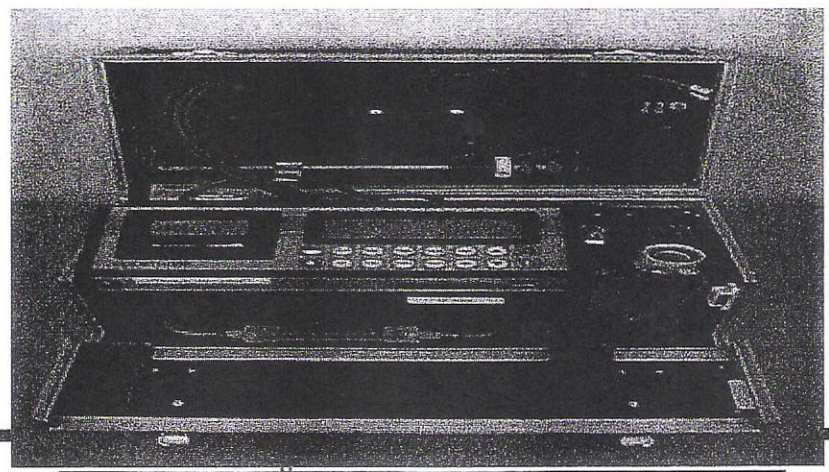

Figure (6): Emission Gas Analyzer

3.3. Ambient Air Sampling

Levels of different ambient air pollutants associated with Lisico Company were assessed during the period of study to study the effect of these levels on the neighboring areas. In addition, noise levels and heat stress index were measured at different locations outside the Lisico Company.

Four locations were selected around the company as air sampling stations. These stations represent the four main directions. Samples of TSP were collected for 24 hours per day during the period of the study. Levels of CO gas were measured for only one hour per day at each sampling station.

3.3.1. Total Suspended Particulates

3.3.1.1. Sampling and Analysis

The recommended instrument for sampling large volumes of air for airborne particulates is high volume sampler shown in figure (7). It consists of an inlet, filter holder, an air mover, a flow controller, and a timer. Air is drawn through a weighed 8×10 inch filter (usually glass fiber filter) at a flow rate about 40 ft^3/min. The volume of air filtered is taken as the product of the sampling time and average flow rate. Concentration of airborne dust is determined gravimetrically in $\mu g/m^3$.

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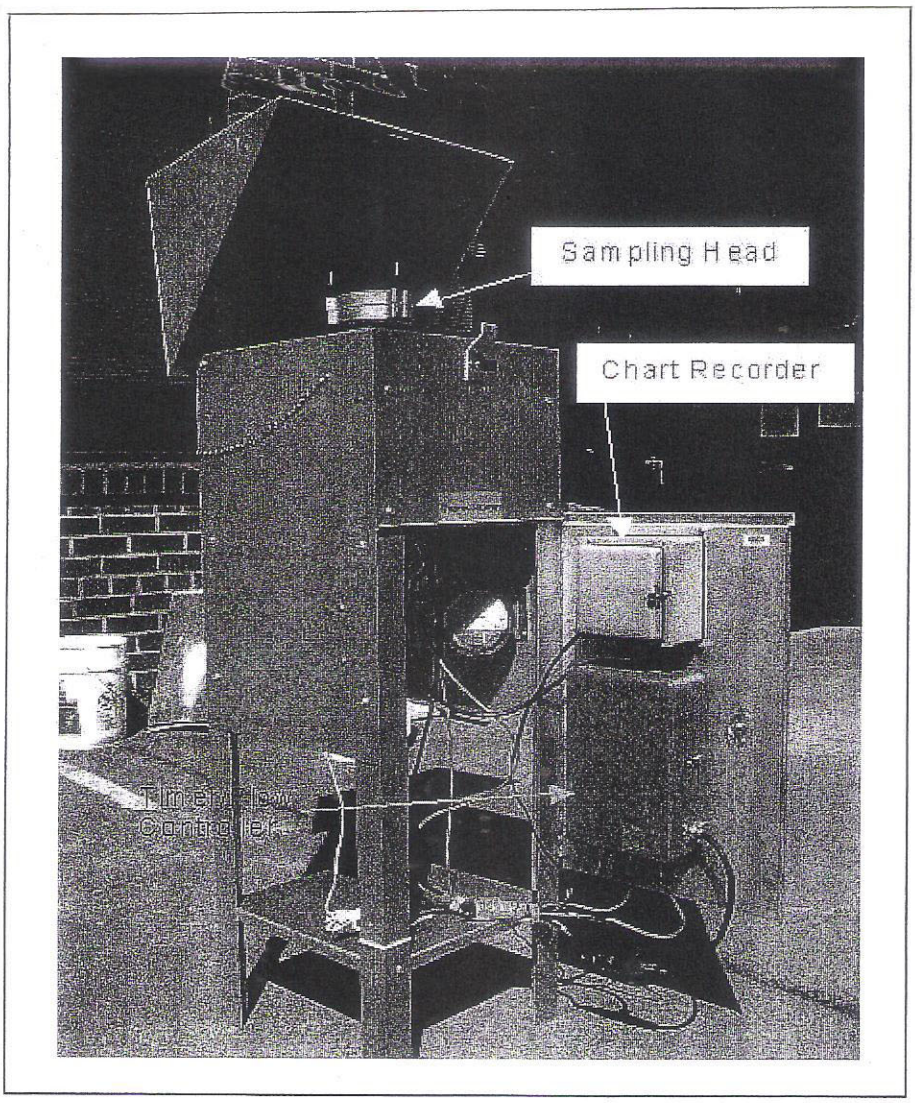

Figure (7): High Volume Sampler

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RESULTS & DISCUSSION

1. Work Environment evaluation

1.1. Noise levels using Sound Level Meter calibrated at 114 dB and Wet Bulb at different departments of Sanitary Production

a) Equivalent noise levels at preparation, pouring, gypsum, glaze, spraying, sorting and models

Departments of the Sanitary Plant	Equivalent noise Level (dB)	TLV according to Egyptian Environmental Law No. 4 for 1994 In case of 8 continuous working hours
Preparing	81.1-82.0	90.0 dB
Pouring	76.7-77.9	
Gypsum	72.5-74.0	
Glaze	84.7-85,2	
Spraying	83.1-84.3	
Sorting	79.4-80.8	
Models	65.9-67.0	

b) Equivalent Noise levels at spraying department

Departments of the Sanitary Plant		Equivalent Noise Level (dB)	Nature of Exposure	TLV according to Egyptian Environmental Law No. 4 for 1994 amended by Law No. 9-2009
Control rooms in spraying departments	Spraying 1(15rooms) without air spraying	92.5-93.7	Work only 30 seconds every 5 minutes (totally 50 minutes in the shift period of 8 hours). Moreover, all workers use ear muffs	*99.0dB*
	Spraying 1(15rooms) with air spraying	97.2-98.1		
	Spraying 2(9rooms) without air spraying	93.2-94.0		
	Spraying 2(9rooms) with air spraying	98.1-99.5		

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It is clear from the two tables that the measured noise levels were lower than the threshold limit values- time weighted average, hence they are safe.

c) Heat stress index at production departments in Sanitary Plant

Departments of the Sanitary Plant	Heat Stress (WBGT °C)		
	Heat stress	Nature of Work	Threshold Limit Value According to Law No.4, 1994 amended by Law No 9-2009
Preparing	33.6**	Average work with 50% work and 50% breaks	29.4°C
Pouring	32.6**		
Gypsum	30.6**		
Glaze	28.5		
Spraying	31.5**		
Sorting	31.1**		
Models	31.5**		

*TLV-TWA according to Annex No 9 of the Executive Law No 1095-2011 of the Egyptian environmental Law No 9-2009

** The measured WBGT > TLV-TWA

It is obvious from the table that the measured levels of wet bulb globe temperature were higher than the threshold limit values-time weighted average at preparing, pouring, gypsum, spraying, sorting, and models. So Exhaust fans are needed to increase air velocity, and evaporation. Moreover, suction fans are recommended to reduce the relative humidity.

At the glaze department, the WBGT is lower than the TLV-TWA. So the exposure is safe and no occupational hazards are recommended.

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d) **Lighting at production departments in Sanitary Plant**

Departments of the sanitary plant	Light Intensity Levels (Lux)		
	Lighting Level**	Required Accuracy	TLV according to decision No 211-2003
Preparing	332.0	Tasks require average accuracy in details	323 Lux
Pouring	50.0**		
Gypsum	104.0**		
Glaze	1783.0		
Spraying	153.0**		
Sorting	1393.0	Tasks require high accuracy in details	1076
Models	741.0	Tasks require accuracy in details	538

* *The levels of light intensity must not be less than the maximum permissible limit

As clear in the tablethe measured levels of lighting were lower than the threshold limit values of the decision of Minister of Man Power & Immigration No. 211-2003at pouring, gypsum, and spraying department. Hence, it is necessary to increase the lighting intensities at these departments. While at preparing, glaze, sorting, and models; the levels were higher than the TLV.So, the levels are safe and no health effects are expected.

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e. Total and Respirable airborne particulates at indoor work environment of different production departments in the Sanitary Plant

Departments of Sanitary Factory	Concentration of Total and Respirable Particulates (mg/m^3)	
	TSP	RSP
Preparation	0.4	ND**
Pouring	1.5	1.0
Gypsum	1.4	1.0
Glaze	0.5	ND**
Spraying	1.0	0.5
Sorting	0.3	ND**
Models	0.3	ND**
Maximum Permissible Level According to Law No.4, 1994 amended by Law No. 9-2009	10.00	3.00

*Threshold Limit Values-time weighted average according to Egyptian Environmental Law No 4-1994 amended by Law No 9-2009, and Annex 8 of its executive law No 1095-2011.
** The measured level is lower than the lower detectable limit of the measurement method.

According to the Egyptian Environmental Law No. 4 for 1994 amended by Law No. 9-2009 and the Annex 8 of its executive rule No 1095-2011, all levels of total and respirable particulate matter were below the Threshold Limit Values (TLVs) and do not cause any occupational adverse health effects for the exposed workers.

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1.2. Tile Production Plant

a. Equivalent noise level using Sound Level Meter calibrated at 114 dB at different departments of Tile Production.

Department at the tile plant	*Equivalent Noise Level (dB)*			
	T2	T4	Duration of Exposure	*TLV according to Environmental Law No.4-1994amended by Law No 9-2009**
1. Preparation	88.6-89.0	86.8-87.7	Continuous exposure for 8hours/day	*90.0*
2. Glaze	85.1-86.5	90.0		
3. Décor	84.8-85.0	88.6		
4. Sorting	85.6-90.0	80.4		
5. Ovens	82.7-83.3	86.2		
6. Pistons	84.7-85.1	90.0		

*** Permissible limits of equivalent noise level according to annex 7 table-2 of the Executive regulations No 1095-2011 and 710-2012 of the Egyptian Environmental law No 4-1994 amended by law No 9-2009**

It is clear from the table that the measured levels of equivalent noise were lower than the threshold limit values-time weighted average. So, they are safe and no health effects are expected.

b) Heat stress index using WBGT index at Tile Production Sectors

Departments of the Tile Plant	Heat stress index (WBGT) °C			
	T2	T4	Nature of Work	Threshold Limit Value According to Law No.4, 1994 amended by Law No 9-2009
1. Preparation	29.0	29.3	Average work with 50% work and 50% breaks	29.4
2. Glaze	28.1	26.0		
3. Décor	29.2	27.2		
4. Sorting	29.2	27.6		
5. Ovens	27.5	27.6		
6. Pistons	29.9**	26.1		

* Permissible limits of equivalent noise level according to annex 9 of the Executive regulations No 1095-2011 and 710-2012 of the Egyptian Environmental law No 4-1994 amended by law No 9-2009

It is obvious from the table that the wet bulb globe temperature at the pistons' department is higher than the permissible limits. So, these levels must be reduced by using exhaust fans to increase air velocity and evaporation; and using suction fans to reduce the relative humidity.

At the other departments the measured levels lower than the threshold limit values-time weighted average. So, the levels are safe and no health effects are expected.

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c) Lighting levels at production Sectors using Lux meter at the Tile Production Plant

Departments of the Tile Plant	*Light Intensity Level (Lux)*			
	T2	T4	Required Accuracy	TLV according to decision No 211-2003
1. Preparation	316.0	326.0	Tasks require average accuracy	323
2. Glaze	1209.0	840.0		
3. Décor	1136.0	325.0		
4. Sorting	260.0**	760.0	Tasks require high accuracy in details	753
5. Ovens	150.0**	620.0	Accuracy in details	538
6. Pistons	292.0**	491.0	Tasks require average accuracy	323

*The levels of light intensity must not be less than the permissible limit according to table No 6 of the decision of Minister of Manpower and Immigration No 211-2003

As clear in the tablethe lighting levels were higherthan the permissible limit at all T4 department and at the preparation, glaze, and décor of T2. So, it is safe and no health effects are expected in these departments. At sorting, ovens, and pistons of T2 the measured were lower than the permissible limits, So It is important to increase lighting at these department.

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d) Total and Respirable airborne particulates at indoor work environment of the Tile Production departments

Departments of Tile plant		Concentration of Total and Respirable Particulates (mg/m^3)	
		TSP	RSP
Tile	Preparation T2	1.0	1.0
	T4	1.5	0.6
	Décor T2	0.3	ND**
	T4	0.6	0.5
	Glaze T2	1.3	1.0
	T4	1.7	1.5
	Pressing T2	0.5	ND**
	T4	1.5	1.0
	Sorting T2	1.6	1.5
	T4	1.5	1.0
	Kilns T2	1.5	0.5
	T4	0.5	0.5
	3rd Fire	1.0	ND**
Maximum Permissible Level According to Law No.4, 1994 amended by Law No. 9-2009		10.00	3.00

*** Permissible limits of equivalent noise level according to annex 8 of the Executive regulations No 1095-2011 and 710-2012 of the Egyptian Environmental law No 4-1994 amended by law No 9-2009**

According to the Egyptian Environmental Law No. 4 for 1994 amended by Law No. 9-2009 and the Annex 8 of its Executive law No 1095-2011, all levels of total and respirable particulate matter were below the Threshold Limit Values (TLVs) and do not cause any occupational adverse health effects for the exposed workers.

1.3- Fret Plant

a. Equivalent noise level using Sound Level Meter calibrated at 114 dB at different departments of Fret Plant.

Department at the Fret plant	*Equivalent Noise Level (dB)*	Duration of Exposure	*TLV according to Environmental Law No.4-1994amended by Law No 9-2009**
Supervisors' room	83.2-84.4	Exposure period not more than 4 hours/day	*93.0*
Preparation	71.8-79.2		
Control room	78.2-80.1		

* Permissible limits of equivalent noise level according to annex 7 table-2 of the Executive regulations No 1095-2011 and 710-2012 of the Egyptian Environmental law No 4-1994 amended by law No 9-2009

It is clear from the table that the measured levels of equivalent noise were lower than the threshold limit values-time weighted average. So, they are safe and no health effects are expected.

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b) Heat stress index using WBGT index at production Sectors of the Fret Plant

Department at the Fret plant	Heat stress index (WBGT) °C	Nature of Work	Threshold Limit Value According to Law No.4, 1994 amended by Law No 9-2009
Supervisors' room	27.4	Average work with 50% work and 50% breaks	29.4
Preparation	27.6		
Control room	26.5		

*** Permissible limits of equivalent noise level according to annex 9 of the Executive regulations No 1095-2011 and 710-2012 of the Egyptian Environmental law No 4-1994 amended by law No 9-2009**

It is obvious from the table that the measured levels lower than the threshold limit values-time weighted average. So, the levels are safe and no health effects are expected.

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c) Lighting levels at production Sectors using Lux meter at the Fret Plant

Department at the Fret plant	Light Intensity Level (Lux)	Required Accuracy	TLV according to decision No 211-2003
Supervisors' room	325.0	Tasks require accuracy in details	538.0
Preparation	3607.0		
Control room	816.0		

*The levels of light intensity must not be less than the permissible limit according to table No 6 of the decision of Minister of Manpower and Immigration No 211-2003

As clear from the table that the lighting levels were higher than the permissible limit. So, it is safe and no health effects are expected in these departments.

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d. Total and Respirable airborne particulates at indoor work environment of different production departments of the Fret Plant

Departments of Fret Plant	Concentration of Total and Respirable Particulates (mg/m^3)	
	TSP	RSP
Supervisors' room	0.6	ND**
Preparation	1.0	ND**
Control room	0.5	ND**
Maximum Permissible Level According to Law No.4, 1994 amended by Law No. 9-2009	10.00	3.00

* Permissible limits of equivalent noise level according to annex 8 of the Executive regulations No 1095-2011 and 710-2012 of the Egyptian Environmental law No 4-1994 amended by law No 9-2009
** The measured levels were lower than the lower detectable limit of the method

According to the Egyptian Environmental Law No. 4 for 1994 amended by Law No. 9-2009 and the Annex 8 of its Executive law No 1095-2011, all levels of total and respirable particulate matter were below the Threshold Limit Values (TLVs) and do not cause any occupational adverse health effects for the exposed workers.

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2. Stack Particulate Emission Evaluation

2.1. Concentrations of particulate in the exhaust emission from stacks

Stack Location	Particulates' Concentrations (mg/m^3)
Furnace (Automizer)	37.2
Preparation 1	35.8
Preparation 2	45.4
Preparation 3	32.3
Preparation 4	31.5
Fret	25.8
Permissible Emission Levels According to Law No. 4, 1994 amended by the Law No 9-2009	50.0

As shown in the table, all concentrations of particulates were much lower than the recommended emission levels in the Egyptian Environmental law No 4 -1994amended by law No. 9-2009 and the executive law of the Prime Minister decisions No. 1095-2011 & 710-2012. Therefore, the emission levels are safe and no public or environmental effects are expected.

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2.2. Concentrations of Pollutants in the exhaust emission from stacks of the Sanitary plant in mg/m3 of the Exhaust

Stack Location	*Pollutant Concentration (mg/m^3)*				CO_2 %	*Combustion Efficiency (%)*
	Suspended Particulates	CO	SO_2	NO_2		
Stack of oven (1)	12.5	72.0	--	45.2	5.2	97.5
Stack of oven (2)	15.8	71.0	--	48.5	5.2	96.3
Stack of oven (3)	10.2	137.0	--	26.6	5.2	96.1
Stack of oven (4)	17.6	125.0	--	25.8	5.2	95.4
Stack of oven (5)	16.4	100.0	--	37.1	5.2	97.8
Stack of oven (6)	22.7	98.0	--	35.8	5.2	97.6
Stack of oven (8)	21.6	89.0	--	28.3	5.2	95.7
Permissible Emission Levels According to Egyptian Environmental Law No. 4, 1994	50.0	150.0	400.0	600.0	-	-

As shown in table, all concentration of pollutants were much lower than the recommended emission limits in the Egyptian law No 4-1994 amended by law No. 9-2009 and the executive law of the Prime Minister decision No. 710-2012. Hence, they do not constitute any environmental danger.

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2.3. Concentrations of Pollutants in the exhaust emission from stacks of the Tile and Fret plants in mg/m3 of the Exhaust

Stack Location		Pollutant Concentration (mg/m^3)				CO_2 (%)	Combustion Efficiency (%)
		Smoke	CO	SO_2	NO_2		
T2	Stack of oven (1)	23.3	28.7	--	63.2	5.2	95.3
	Stack of oven (2)	21.5	28.4	--	55.6	5.2	95.5
	Stack of oven (3)	25.4	37.6	--	55.3	5.2	98.4
	Stack of oven (4)	34.8	42.8	--	52.6	5.2	85.6
	Stack of oven (5)	27.7	35.3	--	53.3	5.2	94.2
	Stack of oven (6)	26.8	28.5	--	57.2	5.2	93.8
T4	Stack of oven (1)	22.1	23.3	--	59.6	5.2	95.2
	Stack of oven (2)	21.6	27.8	--	51.4	5.2	94.6
	Stack of oven (3)	26.7	26.4	--	48.6	5.2	93.1
	Stack of oven (4)	28.3	25.4	--	53.7	5.2	96.4
	Stack of oven (5)	27.9	27.6	--	46.1	5.2	95.3
	Stack of oven (6) (Stack-4 fire)	22.8	18.6	--	40.2	5.2	97.4
	Stack of oven (7)	Not working					
	Stack of oven (8)						
	Stack of oven (9)						
Fret	Stack of oven (2)	33.2	25.3	--	41.6	5.2	81.9
	Stack of oven (3)	31.1	21.7	--	37.3	5.2	68.7
	Stack of oven (4)	26.5	26.8	--	39.7	5.2	61.5
	Stack of oven (5)	35.3	23.5	--	29.8	5.2	76.6
	Stack of oven (6)	36.2	25.8	--	33.4	5.2	84.4
Permissible Emission Levels According to Egyptian Environmental Law No. 4, 1994		50.0	150.0	400.0	600.0	-	-

As shown in the table, all concentration of the emitted pollutants were much lower than the recommended emission limits in the Egyptian law No 4-1994 amended by law No. 9-2009 and the executive law of the Prime Minister decision No. 710-2012 and do not constitute any environmental danger. This may be due to use of natural gas that is cleaner than other types of fuel. CO_2 percentages are within normal range of natural gas combustion. It is worthy noting that there is no limit of CO_2 emissions in Egyptian environmental law.

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3. AMBIENT AIR POLLUTION

Four sampling stations were selected representing the four main directions around the LisicoMisr Company for assessment effect of the company on the surrounding atmosphere. The levels of TSP in µg/m^3 and noise level in decibel (db) are also illustrated in the same table.

3.1. Concentrations of TSP in the ambient air around LisicoMisr Company

Station No.	Location	*Average TSP (µg/m^3)*	
		31/5/2016	*1/6/2016*
1	In front of the sanitary department next to EzbetZaaghloul (South)	154.3	155.5
2	In front of Crusher and tile production and Fret plant next to EzbetKhorshed (East)	168.2	153.6
3	Behind Sanitary plant next to EzbetRahma (West)	143.2	163.2
4	In front of industrial waste treatment plant next to EzbetKhorshed (North)	174.1	171.7
Recommended Outdoor Daily Concentration to law No.4, 1994amended by Law No 9-2009		*230 (µg/m^3 daily average)*	

By comparing the results of total suspended particulates in ambient air with the maximum allowable limits according to annex No. 5 form the executive rule of the Prime Minister decision No. 1095-2011 of Environment low No. 4 – 1994 amended by Law No. 9-2009 (average daily concentration 230 µg/m^3).Itwas found that all the concentrations were less than these limit.So it is safe.

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3.2. A-weighted Equivalent Noise levels in the ambient air around LisicoMisr Company

Station No	Station Location	Equivalent ambient noise level (dB)
1	El-Rahma Street "West"	60.3
2	El-Rahmafarm"North"	62.5
3	Zagloul Farm "South"	64.4
4	Khorshed Farm "East"	63.8
Recommended Outdoor Daily Concentration to law No.9-2009		65.0

According to the Annex No 5 of the executive law of the Prime Minister's decisions No. 1095-2011& 710-2012 of the Egyptian Environmental Law No 4 -1994 amended by Law No 9-2009, the A-weighted equivalent noise levels in ambient air were not exceeded.

Reviewed by **Prepared by**

Dr. Fadia Ahmed El-Marakby **Dr. Gehan Raafat Mohamed**

Best wishes
on behalf

Unit Manager

Prof. Dr. Fahmy Charl Fahmy

3/8/2016

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