WORKING CONDITIONS IN THE FIELD OF STEEL RECYCLING INDUSTRIES (2ND SMELTING)

S. Drivas, L. Radin, S. Dontas, X. Cominos, V. Drakopoulos,
I. Mourelatou, E.Georgiadou

Center for Health and Hygiene in the Work Place, EL.IN.Y.A.E.

The work environment in the steel recycling industries (2nd smelting) is considered to be one of the most hazardous in the field of metal industries.

The exposure of the workers to physical, chemical and even ergonomic risk agents that characterize the production process of iron scrap smelting, casting, rolling the produced iron and steel billets, contributes to the manifestation of several professional diseases (e.g. loss of hearing, pneumoconiosis, musculoskeletal diseases, toxicoses etc.)

The aim of this study is to determine qualitatively and quantitatively the risk agents in the work environment of steel-mills, in terms of the methodological health models in the industrial environment.

1. DESCRIPTION OF THE TECHNICAL PROCESSES

The typical steel mill process (2nd smelting) is the production of iron and steel billets by means of iron or metal scrap that is put into an electric furnace where the metal is melted by the heat of a voltaic arc. Then the molten metal is cast through special pots (called ladles) into ingot moulds. The next step takes place in the rolling section, ingots are converted into billets, after being heated uniformly in a special furnace and then are passed moving constantly between stands of rolls which finally produce iron or steel in rectilinear rods or blooms.

2. MATERIALS AND METHODS

The research took place in the basic sectors of two steel mills (2nd smelting), namely in the sections of smelting, casting and rolling, following the "Subjectivity of the Homogenous Group of Workers" methodology for creating a realistic Chart of Hazards. The research conducted as follows:

- **Phase of data acquisition**: it determined, on a theoretical basis, the risk agents in the work environment by means of charting the work areas, recording the production process, raw materials used, the machinery etc. At this stage, the Homogenous Group of Workers also conveyed their knowledge and experience.
- **Phase of verification:** it outlined the content and type of qualitative and quantitative determinations of the risk agents in the workplace.

At this stage, measurements were taken regarding:

- noise levels
- pollution of the work environment caused by suspended solid particles (dust)
- pollution of the work environment caused by metals such as iron (Fe), chromium (Cr), nickel (Ni) and manganese (Mn)
- thermal environment
- magnetic fields in the vicinity of cables that supply the voltaic arc electrical furnace.

The quantitative determination of pollution caused by suspended particles of dust was carried out by weighting filters mounted on portable pumps. These steady flow pumps are used for measuring the inhalable and respirable fractions of suspended particles according to the following sample conditions:

	Filter Diameter	Pores	Flow	Air velocity (input)
Inhalable fraction	25mm	0.8μ	1.9 lit min	1.2m sec
Respirable fraction	37mm	0.8m	1.7 lit min	

Definitions are as follows:

Inhalable fraction of suspended particles: the total of solid dust particles suspended in the air that can be inhaled by the worker through the nose and the mouth.

Respirable fraction of suspended particles: the total of particles in the Inhalation fraction that actually reach the pulmonary alveoli.

✓ The determination of the metals in the air was based, as far as the first stage of sampling is concerned, on the 7300 method of NIOSH, and, for the second stage on the 303A method of the textbook “Methods of Air Sampling and Analysis”, American Chemists' Society (ACS). The analysis technique employed was that of the Atomic Absorption Spectroscopy using a graphite furnace (GF-AAS). Aqua regia was used for dissolving the filters (HNO3: HCl = 1:3).

✓ To measure the noise levels in the workplace, the following method stipulated by the Presidential Decree 85/1991 was used:

- integral echometer, in compliance with the specifications of ELOT 1106 and ISO R- 1999, calibrated before and after use.
- Sound dose meters according to the specifications of ISO R-1999 for measuring industrial noise.

✓ For measuring the heat environment, a micro-climatic station was used, which is compliant with the following specifications: ISO DIS 7726, ISO DIS 7730 and ISO DIS 7243.

The micro-climatic station was equipped with the following sensors:

- a sensor to measure the temperature of the globe thermometer (tg),
- a sensor to measure the temperature of the natural wet bulb thermometer (twn),
- a psychrometer to measure the air temperature (ta) and the relative humidity,
- air velocity probe (Va).

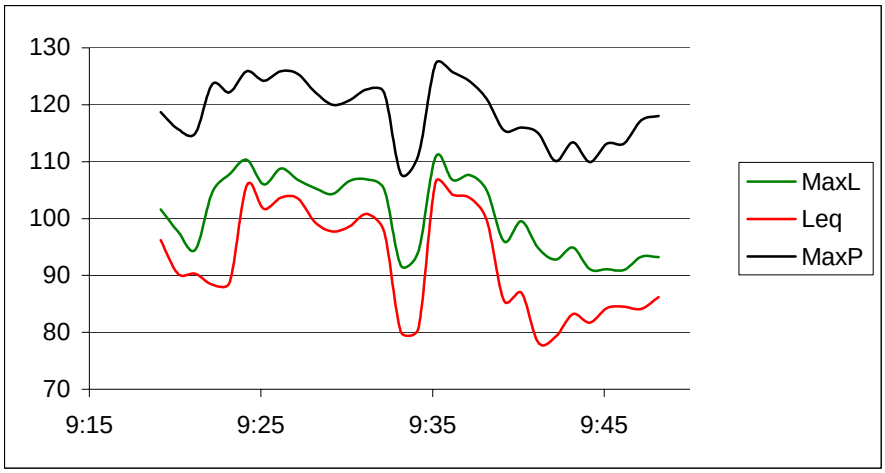
The following parameters were measured:

- relative humidity (%)
- air velocity (Va m/s)
- temperature of the bulb thermometer (tg)
- air temperature (ta)
- heating stress factor WBGT

3. RESULTS OF THE STUDY

Point	Leq dB(A)	Max dB(A)	Max Peak dB	Point description
1	87.4	102.1	114.0	Working post - Furnace control (furnace in operation)
2	83.8	101.6	121.0	Working post - Furnace control (furnace in operation)
3	103.5	111.1	126.7	Working post - on platform of smelting furnace (furnace in operation)
4	106.2	112.2	125.4	Working post – on platform of smelting furnace (furnace in operation)
5	99.1	110.8	127.3	Working post – on platform of smelting furnace (furnace in operation)
6	79.8	90.5	113.7	Working post – on platform of smelting furnace (not in operation)
7	92.2	99.3	130.3	Working post – on platform of smelting furnace (in operation)
8	92.7	99.9	111.7	Working post during casting

Table 1 *– sound level in the smelting and casting section (non-portable measurements)*



In the above sound level diagram we observe the behaviour of Leq, MaxL and MaxP for point 5.

Point	Leq dB(A)	Max dB(A)	Max Peak dB	Point description

1	99.5	126.0	134.8	Sound dose on worker on platform of smelting furnace
2	102.7	120.8	133.7	Sound dose on worker on platform of smelting furnace
3	105.0	141.5	149.4	Sound dose on worker on platform of smelting furnace
4	100.0	119.4	133.4	Sound dose on worker on platform of smelting furnace
5	92.1	114.7	133.7	Sound dose on worker on platform of smelting furnace
6	92.3	118.1	142.0	Sound dose on worker as crane operator on platform of smelting furnace
7	97,3	115.0	129.5	Sound dose on worker on platform of smelting furnace
8	92.4	114.9	138.2	Sound dose on worker on casting platform

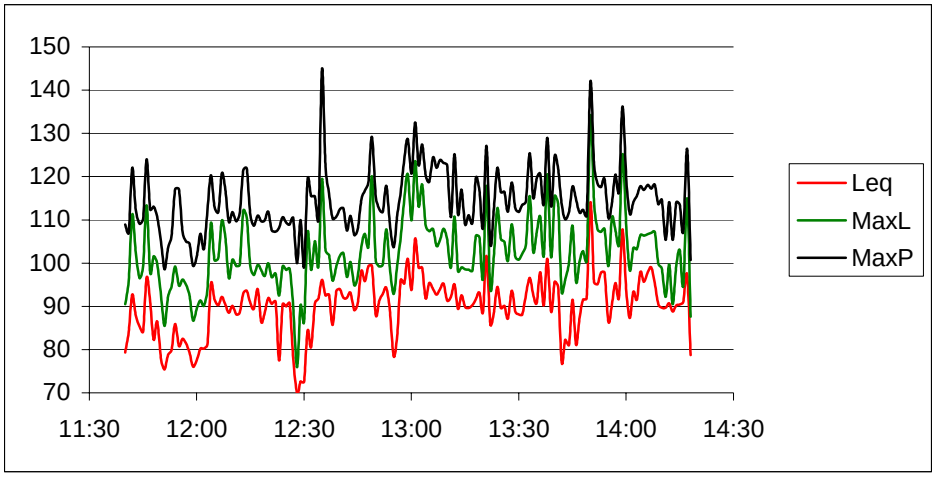
Table 2 *– Sound dose in the smelting and casting section*

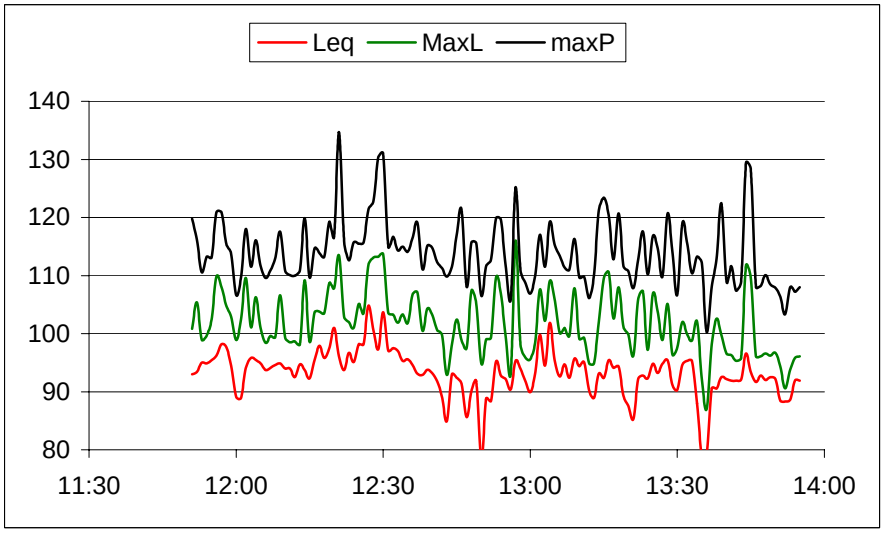
point	Leq dB(A)	Max dB(A)	Max Peak dB	Point description
1	95.4	102.1	117.5	Working post: rolling
2	104.5	106.0	119.1	Working post: rolling- rolls production
3	89.4	101.5	116.3	Working post: rolling- iron production line
4	87.1	95.5	109.3	Rolls room- workers rest place
5	90.5	104.2	120.9	Working post: rolling- end of production
6	99.0	118.7	134.2	Working post: rolling –bundle the rectilinear rods

Table 3 *– Sound level in the rolling section (non portable measurements)*

Point	Leq dB(A)	Max dB(A)	Max Peak dB	Point description
1	93.3	<115.0	140.4	Sound dose on worker at the rolling furnace
2	93.1	<115.0	132.9	Sound dose on worker in the rolling section
3	96.2	134.0	144.9	Sound dose on worker in the bundling production
4	94.9	116.0	134.7	Sound dose on worker in the production of rectilinear rods
5	91.2	<115.0	128.4	Sound dose on worker in the production of rectilinear rods (painting operator)
6	97.2	>115.0	135.2	Sound dose on worker in the rolling section-bundling of rectilinear rods
7	96.2	125.4	147.0	Sound dose on worker in the rolling section (center of the area)
8	98.2	120.3	134.0	Sound dose on worker in the rolling section-bundling of rectilinear rods

Table 4 *– sound dose measurements in the rolling section*





The above diagrams register the Leq, MaxL and MaxP readings for sound dose measurements in points 4 and 7 respectively

Table 5 shows the measurement results of the thermal environment in the smelting, casting and rolling sections during different phases of the production process.

Point	Ta ºC	Va (m/sec)	Rel.Hum(%)	WBGT (ºC)	Point description
1	36.1	2.5	20.0	26.1	Platform of the smelting furnace
2	33.2	2.0	24.0	24.8	Smelting furnace monitoring office
3	38.3	3.0	23.0	30.2	Casting platform

4	28.2	1.8	25.0	24.3	Rolling section (center of area)
5	27.8	2.2	24.0	24.9	Rolling section- bundling the rectilinear rods

Table 5 *– Results of the thermal environment measurements*

Table 6 shows the results of the level evaluation of the suspended solid dust particles in the sections of smelting, casting and rolling during different phases of production activities on the measuring inhalation (inhal.fr.) as well as the respiration fractions (resp.fr.).

Point	Time (min)	Result (mg/m³)	Point description
1 (inhal.fr)	103	13.9	Crane operator on platform of smelting furnace
2 (inhal.fr)	90	29.5	Worker on platform of smelting furnace
3 (inhal.fr)	112	15.3	Worker on platform of smelting furnace
4 (inhal.fr)	109	14.9	Worker on platform of smelting furnace
5 (inhal.fr)	128	11.4	Worker on platform of casting furnace
6 (inhal.fr)	94	3.7	Worker on rolling section (center of area)
1 (resp.fr)	92	8.6	Crane operator on platform of smelting furnace
2 (resp.fr)	89	7.5	Worker on platform of smelting furnace
3 (resp.fr)	110	5.3	Worker on platform of smelting furnace
5 (resp.fr)	118	5.4	Worker on platform of casting furnace
6 (resp.fr)	90	1.6	Worker in the casting section (center of area)

Table 6 *– Results of suspended solid dust particles.*

Table 7 shows the results of the determination of metal concentration in the air of the working environment in the smelting, casting and rolling sections during different phases of the production process.

Measuring point	CONC. Fe (mg/m³)	CONC. Ni (mg/m³)	CONC. Cr (mg/m³)	CONC. Mn (mg/m³)	
1	0.28	0.0086	0.0005	0.17	Crane operator on the platform of smelting furnace
2	0.04	0.0033	0.0000	0.28	Worker on platform of smelting furnace
3	0.49	0.0046	0.0011	0.81	Worker on platform of smelting furnace
4	0.06	0.0021	0.0000	0.67	Worker on platform of smelting furnace
5	0.06	0.0039	0.0000	0.21	Worker on platform of casting furnace
6	0.26	0.0030	0.0007	0.39	Worker on platform of casting furnace

7	0.36	0.0044	0.0012	0.08	Worker in rolling section (center of area)
8	0.21	0.0052	0.0009	0.02	Worker in rolling section
L.V.mg/m3 (Pr.D.90/99)	10(a)	1.0(b)	1.0(c)	5(d)	
TLV-TWA mg/m3 (ACGIH2002)	5(a)	1.5(b)	0.5(c)	0.2(d)	

Notes:

a: Limit value for dust and Iron Oxide fumes (Fe2O3) as Fe
b: Limit value for Ni, as Ni
c: Limit value for metallic Cr
d: Limit value for inorganic compound of Mn, as Mn

Table 7 *– Measurements for the concentration of metals*

The determination of the magnetic fields in the vicinity of the power supply cables of the voltaic arc electric furnace resulted in figures beyond 2000mT (2mT). The exposure of professionals in the area of extremely low frequencies (ELF) between 1 and 300 Hz, should not exceed the ceiling value given by the equation: mt=60f (where f is the frequency in Hz). The use of the above mentioned equation for the 50 Hz frequency defines that the allowed intensity of the magnetic field for an eight -hour exposure at the work place corresponds to 1.2 mT or 1200 μt (60 50 = 1.2mT or 1200 μT).

4. CONCLUSION

The reading of the results produced by the qualitative and quantitative determination and evaluation of the risk agents in the working environment in the iron recycling industries (2nd smelting) demonstrate that noise, air pollution caused by suspended dust particles, thermal environment and the presence of large concentrations of metals (especially manganese) are basic factors that have a negative influence in the health and safety of the exposed workers.

Regarding sound level, it must be pointed out that in almost every measuring that took place in both, the smelting/casting and rolling sections, the Leq dB(A) figures exceed 90dB(A), which the Presidential Decree 8591 stipulates as the maximum limit value for

an eight hour exposure in the work environment. Additionally, in numerous cases the Max Peak figure (of non equalized sound pressure) reached or exceeded 200 Pa.

As far as thermal environment is concerned, the thermal stress factor WBGT in many production activities, exceeds the Limit Values of Allowed Exposure, proposed by the American Conference of Governmental Industrial Hygienists (ACGIH) for work of medium load.

The determination of suspended solid dust particles showed concentrations of inhalation and respiration fractions that exceed the limit values proposed by the ACGIH in 2002, for inert or simply discomforting dust, with a less than 1 percent concentration in crystal silicon dioxide and which corresponds to 10 mg/m³ and 3mg/m³ for the inhalation and respiration fraction respectively. The concentrations in manganese (Mn) vary from a minimum of 0.17 μg/m³ to a maximum of 0.81 μg/m³, exceeding in many working posts the 0.20 μg/m³ proposed by the ACGIH in 2002 as TLV-TWA for an eight-hour exposure.

The magnetic field measurements in the vicinity of power supply cables of the voltaic arc electric furnace, resulted in figures beyond 2000 μT (2Mt), exceeding the 1200 μT (2mT) which is considered to be the maximum allowed intensity of a 50 Hz magnetic field, for an eight hour exposure at the work place.

References

- ✓ Comunità Europea del Carbone e dell' Acciaio, I FATTORI UMANI E LA SICUREZZA NELLE MINIERE E NELLA SIDERURGIA, LUSSEMBURGO 1967.
- ✓ Gruppo di Ergonomia della Siderrurgia Italiana, ESPERIENZE INTERNAZIONALI IN SIDERURGIA, Taranto 1986.
- ✓ Violi G., PROCESSI SIDERURGICI, Etas Kompas, Milano 1972.
- ✓ Candura F., ELEMENTI DI TECNOLOGIA INDUSTRIALE, Ed. Comet, Pavia 1991.
- ✓ Badini L., Mazza B., Nano G., Scinigallia D., Alva J., CICLO TECNOLOGICO E MAPPA DI RISCHI PRESENTI NELL' INDUSTRIA BSIDERURGICA E NELLA FONDERIA DI GHISA E ACCIAIO, Atti XL Cong. Nat. Soc. It. Medicina del Lavoro ed Igiene industriale, Milano 1977.