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OCCUPATIONAL EXPOSURE TO IONISING RADIATION AT COPPER MILL

Jelica Kaljević [1], Mirjana Cvijović [1], Jelena Stanković [2, 1], Vojislav Stanić [1]

[1] Vinca Institute of Nuclear Sciences, University of Belgrade, Belgrade, Serbia
[2] School of Electrical Engineering, University of Belgrade, Belgrade, Serbia

Abstract. *The Copper Mill Sevojno produces various copper and copper alloy products for utilization in different industry sectors. Technological process of copper rolling from blocks to strips consists of cold and hot rolling. For the control of copper strip thickness radio-isotope strip thickness gauges are installed. These gauges are widely used for contactless measurement of the metallic or non-metallic strip thickness. At the Copper Mill Sevojno, radio-isotope strip thickness gauges are with radio-isotope ^{90}Sr. The gauges are placed on the machines for cold rolling of copper and brass strips, named rolling mills. The employees that operate on these rolling mills are exposed to gamma radiation and are under legislation dosimetric control. The results of dosimetric monitoring of rolling mills workers are presented here. The doses, in terms of personal dose equivalent, Hp(10), are reported quarterly, as those workers are categorized as "B" group workers occupationally exposed to ionizing radiation. Measurements are done with thermoluminescent system that consists of Harshaw 6600 Plus automatic reader and thermoluminescent dosimeters for whole body TLD-100 (LiF:Mg,Ti). Annual doses are given for all four groups of monitored twenty-one persons for three-year period. The results show that maximal measured personal annual dose is less than recommended annual dose limit of 20 mSv.*

Key words: *Copper Mill, Thickness Gauge, ^{90}Sr, Hp(10), TLD, Harshaw*

1. INTRODUCTION

The Copper Mill Sevojno produces copper and copper alloy products for utilization in different industry sectors. Technological process of copper rolling from blocks to strips consists of cold and hot rolling. The standard strip thicknesses are from 8 to 12 mm depending on strip composition (copper or brass) and on strip width. For the control of copper strip thickness radio-isotope strip thickness gauges are installed. The gauges are widely used for contactless measurement of the metallic or non-metallic strip thickness. For this measurements beta sources and gamma sources are used, since short range of alpha particles limits their use to thin and light materials. When strip material composition variation is expected the use of more than one measurement is done [1]. Hence, sources that emit beta particles and gamma rays are used for composition-independent thickness measurements.

At the Copper Mill Sevojno, radio-isotope strip thickness gauges are equipped with radio-isotope ^{90}Sr. This source decays by beta minus emission to the ^{90}Y, with $T_{1/2}$ of 28.80 years [2]. Energy of β^- particles are around 545,9 keV. Furthermore, ^{90}Y emits 2.28 MeV β^- particles with $T_{1/2}$ of 2.67 days. Beside β^- particles ^{90}Y emits gamma radiation of 1.7 MeV with the 0.01% yield. The gauges are placed on the machines for cold rolling of copper and brass strips, named rolling mills (see Fig. 1).

Fig. 1. Duo Rolling mill: 1) ^{90}Sr gauge

Doses produced by industrial gauges without high activity are category 4 sources. This means that their activity is from 100 to 1 times smaller than activity considered dangerous [3]. Thus, dosimetric monitoring of workers has to be provided.

The purpose of this work is to evaluate the radiation exposure to the workers who manage rolling mills in the biggest copper mill in Serbia.

Personal dose equivalent, Hp(10), was measured via thermoluminescent dosimeters (TLDs) and annual effective dose values were estimated.

2. THE METHOD

Data presented in this work is acquired from Copper Mill Sevojno. Occupational doses from twenty-one persons working at four rolling mills were assessed. Information about procedures done on four rolling mills and workers involved is given in Table 1. The rolling type can be D-duo or Q-quatro. Duo rolling mill has two parallel rolls, between which the material is rolled down. Quatro rolling mill has two set of parallel rolls and two ^{90}Sr sources.

The workers operating rolling mills are supervising quality of rolling process that include input and output dimensions of stripes, and are taking care of the preventive maintenance of the equipment. They are operating rolling mills only when raw material is present, and this is not accomplished every day. When operating, workers are exposed to scattered radiation.

Table 1. The Rolling mills information

Rolling mill	No. of Workers	Rolling Mill Type	Strip width [mm]
VB-8/I	3	D	420
VB-6/III	5	D	specific
VB-5/III	9	Q	>800
VB-3/I	4	Q	<800

Workers were equipped with whole body TLDs that are typically used for individual monitoring of external ionizing radiation. One dedicated TLD per worker was worn at the chest level during working hours. Ambient dose equivalent, H*(10) showed that copper mill workers can't receive effective dose higher than 6 mSv. For that reason monitoring was done on three months basis [4].

Measurements are done with thermoluminescent system that consists of Harshaw 6600 Plus automatic TLD reader with WinREMS software and thermoluminescent dosimeters for whole body TLD-100 (LiF:Mg,Ti).

Each TLD had holder and aluminum plate with two thermoluminescent (TL) chips (see Fig. 2).

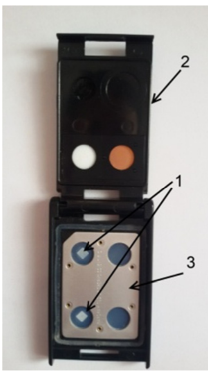

Fig. 2. TLD system: 1) TL chips, 2) holder and 3) Al plate.

The calibration of dosemeters in terms of personal dose equivalent, Hp(10), was performed at Secondary Standard Dosimetry Laboratory of Vinca Institute of Nuclear Sciences (SSDL-INNV). Calibration source used was ^{137}Cs. During calibration dosimeters were positioned on the ISO slab phantom [5].

The measurements of the TLD signal are provided by accredited Individual monitoring service (IMS), Radiation protection laboratory at "Vinca Institute of Nuclear Sciences", Belgrade, Serbia (INNV).

The annual effective dose estimation was done via TLD measurements of personal dose equivalent, Hp(10) [6].

Data and results presented in this work were collected and measured from 2012 to 2014.

3. RESULTS

Figure 4 to 6 presents the estimated annual effective dose per worker per year. Worker's ID shown in graphs was generated as follows in Fig. 3.

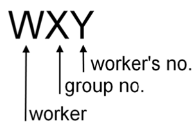

Fig. 3. Worker's ID

The estimated mean annual effective doses for a worker in Copper Mill Sevojno are shown in Table 2.

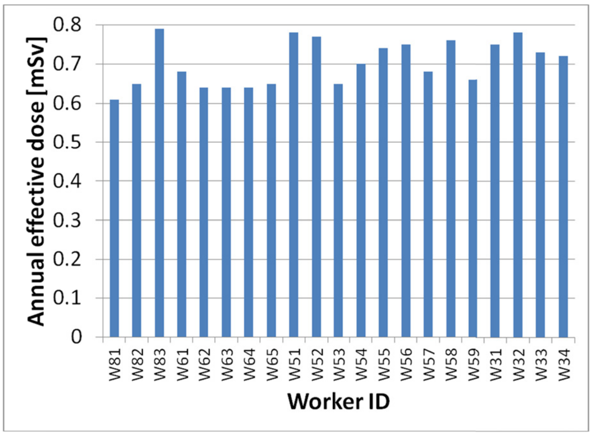

Fig. 4. 2012: Annual effective doses

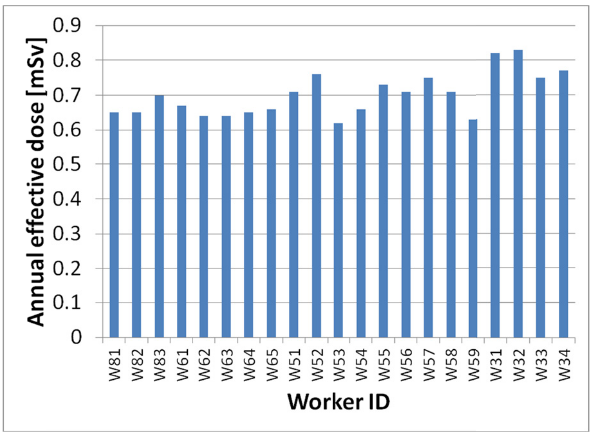

Fig 5. 2013: Annual effective doses

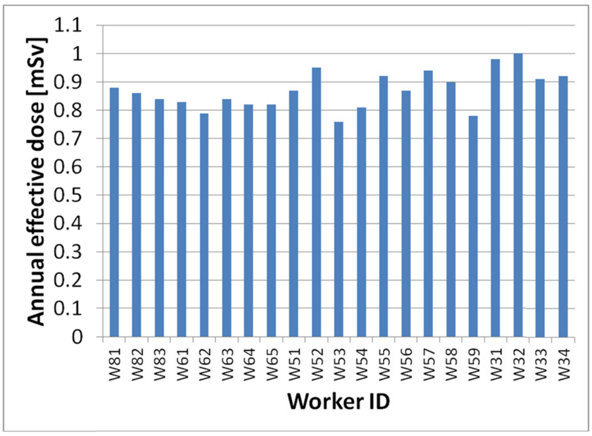

Fig. 6. 2014: Annual effective doses

Table 2. Mean annual effective doses at Copper mill

Year	Effective dose [mSv] (Mean value ± st. dev.) (min-max)
2012	0.70±0.06 (0.61-0.79)
2013	0.70±0.06 (0.62-0.83)
2014	0.87±0.06 (0.76-1.00)

4. DISCUSSION

This paper presents doses for wokers operating rolling mills in the biggest copper mill in Serbia. The workers are categorised accoring to the rolling mill they operate on into four groups (VB-8/I, VB-6/III, VB-5/III and VB-3/I).

Figure 4-6, shows that work practice is optimally organized between the groups. Workers are nearly equally exposed and work load is evenly distributed.

Presented personal doses during three months period are as high as background doses. Thus, they are considered as low doses.

Workers were not constantly exposed from day to day, but only when resources for stripe rolling were present. Daily dose could be estimated if daily exposure is constant. As daily exposure is varying according to resources presence doses per day could be higher than implied here.

As a consequence to low doses per quarter, annual occupational doses are low and below recommended annual limit of 20 mSv [4]. Moreover, doses are in line with global average of 0.5 mSv per year reported by UNSCEAR, 2008 [7].

Very small standard deviations of annual doses confirm that doses are uniformly distributed among workers and that work practice is optimal. There is no difference in doses of workers who operate D and Q rolling mill. Also, the size of stripes produced isn't affecting the doses.

In this work the doses from beta particles were not analyzed. Thus, further research will be focused on influence of mixed field on personal dose equivalents for roll mill workers.

5. CONCLUSION

This paper presents occupational doses of the workers exposed to gamma radiation at the copper mill factory in Serbia. The monitoring of the worker was done using TLD system. Annual effective doses were estimated during three year period. Estimated doses were much lower than recommended annual limit.

Although the individual doses are within the recommended regulatory limits, the increase in the workload would result in somewhat higher employees' doses. Further research would be oriented on assessing doses to skin of workers by means of Hp(0.07) measurements and β–γ fields will be mapped at the source location. An effort would have to be made to review the radiation monitoring procedure at this site.

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REFERENCES

1. Esam M. A. Hussein, Handbook on Radiation Probing, Gauging, Imaging and Analysis, Vol. 2, Part 3, Springer Netherlands, 2003, pp. 465-520.
2. M.-M. Be et al, Table of radionuclides, Bureau international des poides et mesures, Sevres, France, 2004.
3. IAEA, Radiation Protection and Safety of Radiation Sources: international Basic Safty Standards, No. GSR Part 3, Vienna, 2014.
4. Rulebook on limits of exposure to ionizing radiation and measurements for assessment of the exposure levels, Official Gazette of Republic of Serbia, no. 86/2011, 2011.
5. X and gamma reference radiation for calibrating dosemeters and dose-rate meters and for determining their response as a function of photon energy - Part 3: Calibration of area and personal dosemeters and the measurement of their response as a function of energy and angle of incidence, ISO 4037-3, 1999.
6. Technical Recommendations for Monitoring Individuals Occupationally Exposed to External Radiation, European Commission, Luxembourg, RP no. 160, 2009.
7. S. W. Gordon, "Optimization of radiation for the control of occupational exposure in Ghana", RPD, Vol. 147, No 3, pp. 386-393, 2011.