OCCUPATIONAL EXPOSURE FOR WORKING STAFF IN THE EGYPTIAN CERAMICS INDUSTRY

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Zirconium Process

- Non – Nuclear industries use raw materials containing significant levels of radionuclides; the processing of these materials can expose workers and people living and working near such sites to radiation levels well above the natural background.
- Zircon sands processing, falls within this category.
- Zircon sands are mainly made of zirconium silicate ($ZrSiO_4$) or baddeleyite (ZrO_2) with natural radioactivity content exceeds by one or two orders of magnitude the one present on average in the earth's crust. This is due to the fact that, during zircon crystals formation owing to magma masses cooling, uranium and thorium atoms get trapped into the crystal structure.

OBJECTIVE

- This study deals with the determination of occupational exposure due to industrial materials processing and storage in the surrounding in some ceramic companies.
- The regulations and measures needed for workers dealing with zirconium materials were implemented.

EXPERMENTAL WORK

The occupational radiation dose received by the workers in ceramic factories was calculated according to the Basic Safety Standard 115 as follow:

$$E = E_{ext} + \Sigma_j h(g)_{j,\,ing} J_{j,ing} + \Sigma_j h(g)_{j,\,inh} J_{j,inh}$$

E_{ext} is the external exposure in a year;

$h(g)_{j,\,ing}$ and $h(g)_{j,\,inh}$ are the committed effective dose per unit intake for ingestion and inhalation radionuclide j ($Sv\ Bq^{-1}$) by the group of age g;

$J_{j,ing}$ and $J_{j,inh}$ are the relevant intake via ingestion or inhalation of radionuclide j in a year (Bq).

- The external exposure due to gamma radiation was measured using a TLD card.
- The effective dose for inhalation has been obtained by summing the dose derived from dust inhalation and the dose due to the inhalation of radon released by zircon sands.
- The direct ingestion of contaminated particles can be neglected due to the type of activity carried out and work methods adapted.

Determination of external dose using TLD

- Three locations were chosen for area monitoring according to the activity of work (storage, grinding and production).
- The TLD dosimeters LiF-100 (Lif: Mg, Ti), with dimensions 3x3x0.38 mm^3 encapsulated between two sheets of Teflon l0mg/Cm^2 thick and mounted on an aluminum substrate were hanged in these locations for three months.
- A Harshow 6600 reader was used to determine the external dose.

Determination of internal dose from inhaled dust

- air samples were collected by an electrical pump positioned away from walls and 1 m above the floor.
- Samples locations, time duration and flow rate were adjusted in the grinding department.
- High efficiency filter papers were used.
- Samples filters were stored in protective envelopes before and after use.
- The annual inhaled dust by workers has been calculated by considering 8 working hours for 250 days a year, breathing rate equal 1.25 m^3h^{-1} with a breathable fraction equal to 1.

Determination of internal dose from inhaled radon

- The air samples were collected for 5 min at a flow rate about 2.4 l/min on high efficiency filter paper (Milliopre, diameter 2.5 cm), followed by alpha counting after a delay time of about 5 min.
- The period of delay was selected to minimize the error resulting from variations in radon daughter ratios. The filter papers were counted using an EDA (RAD-200radon daughter detector, EDA Instrument Inc.) type counting system by placing the filter paper on a scintillation tray coated with silver-activated zinc sulphide.
- For 5 min counting time measurements, a radon can be measured with a reproducibility of ± 15 %.

- The radon concentration expressed as Working Level (WL), was calculated using the following equation:

$$WL = R/E\nu Tf$$

Where

✓ R is the alpha count rate in count/min,

✓ E is the counting efficiency,

✓ ν is the volumetric sampling rate in l/min,

✓ t is the sampling time in min and

✓ F is a conversion factor.

Gamma Spectrometric Analysis

- All samples have been prepared in 100 ml Marinelly beakers, weighted and sealed to avoid radon exhalation. Radioactivity measurements have been conducted after period of at least 28 days for secular equilibrium between the ^{222}Rn and its short-lived decay products.
- HPGe gamma-spectrometer with 40 % efficiency and 2.0 kev resolution at 1.33 Mev photons, shielded by 4’Pb, 1 mm Cd and 1 mm Cu linked up to a multichannel analyzer have been used for measurements.
- The system was calibrated and the calibration quality control has been carried out by using a soil (IAEA-226 and IAEA-375) whose concentration of natural radioactivity have been certified by the IAEA.
- Activity concentrations of ^{238}U and ^{232}Th have been determined.

Results

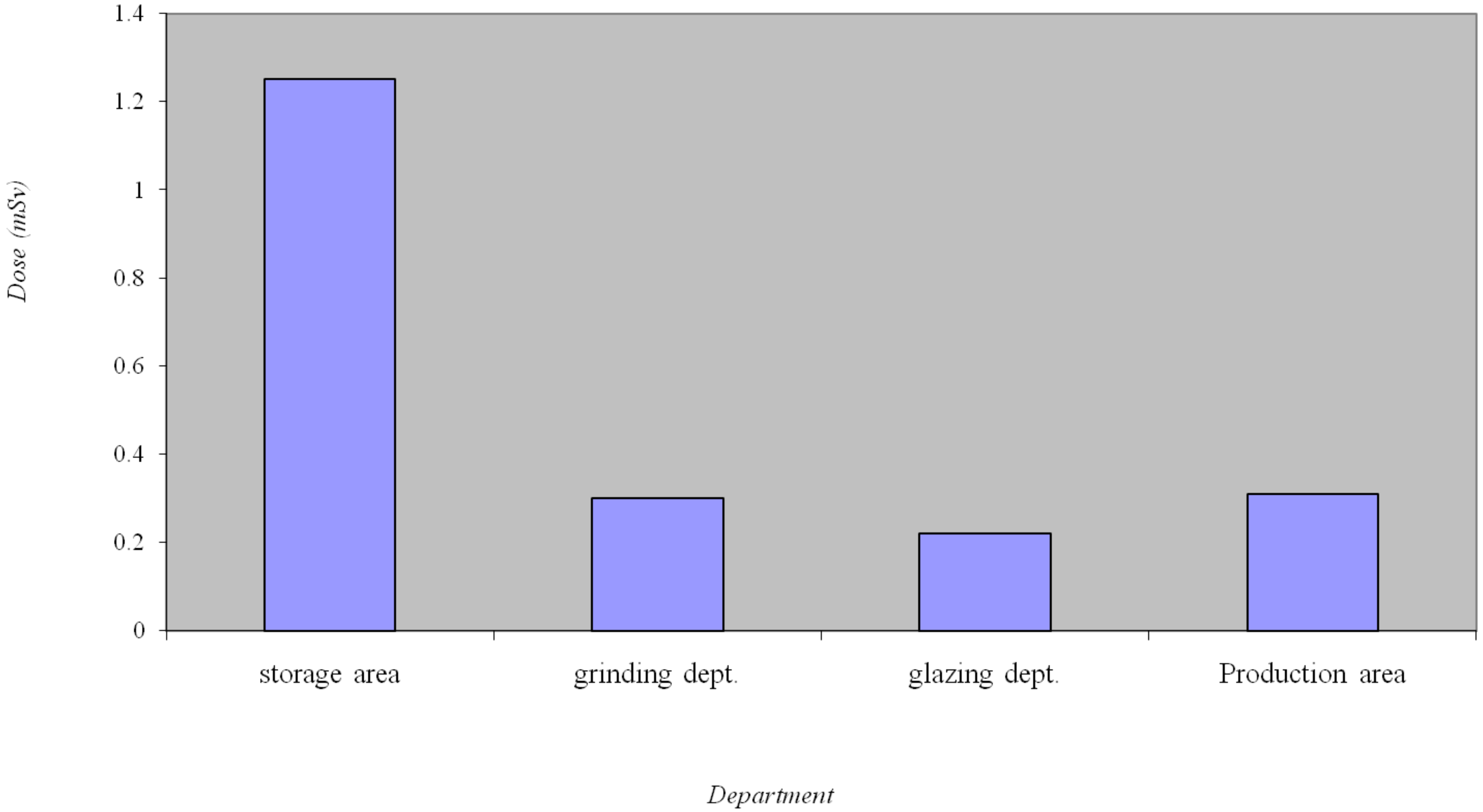
- The external radiation dose was measured using TLD at three locations in each factory.
- The mean external dose at each site was :

  0.2 mSv/a in the grinding area,

  0.3 mSv/a in the production area and

  1.25 mSv/a in the storage area.

Fig. (1): The annual external dose (mSv)

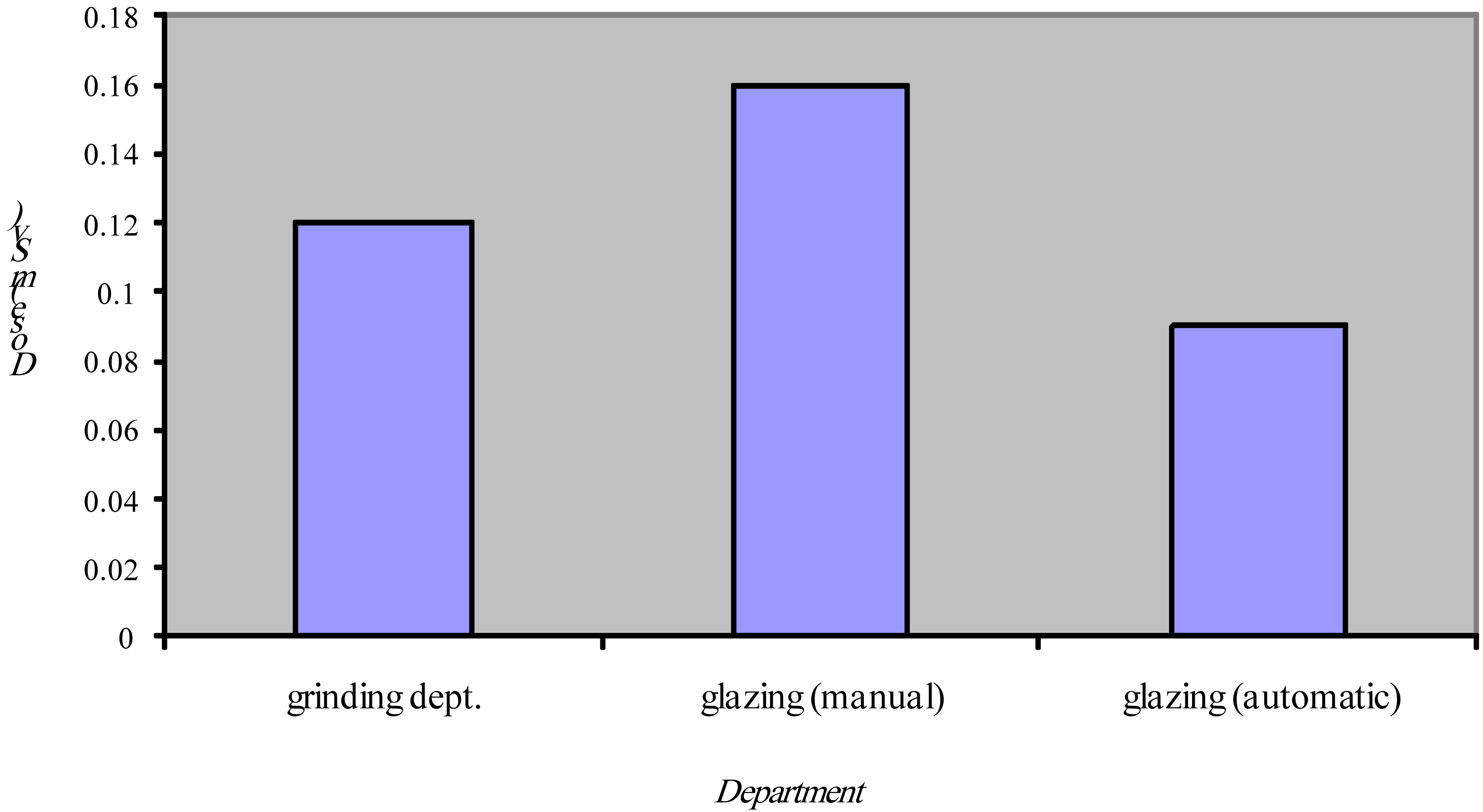


- The average dust concentration in the grinding department was varied from 0.3 to 0.7 mg m^{-3}. The dust concentration was adapted to equal 0.5 mg m^{-3}.
- The activity concentrations of ^{238}U chain and ^{232}Th chain were determined in zircon silicate and their values ranged from 1500 to 2000 Bq/Kg with average 1800 Bq/kg and from 390 to 600 Bq/kg with average 500 Bq/kg respectively.
- The intake value for inhalation of radionuclide j over one year ($J_{j,inh}$) can be calculated taking into account the following assumptions;

- The dust concentration is 0.5 mg m^{-3},
- The worker breathing rate of 1.2 m^3/hr,
- The duration of exposure was 2000 hr,
- The particle size was 5 micro m and
- There is no respiratory protections.

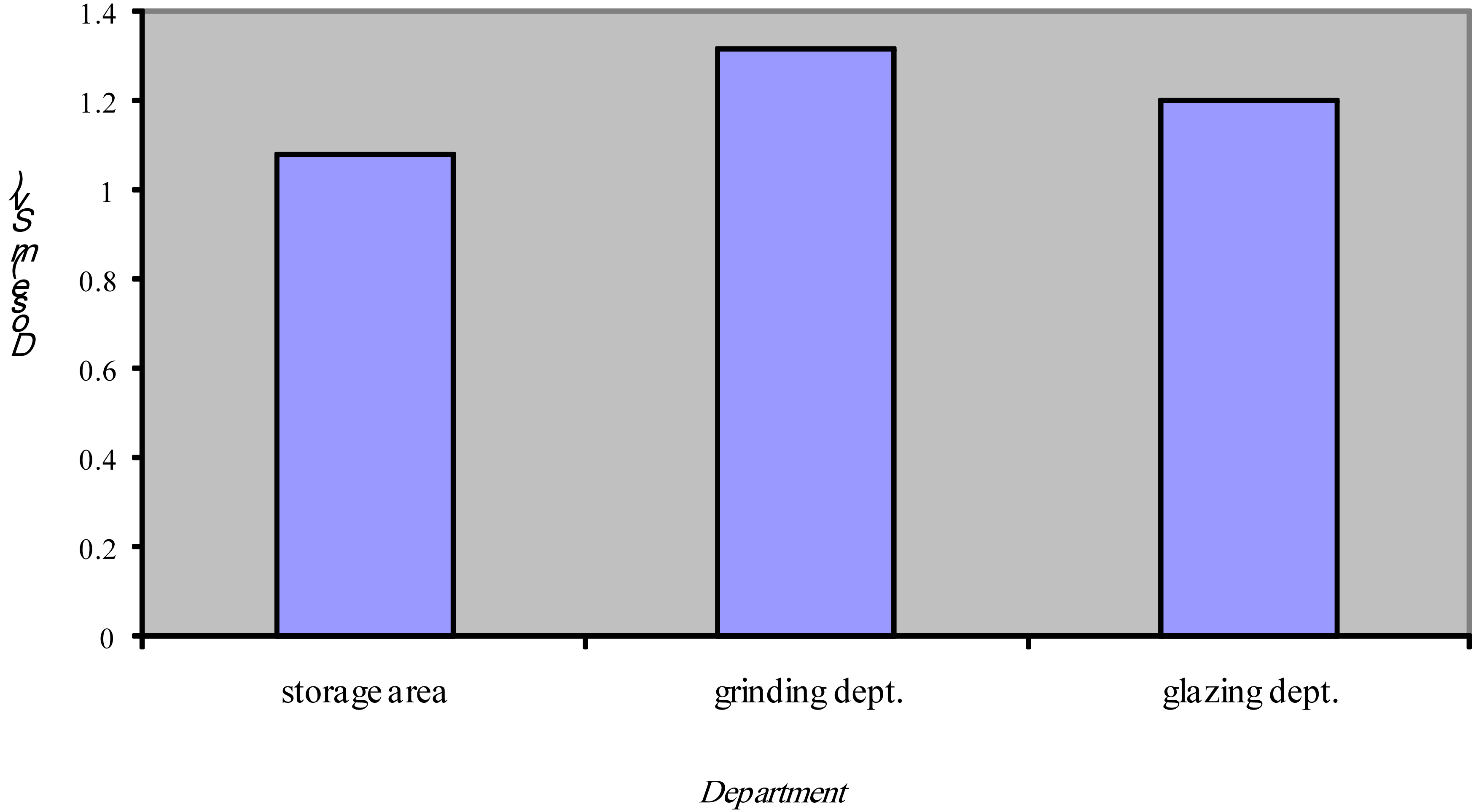
The committed effective dose for inhalation of dust has resulted to be equal 0.2 mSv/a.

Fig. (2): The annual internal dose due to dust inhalation



- The effective dose for inhaled radon (mSv/y) has been determined according to the ^{222}Rn decay products in working level unit.
- Maximum personal effective radiation doses were calculated using the conversion factors: 1WL = 60 μSv/h for ^{222}Rn progeny.
- The committed effective dose for radon inhalation has been resulted to be 1.3 mSv/a.

Fig. (3): The annual internal dose due to radon inhalation



- According to the BSS formula the occupation exposure dose has been calculated as the summation of the three main contributions:

✓ external exposure

✓ internal exposure from dust

✓ and radon inhalation

taking into consideration that the committed effective dose due to ingestion is neglected.

The total exposure dose for workers has resulted to be more than 1.5 mSv/a which falls within the exposure limit for workers (20 mSv/a) but it exceeds the action level of 1 mSv/a.

CONCLUSION

- From an occupational point of view, simple precautions are generally sufficient to minimize the external radiation exposure

a. job rotation of workers,

b. proper industrial hygiene rules are sufficient to avoid internal contamination resulting from zircon silicate (dust masks) and

c. efficient ventilation is very important in grinding and glazing preparation.