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A PICTURE OF INDUSTRIAL HYGIENE IN GERMISTON

ANTI-RUST PROOFING BY ZINC GALVANIZING (HOT DIPPING)

A REPORT OF SUSPECTED CLINICAL HAZARDS ('METAL AGUE') AND LOCAL DANGERS (BURNS) ENCOUNTERED IN THIS INDUSTRY

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A health inspector of the City Council of Germiston, who visited and inspected a local engineering works, was not altogether convinced that the industrial process of zinc galvanizing (by hot dipping) as at present conducted at the works, was hygienic and without danger to health (possibility of the inhalation of noxious fumes) and to life (absence of adequate protective safeguards during dipping).

In 1958, the Health Department (under the guidance of its former Medical Officer of Health, Prof. P. B. Peacock) inaugurated the extension of occupational health services to industrial concerns situated within the Germiston municipal area. In the case of the engineering works referred to, a medical officer was instructed to inspect the works and to obtain the management's concurrence in allowing the 22 non-White employees engaged in dipping to have themselves medically examined. In addition the workers were closely questioned about the incidence and frequency of their absence from work for reasons of ill-health during the period of employment on their present duties. The medical officer's findings and report form the subject of the present article.

SITE OF THE ENGINEERING WORKS AND THE WORKS CONSTRUCTION

The engineering works under consideration is situated on the outskirts of Germiston (within the municipal area) and is primarily engaged in the anti-rust proofing (by the process of hot-dip zinc galvanizing) of manufactured steel or iron parts for use in industry and commerce.

The galvanizing process is carried out in a building of zinc-iron construction, apparently of sufficient height and breadth, and completely open at its east and west wings to allow of free ventilation by the natural perflation of air in the same direction, east to west. In the centre of this building, running east to west, is a longitudinal steel melting tank 41 feet long, 3 feet 6 inches wide and 3 feet 6 inches deep. Bordering on and adjacent to the upper edges of the vertical sides of the tank is a metal platform surrounding it, approximately 3 feet 3 inches wide, on which the workers stand while periodically removing the waste material (dross) from the surface of the molten zinc. The platform rests on and is incorporated into a brick framework which surrounds the entire tank up to the height of the level of the platform. At the west end of the tank is a furnace, the flames and heat of which are dispersed under the tank by means of a blower situated adjacent to the furnace. There is a complete absence of any protective guard rails along the inner sides of the platform nearest the cavity of the tank, which holds the molten zinc.

HOT DIPPING

The Process of Zinc Galvanizing (Hot Dipping)

In the steel tank described above, about 100 tons of metallic zinc are reduced to a molten mass by direct heat at about 450°C. Into this the objects to be coated with zinc are dipped by the workers, using a system of overhead pulleys. In performing this task, the workers stand at a safe distance from the tank. The objects remain immersed for short periods, approximately 5 - 10 minutes. They are then elevated and the excess, now solidified, zinc protruding from the sides of the objects is then scraped off.

If, after close inspection, the galvanizing is considered to be unsatisfactory, the objects are reimmersed for further coating, after being feathered with ammonium chloride over such 'raw' areas. It is especially in the region of welded joints of metal parts that galvanizing must be perfectly completed, otherwise rusting commences in these areas, under exposure to everyday atmospheric conditions. The absence of an adequate protective zinc coat leads to decay and weakening of constructural supports.

Procedures Preparatory to Hot Dipping

Before hot dipping, the iron or steel objects have their metallic surfaces rendered free of foreign matter (rust, etc.), either by sand blasting or by immersion in troughs of diluted hydrochloric acid. The objects are then dipped in zinc-ammonium-chloride solution; this solution acts as a flux in binding the zinc coating to the basic metal. At this stage the wet objects are hoisted from the immersion tanks by the overhead pulleys and then conveyed to the body of the molten zinc for coating.

Observations during Hot Dipping

During the actual process of dipping, it was noticed that:

(*a*) Considerable splashing of molten zinc occurs up to an estimated distance of 25 feet from the tank.

(*b*) An appreciable cloud of opaque mist is formed in the tank which disperses into the immediate surroundings of the tank and then disappears very quickly into the air.

Emission of ?Noxious Zinc-oxide Fumes during and in between Dipping

The cloud of opaque mist which is formed during dipping has not been chemically analysed; it is impossible

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to state whether or not it consists of volatilized steam only or whether it contains an admixture of zinc or ammonium-chloride fumes or even fumes of zinc oxide.

In between the periods of dipping a very fine, barely discernible opalescent haze arises from the surface of the molten zinc. This is best seen at a distance from the tank. The presence of this haze suggests that oxidation of zinc is taking place, and since its composition has also not been chemically determined, it is impossible to establish whether or not finely sublimated zinc-oxide fumes are ascending to the height at which inspiration by the workers would normally take place. Since the level of the molten liquid zinc is usually 10 - 12 inches below the level of the platform, and if the height of the average Bantu male is taken as 5 feet 6 inches, the height to which the zinc-oxide fumes would have to ascend to be noxious is judged to be in the region of 6 - 7 feet.

Formation of Zinc Oxide in the Melting Tank

It was clearly observed that certain chemicals are formed in the bath during the galvanizing process. In the dipping-free intervals, appreciable amounts of dross, including a greyish powder, were skimmed off the surface of the molten zinc. The manager confirmed that this dross contained zinc oxide.

From the circumstantial evidence gathered during the inspection (the presence of the persistent haze during the dipping-free intervals and the formation of zinc oxide on the surface of the bath) the impression was gained that the workers are being exposed to the inhalation of freshly formed pathogenic zinc-oxide fumes during the course of their work. Despite this observation, it is extremely difficult to satisfy legal and technical criteria that zinc fumes are actually ascending to a height at which they could give rise for concern. Bending over the bath during operations such as dross removal would decrease the height of exposure and increase the likelihood of the inhalation of fumes.

An investigation, such as the determination of the content of zinc oxide in a given volume of air over the bath and the measurement of its particle size, would be costly (estimated cost varies from R72 to R210) and the expense involved is non-refundable to the Department. According to the Code of Practice for Noxious Dusts and Fumes approved by the Council of the South African Bureau of Standards (1952) the maximum allowable concentration (MAC) of zinc-oxide fumes is laid down as 15 micrograms per litre of air.

Number of Workers Engaged on Hot Dipping and their Periods of Service

As has been mentioned, 22 workers were engaged in dipping. Their periods of service in their present employment were as follows: Over 5 years' service, 1; between 4 and 5 years, 2; between 3 and 4 years, 3; between 2 and 3 years, 2; between 1 and 2 years, 4; under 1 year, 10.

Since the total number of employees engaged in dipping has remained more or less constant, the above figures suggest that up to the present time (end of September 1961) there has been a labour turnover of about 50% in this section of the works during 1961.

MEDICAL PICTURE

Workers' Sickness Absences during their Present Employment and the Nature of their Symptoms

Of the 22 employees engaged in dipping, 7 said they had been away from work on account of illness at least once at some stage during their present employment. The statements made by them suggest that in the majority of cases their symptoms were of a general nature — bodily aches and pains. It is noteworthy that of the 10 workers engaged during 1961, 5 were among those who were away from work on account of illness.

Clinical Findings during Present Medical Examination

During the present medical examination of employees, no direct evidence of the presence of any acute febrile illness could be obtained among those investigated. Of the 7 workers who absented themselves from work, one still complained of generalized cramps in his muscles and bones, and another had a very poor lung air entry with occasional rhonchi.

Despite the absence of any clear-cut clinical evidence to the contrary, there remains, in my opinion, a distinct likelihood that one cause of the workers' absence from work may be the inhalation of zinc-oxide fumes during the course of their employment.

The Symptomatology of Metal-fume Fever ('Metal Ague')

It was stated by Hunter[1] that no long-term poisoning occurs in industry from the handling of zinc compounds. Metal-fume fever (owing to the inhalation of the fumes of many metals including zinc) is an acute disability of short duration which occurs when fumes are inhaled from a metal heated above its melting point. Galvanizing as such is one among many industrial processes where there is a distinct hazard of exposure to zinc fumes.

In a typical case of metal-fume fever, the symptoms are: fever (up to 102°F.), nausea, thirst, headache, pains in the limbs, and a feeling of exhaustion. The attack is usually of short duration with complete recovery after 48 hours. The frequency and severity of the attacks are apparently affected by the regularity of exposure, for those who work continuously in proximity to the fumes seem to acquire a tolerance. However, this tolerance is rapidly lost, and mere absence from work during a week-end is sufficient to re-expose workers to the liability of a fresh attack of fume fever.

The Presence of Localized Burns from Splashing by Molten Zinc

The construction of the metal tank used in this industry has been described and the absence of any adequate safe-guard rail, protecting the workers from the hazard of contact with molten zinc, has been recorded. It was not surprising, therefore, to find evidence that all the workers showed signs of having been burned by splashes of molten zinc. The size and shape of the burns varied from those of a round scar (a few millimetres wide) to linear burns 1 inch long. In one case there were 3 separate burns each about 1 inch long (in a granulating stage) over the left scapula, suggesting that the molten zinc may have dropped from a height or that the worker had his back turned to the bath when the splash occurred. An example of a zinc-splash burn in the left-elbow region, which took over a month to heal, is shown in Fig. 1.

Fig. 1. Zinc-splash burn in left-elbow region.

Several of the workers' overalls showed evidence of having been peppered with punched-out burn marks. The manager stated that he had been compelled to provide a protective guard rail around the platform in front of the bath, but that on the first day of its use, 3 workers had overbalanced on the rail and directly burned themselves on the molten zinc. A rail of greater height would obstruct the freedom of movement of the pulley system and thus interfere with the efficiency of the dipping operations. With official permission, he had immediately dismantled the rail. The presence of the protective rail had, in practice, proved to be a greater hazard than its absence, as his experience had indicated.

The regime of safety measures at present in force is extremely strict and disciplined. Adequate warning of the imminence of dipping is given. If any worker is burned by molten zinc, it is regarded as being due solely to his own carelessness. According to the manager's statement, if a worker is burned while on duty, he is liable to a fine.

APPLICATION OF SUITABLE PREVENTIVE MEASURES

From the hygiene engineering aspect, the provision of suitable remedial measures aimed at the exclusion of the hazards outlined, has proved extremely difficult in practice.

The following measures received due consideration:

1. Provision of an exhaust ventilation system over the bath at the level of the platform to extract fumes as near to their point of origin as possible. However desirable a measure this is, it is considered that, because of the propinquity of the zinc splashing, the inlet ducts of an exhaust system constructed at this level would be clogged with solidified zinc in a matter of days, and their maintenance (cleaning) would be impracticable. The cleaning process itself would involve frequent stoppages of work, and in addition constitutes a hazard on its own account. Also, the cost of an exhaust system is reported to be beyond the means of the company. It was concluded that the galvanizing process is at present operating under the best possible conditions of maximum general ventilation.

2. Provision of an adequate protective rail around the bath. Although the law requires protective barriers to be placed around the bath, experience has shown that the presence of these fixtures constitutes a great potential hazard to life and limb. In seeking to avoid burns, reliance has thus had to be placed on the enforcement of a strict code of personal safety measures.

This hazardous type of industry prompted us to seek the immediate assistance of the local branch of the National Occupational Safety Association (NOSA). With the ready cooperation of the management, this organization has instituted a regular series of mother-tongue lectures at the works to further self-discipline and the avoidance of unnecessary disability among the non-White employees.

SUMMARY

A brief outline of the practice of industrial hygiene in Germiston has been described and some specific difficulties (occupational health and engineering problems) associated with the process of hot-dip galvanizing have been detailed.

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REFERENCE

1. Hunter, D. (1957): *The Diseases of Occupation,* 2nd ed., p. 390. London: The English University Press.