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# Recycling of Industrial Waste Containing Mercury by the Sole Refinery Plant in Japan

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Since 2003, The UNEP (United Nations Environment Programme) has started programs for the prevention of mercury pollution, a problem that threatens our environment and public health on a global scale. UNEP is also heavily involved in negotiations between governments as we approach the establishment of this treaty in 2013. The major issue in this discussion revolves around the regulation of the use of mercury in products and manufacturing processes, and the importance of creating an inventory throughout that process. As we move forward, wide-scale restrictions are going to be enacted regarding the import and export of mercury between nations. As the only mercury recycling operation in Japan, here we want to introduce, in detail, the flow of Nomura Kohsan's mercury recycling technologies in order to aid other nations in the prevention of environmental pollution. One of these technologies to roasting detachment recycles mercury from fluorescent lamps, a common source of lamps used around the world, in order to produce cullet for industrial use. We would also like to discuss another one of our technologies that enables us to extract mercury, zinc, manganese, Iron, and other elements from dry-cell batteries, another common household item. They are necessary things to live a modern life for people, but they contain various toxic substances. We would appreciate it if you refer to this report in order to avoid environmental pollution risk at disposal of them.

**Keywords:** Mercury, Recycling, Lamp, Battery, Hokkaido, Itomuka

## 1. Introduction

In 2003, UNEP (United Nations Environment Programme) started program for the prevention of mercury pollution which may cause environmental contamination and damage to human health. The first session of the Intergovernmental Negotiating Committee was held in Stockholm in 2010. Concrete intergovernmental negotiations headed toward the establishment of a treaty in 2013 and they are now drawing to a close. Important points at issue include regulation of products and manufacturing processes that use mercury as well as the development of inventories for those processes. In other words, significant restrictions will be imposed on exports and imports of mercury between countries, and environmentally appropriate handling will be required. Accordingly, as the only company in Japan in the business of mercury recycling, we hope we actively introduce our technological process and contribute to the prevention of pollution in other countries.

Nomura Mining, Ltd., which was the predecessor of us, was established in 1939. Since then, it has contributed greatly to the modernization of the mercury mining industry, not to mention that the company produced the most mercury in the East. Various circumstances have led to the reduction of mercury usage, starting with Minamata disease that was common in the latter half of the 1950s, lead mercury mines to be shut down. Years after, we succeeded in creating a new type of mercury smelting technology, and started the only mercury recycling enterprise in Japan in 1973. This included detoxification processing and the recycling facilities for mercury waste, which recycled the waste in the form of fluorescent lamps and the dry batteries. To deal with the many environmental problems that Japan faces today, we have created a developing recycling technology so as to turn the negative effects of industry on the environment into positive ones. In this case, I would like to introduce on the flow of the recycling processes of fluorescent lamps and dry batteries, our main activity, and the mercury regulations (agreement), through which UNEP works to prevent serious mercury pollution.

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## 2. The Recycling System of Used Fluorescent Lamps

### *2.1 The principles of fluorescent lamp emission*

Heat is generated and the thermion is discharged by transferring electricity into the electrode in the fluorescent lamp. When this occurs, the thermion bumps the mercury atom in the fluorescent lamp and discharges ultraviolet rays. The ultraviolet rays expose the fluorescent substance in the fluorescent lamp's inner wall, and it changes into a visible ray (that people can see). Therefore, this proves that the fluorescent lamp contains a small amount of mercury.

### *2.2 The flow of recycling used fluorescent lamps*

Used fluorescent lamps, which include mercury are crushed by the crusher originally developed, and are separated into the metallic cap part and glass (Fig. 1). The glass washes, rinses, and removes the mercury from the

other substances. The mercury sludge taken out of the water is heated at 600-800 °C to vaporize the mercury in a roasting furnace (named multiple-hearth vertical furnace). The mercury vapor is cooled in the cooling tower (named condensation tower), and collected in the state of the liquid again. The collected crude mercury is sold as high-purity metallic mercury after going through various refinement processes. This mercury is exported to foreign countries and used as raw material for fluorescent lamps and research reagents in universities and laboratories. The glass, which accounts for 90% of the weight of fluorescent lamps, is dried and then commercialized as glass cullet. After that, it is used again by the fluorescent lamp manufacturer as materials for making new fluorescent lamps and as raw material in glass fiber manufacturing. The aluminum of metallic base and other non-glass pares is shipped as raw material.

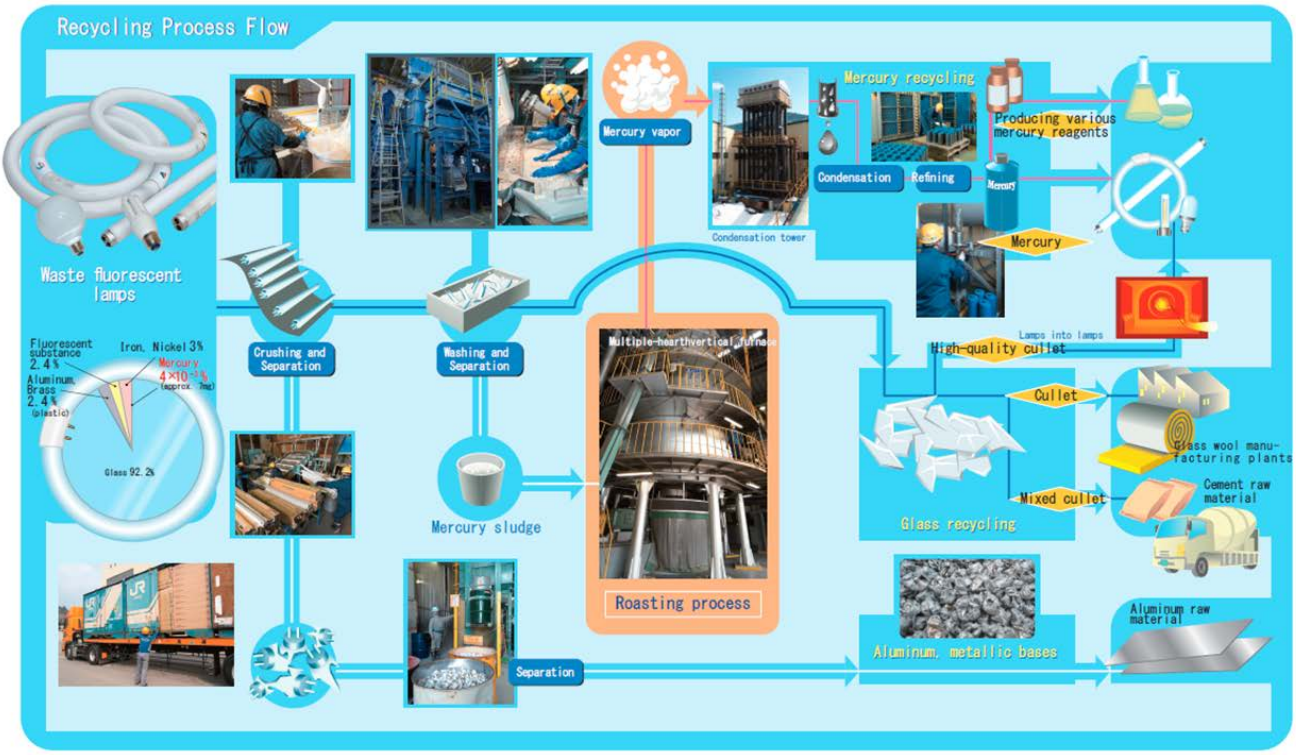


**Fig. 1** Used Fluorescent Lamp Recycling Process Flow

## 3. The Recycling System of Used Dry-cell Batteries

### *3.1 Zero mercury use in dry batteries*

Although dry batteries marketed domestically since 1992 does not contain mercury or have any significant adverse effects on the environment, but dry batteries disposed of today often still contain mercury, disposed of batteries made before 1991, We conducted a factual investigation of used dry cell batteries received in 2007 by randomly selecting 56 segments from received lots at two local governments and then distinguishing by hand with regard to battery, type, country of manufacture, and date of manufacture. From our results we found that 20–25% of the batteries were not mercury-free. We accepted the 14,000 t of used dry cell batteries in 2009. We can find that 3,000–3,500 t were not mercury-free batteries from our investigation figures. Moreover, we have run this survey every year since 2007, and for some organizations the relatively high-mercury dry cell batteries from overseas occupy a little less than 20% of the total.

### *3.2 The flow of recycling used dry batteries*

The used dry-cell batteries are sorted by type after removing non-dry-cell batteries by machine and by hand (Fig. 2). The selected dry-cell batteries are heated at 600–800 $^{o}$C in a large roasting furnace (named rotary furnace) that has an ability to roast 100 t of batteries per day, and the mercury in the dry-cell batteries is vaporized. The mercury vapor is cooled in the cooling tower (named condensation tower), and it is collected in liquid form. The collected crude mercury is sold as high-purity metallic mercury after going through various refinement processes. The furnace adopts the closed system which prevents mercury emission, which reduces dioxin emission and secures safety by capturing mercury in the exhaust. Roasted refuse, after being cooled, is pulverized and sorted into zinc and iron by magnetic separation. Residual zinc is shipped as raw material for soil conditioners and zinc ingots, and the iron scraps are used as raw material in iron works.

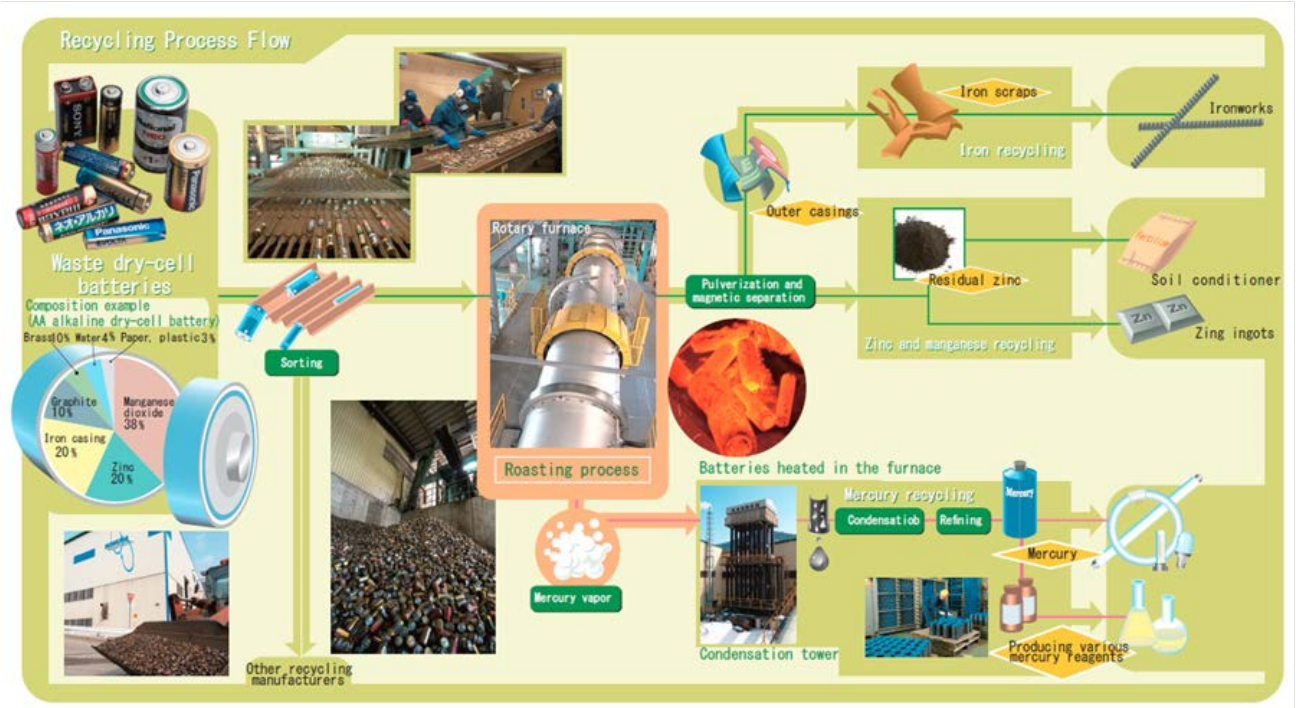


**Fig. 2** Used Dry-cell Battery Recycling Process Flow

## 4. The Trend of the UNEP and our examination of mercury storage

In recent years, mercury demand, and consequently its adverse effects, in Japan has gradually been decreasing, but in developing counties, the problem of mercury pollution has become quite serious. UNEP is expected to sign a legal international treaty to prevent environmental pollution and health damage caused by mercury in Japan in 2013. Five INC (Intergovernmental Negotiating Committee) meetings for the establishment of the treaty are scheduled. Similar meetings have already been held in Stockholm in 2010 and in Makuhari in July 2011. The final INC meeting is scheduled to be held in Kumamoto Japan in 2013. The main points in this treaty are the prohibition of using mercury in small-scale gold mining, the proper handling of mercury, and the prohibition of exporting mercury. Export has already been prohibited in the EU in March, 2011, and it will be prohibited in the United States in January 2013. Exemptions to export bans and proper storage will likely to be discussed until the treaty is established. It is easily conceivable that, if export controls are conducted in the future in Japan, we will be forced to maintain long-term storage of a 50 t surplus of mercury per year at our company alone (2011 records). For that reason, we are trying to develop the methods of storing 1,000 t of metallic mercury for 50 years, but some doubts have arisen regarding whether such storage is appropriate in an earthquake country.

## 5. Conclusion

While many mercury storage methods have been proposed all over the world, the best technologies have not been determined with regard to stability of chemical compounds, manufacturing safety, and cost. On the other hand, realistically it will not be possible to restrict the use of products that cannot be manufactured with mercury substitutes, such as fluorescent lamps, special batteries, industrial measuring instruments, and medical equipment. When we think about necessary to use mercury and present situation of export-import controls, we believe that establishing safe recycling technology is one of the required and effective solutions. At the same time, we intend to proceed with the development of mercury stabilization technology and examine appropriate storage methods.