ZINC IS NATURAL

ZINC AND SUSTAINABLE DEVELOPMENT FACTSHEET

Zinc, like all metals, is a natural component of the earth's crust and an inherent part of our environment. Zinc is present not only in rock and soil, but also in air, water and the biosphere - plants, animals and humans.

Zinc is constantly being transported by nature, a process called *natural cycling*. Rain, snow, ice, sun and wind erode zinc-containing rocks and soil. Wind and water carry minute amounts of zinc to lakes, rivers and the sea, where it collects as sediment or is transported further. Natural phenomena such as:

- volcanic eruptions
- forest fires
- dust storms
- sea spray

all contribute to the continuous cycling of zinc through nature.

During the course of evolution, all living organisms have adapted to the zinc in their environment and used it for specific metabolic processes.

The amount of zinc present in the natural environment varies from place to place and from season to season. For example, the amount of zinc in the earth's crust ranges between 10 and 300 milligrams per kilogram, and zinc in rivers varies from less than 10 micrograms per litre to over 200 micrograms[1]. Similarly, falling leaves in autumn lead to a seasonal increase in zinc levels in soil and water.

Zinc is a natural component of the earth's crust and an inherent part of our environment

[1] *Zinc in the Environment.* Second edition. IZA 1997.

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The Natural Cycling of Zinc

Sea salt and the movement of soil dust particles in the air are the principle sources of natural zinc emissions in the atmosphere. Forest fires and volcanoes also contribute in a minor way to zinc's natural cycling. It is estimated that these natural emissions of zinc amount to 5.9 million metric tonnes each year [2].

Anthropogenic emissions of zinc to the atmosphere - those that result from man's activities (metal production, waste disposal, fossil fuel combustion, etc) - are estimated at 57.000 metric tonnes per year worldwide [3].

[2] M Richardson. *Critical Review of Natural Global and Regional Emissions of Six Trace Metals to the Atmosphere.* Risklogic Scientific Services, Inc. 2001

[3] *An assessment of global and regional emissions of trace metals to the atmosphere from anthropogenic sources worldwide.* J M Pacyna and E G Pacyna. Norwegian Institute for Air Research (NILU) – in publication 2002. See also *Zinc in the Environment - An Introduction.* IZA, 1997.

Zinc is Essential for Man and the Environment

All living organisms need zinc. For this reason, zinc is termed an essential element. Because the amount of zinc present in nature varies widely, living organisms have natural processes that regulate their uptake of zinc. Nevertheless, deficiency occurs when the amount of zinc available is insufficient to meet the needs of a given organism. Toxicity too can occur when an excessive amount of zinc is ingested.

All living organisms have natural processes that regulate their uptake of zinc.

Zinc is essential for human health. Adequate daily intake of zinc is vital for the proper functioning of the immune system, digestion, reproduction, taste and smell and many other natural processes [1]. Analysis of diet and nutritional needs have led researchers to estimate that a large part of the world's population is at risk from zinc deficiency [2].

Zinc is also used in a variety of medical and pharmaceutical forms, such as bandages, cold lozenges, skin treatments, sunblock creams and lotions, burn and wound treatments, baby creams, shampoo, and cosmetics.

For many food crops, zinc is an essential micronutrient [3]. Zinc deficiency in agricultural soils is common on all continents and constitutes a major problem in many parts of the world because it causes serious inefficiencies in crop production. Relatively small amounts of zinc compounds, however, can cure deficiency and last for several years before they need to be repeated. This treatment is highly cost effective when the costs of the zinc application and the value of the extra yield are considered.

Zinc deficiency is now recognized as one of the most important risks to human health. In *The World Health Report 2002* the WHO says that zinc deficiency is one of the leading causes of illness and disease in low-income countries.

In developing countries, zinc deficiency ranks 5th among the leading 10 risk factors. Even on a global scale, taking developed and developing countries together, zinc deficiency ranks 11th out of the 20 leading risk factors. WHO attributes 800,000 deaths worldwide each year to zinc deficiency and over 28 million healthy life years lost . It is estimated that zinc deficiency affects one-third of the world's population, with estimates ranging from 4% to 73% according to region. Worldwide, zinc deficiency is responsible for approximately 16% of lower respiratory tract infections, 18% of malaria and 10% of diarrhoeal disease.

"Severe zinc deficiency causes short stature, impaired immune function and other disorders and is a significant cause of respiratory infections, malaria and diarrhoeal disease", says the Report. WHO points out that zinc deficiency is largely related to inadequate intake or absorption of zinc from the diet and zinc supplementation and fortification both prove to be very cost-effective interventions in all regions of the world[4].

(1) S Cunningham-Rundles. *Zinc and Immune Function.* IZA 1998.
M Penny. *The Role of Zinc in Child Health.* IZA 1999.
(2) K H Brown. Reported in: *Conclusions of the International Conference on Zinc and Human Health – Recent Scientific Advances and Implications for Public Health Programs.* Stockholm, June 12-14, 2000. International Zinc Association, 2000.
(3) B J Alloway. *Zinc – The Vital Micronutrient for Healthy, High-Value Crops.* IZA 2001.
(4) The World Health Report 2002. World Health Organization, Geneva.

"Zinc is indeed an essential micronutrient. Over the last few years, a great deal of work has been carried out in both the industrialized and non-industrialized countries of the world, which shows that zinc deficiency is likely to be a public health problem both in terms of its magnitude and its health consequences. Furthermore, the evidence suggests that zinc deficiency affects the most vulnerable segments of a population - pregnant women and young children, especially in developing countries. For the health consequences, zinc deficiency affects a range of functions, chiefly, reproduction, growth, immunity and brain development."

Dr Bruno de Benoist, Medical Officer, Micronutrients –World Health Organization

"In countries where staple diets are based on unrefined cereals and legumes, and intakes of flesh foods are low, dietary strategies should be developed to improve the content and bioavailability of zinc."

Environmental Health Criteria 221: Zinc. WHO 2001.

The International Rice Research Institute (IRRI) is currently testing a new variety of rice enriched with iron and zinc.

National food balance data indicate that as much as one half of the world's population is at risk of inadequate zinc intake. National surveillance data indicate that 33% of preschool children in low-income countries have stunted growth. While zinc is not the only nutrient associated with poor growth of children, the association between zinc and stunting is strong and frequently observed. Stunted children tend to have higher risk of illness, higher mortality rates, and delayed development.

www.izincg.ucdavis.edu

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Zinc's Major Contribution – Protecting Steel

Zinc brings a multitude of economic and social benefits to society. Man has found a wide range of uses for this versatile natural element, whose properties are valued in many industries.

Galvanizing – the protection of steel against corrosion by metallurgically bonding zinc to steel – is the most important application of zinc, both in terms of volume and economic benefit to society. Corrosion is a significant drain on the economy and is estimated to cost over 4% of GNP each year[1]. Zinc is helping to reduce this loss and new technology is making it possible to improve zinc's performance while at the same time reducing the amount of zinc needed.

By protecting steel, zinc increases the durability and life of public infrastructure

Steel is one of the most widely used materials on the planet and thanks to zinc, steel's durability can be prolonged. Both steel and zinc are 100% recyclable. The zinc-steel combination has significant economic benefits in terms of life-cycle costs. Improved air quality in many industrialised countries, with diminishing levels of SO_2, means that today, zinc coatings provide even longer protection for steel[2].

Other significant benefits from using zinc-coated steel are long service life, low maintenance costs and minimal service interruption. In the case of public infrastructure, these benefits contribute to lower maintenance budgets, thereby freeing up public funds for other priorities, without compromising safety or aesthetics.

Increased attention to whole-life costing is causing designers, specifiers and investors to opt for zinc-coated steel in many traditional and new applications, from construction to automobiles, from electricity distribution poles to safety barriers, from farm gates to ski-lifts.

(1) Battelle Columbus Laboratories (BCL) and the National Bureau of Standards (NBS) estimated in 1975 that the *direct and indirect* costs of corrosion to the US economy was $82 billion, equivalent to 4.9 per cent of GNP that year. BCL updated the study in 1995 and estimated the cost of metallic corrosion at $296 billion, equivalent to 4.2 per cent of GNP. In Japan, the Society of Corrosion Engineering (JSCE) reported the *direct* cost of corrosion to be Yen 2,500 billion in 1975, equivalent to 1.8 per cent of GNP, and in 1997, Yen 3,938 equivalent to 0.77 per cent of GNP. These decreases in the costs of corrosion over a twenty-year period are due to improvements in corrosion-protection technology, more widespread use of zinc coatings and continuing education of scientists, engineers and investors. T Shibata, *Corrosion Management*, March/April 2001, pp.16-20 and www.nace.org/naceframes/Government/eemcus2.htm.

(2) *Zinc in the Environment.* Second edition. IZA, 1997; and *Large falls in atmospheric pollutants mean galvanizing now lasts much longer:* www.hdg.org.uk/

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"No substitute for galvanizing exists for protecting large tonnage iron and steel products from corrosion."

U.S. Congress, Office of Technology Assessment

"From the natural resource management point of view, it is relatively favourable to use zinc compared with most other base metals in society. The use of zinc as corrosion protection permits a considerable saving of both natural resources (iron/steel) and energy."

Landner & Lindeström, Swedish Environmental Research Group, 1998: *Zinc in Society and in the Environment.*

"The atmosphere at Cape Canaveral is documented as one of the most corrosive natural environments in the United States, if not the world... zinc materials have continued to provide complete protection of the steel substrate for over 20 years ...the performance provided by zinc coatings has helped to reduce the maintenance costs on many steel structures at the Cape to an acceptable level ..."

U.S. National Aeronautics and Space Administration (NASA).

Comparison of data obtained from the latest zinc corrosion rate mapping exercise (2001) with results from previous mapping programmes (1982 and 1991) show a clear, and very significant, drop in the corrosion rate for zinc for most atmospheric exposures across the UK and the Republic of Ireland. The Zinc Millennium Map results show that a standard 85µm galvanized coating may now achieve a coating life of 50 years in most environments. Similarly, a thicker 140µm galvanized coating, often produced on structural steel, may achieve a coating life of over 100 years.

Galvanizers Association, United Kingdom. 2001.

"Galvanized steel poles saved Farmers Electric Cooperative in Clovis, New Mexico (USA) more than $50,000 on a recent 225-pole line project. Jeff Hohn, the co-op's engineering manager, says the poles took less time to install than wood, the materials cost less and fewer poles were required because they were strong enough to support longer spans. Hohn's findings are not unique, according to the American Iron and Steel Institute. AISI says that steel poles last 60 to 80 years, have a reduced risk of catastrophic "domino effect" system failure, require less labor to install and maintain, and are lighter, cutting transportation and handling costs and easing remote installations. Labor savings can be significant, since a steel-pole distribution system requires little maintenance and crews need no additional training. And there's minimal need for tightening hardware to compensate for pole shrinkage."

Rural Electric Magazine, April 2002
http://www.steel.org/news/innews/utilitypoles.htm

Zinc and Economic Growth

Zinc is essential to modern society. It is used everywhere. As anti-corrosion coating on steel, for the manufacture of precision components, as a construction material, for the production of brass and rubber, in pharmaceutical and cosmetic products, in fertilisers and food supplements.

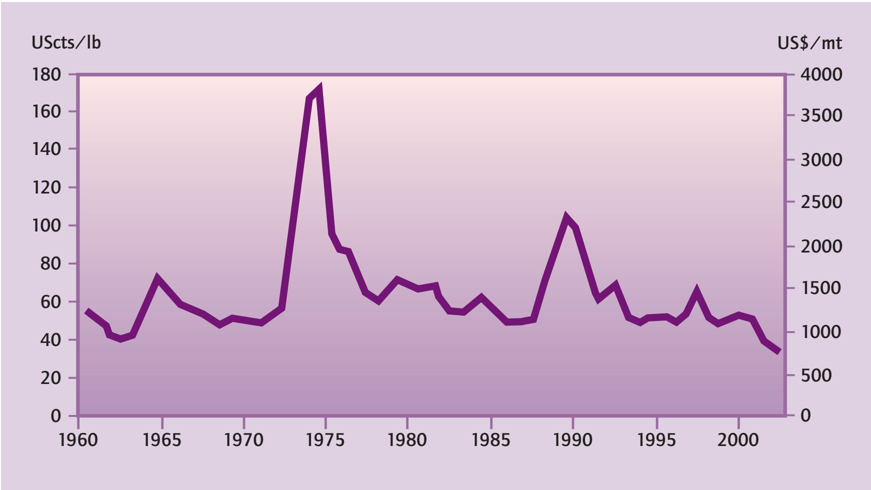
By protecting steel from corrosion, zinc performs an invaluable service. It helps to save natural resources by significantly prolonging the life of steel goods and capital investments, such as homes, cars, bridges, port facilities, power lines and water distribution, telecommunications and transport.

Each year, zinc and zinc-containing products contribute an estimated US$ 40 billion to the global economy (1). The mining, smelting and refining of zinc is alone estimated to contribute US$ 18.5 billion to the world economy each year. This economic importance of zinc is not surprising, given the wide range of industries that depend on its unique properties.

World use of zinc, like that of all metals, is closely tied to fluctuations in the world economy and periods of strong demand alternate with periods of recession. The price of zinc, despite constant fluctuations, has nevertheless remained remarkably stable over the last 100 years.

During the 20th century, use of zinc grew on average by 3% each year. World consumption in 1900 is estimated at 500.000 metric tonnes (mt) and this grew to 11 million mt by 2000, including recycled zinc (2). By comparison, world GDP over the last fifty years grew at 3.4% each year (3).

Zinc Prices 1960 to 2002(4) (in constant 2002 terms)



(1) *The Economic and Environmental Role of Zinc*. International Lead Zinc Study Group, 2000.
(2) IZA-IZLSG
(3) A Maddison. *The World Economy – A Milennial Perspective*. OECD 2001
(4) Outokumpu Economic Research, ILZSG.

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Some traditional uses of zinc ...

Food	*Fertilisers to overcome zinc deficiency in soil and improve crop yields – animal feed supplements to improve health and performance – food supplements for human health.*
Shelter	*Roofing and cladding for industrial, commercial and residential construction, rainwater evacuation, heating, ventilation and air conditioning.*
Safety	*Protecting the durability and integrity of steel infrastructure and steel goods against corrosion – such as highway barriers, guardrails, transmission towers, bridges.*

... and some new uses

Batteries	*For hearing aids, portable computers and mobile phones; to power zero-emission electric vehicles such as buses, postal vans, delivery carts and wheelchairs; to power air-conditioning units on trucks so that engine idling is unnecessary.*
Water Purification Systems	*Zinc is alloyed with other metals for new-generation water purification systems.*
Satellite Shields	*Zinc compounds are used to help shield the outer surface of satellites and space vehicles from extremes of heat and cold.*
Varistors	*Zinc compounds are used in electrical systems for circuit protection against power surges and lightning strikes.*
Undersea Cables	*Zinc cladding is used to protect undersea cables that enable remote operation of deep-water oil wells.*

Zinc and Social Progress

The processing, use and recycling of zinc provides work and income for thousands of families around the world. It is estimated that over 210,000 people are employed in the zinc industry worldwide [1].

Social progress is inextricably linked to improvements in employment, healthcare and education. Zinc's role in human health cannot be overlooked in this regard. Adequate zinc intake is essential for the health, growth and learning capacity of children. For adults, zinc is essential for good health in general, and in particular, for reproduction and the functioning of the immune system.

Zinc has become an integral part of modern society's way of life – the tools and appliances, the infrastructure, vehicles and food production systems that are taken for granted. Some lesser-known applications also illustrate the role of zinc in improving the quality of life:

- Zinc-air battery technology has made possible miniaturised batteries for hearing aids.
- Zinc-based skin creams provide safe and effective protection against the harmful rays of the sun.
- Zinc compounds are indispensable for the production of rubber.
- Zinc and copper combine to form brass. This bacteriostatic alloy helps to diminish the spread of bacteria, for example when used for door handles in public places, and is used also for water purification systems.

Wuehler, Peerson, & Brown, 2000.

[1] *The Economic and Environmental Role of Zinc.* International Lead Zinc Study Group, 2000. (excludes China)

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Over 200,000 people are employed in the zinc industry. Of this number, zinc mining employs approximately 55,000 people and zinc smelting, refining and recycling employs an estimated 65,000 people. Major first-user industries such as continuous galvanizing, general galvanizing and zinc oxide production employ a further 100,000 people.

From: *The Economic and Environmental Role of Zinc.* International Lead Zinc Study Group.

"The eight million tonnes of zinc produced by the Sullivan mine from 1909 to 1999, translates into enough zinc to supply the zinc content of 160,000,000 automobiles. Over the past 91 years of mine operation, the average number of employees has exceeded 1,000 people. With salary plus benefits estimated to average $68,000 per employee, the total contribution from the mine to employees has exceeded $5 billion. Taxes, payments to suppliers and the purchase of local and provincial services, along with smelting and refining of concentrates in Trail, have helped to make up a good part of the mine's $20 billion direct contribution to the local and provincial economies...

Beyond the direct contribution, economists often refer to the indirect effects of a major resource industry. These include the economic contribution in the local retail industry, purchases of services, housing, education, etc. through the region. This would amount to three times the direct contribution, or another $60 billion added to the British Columbia economy from the Sullivan mine over its long and illustrious life...

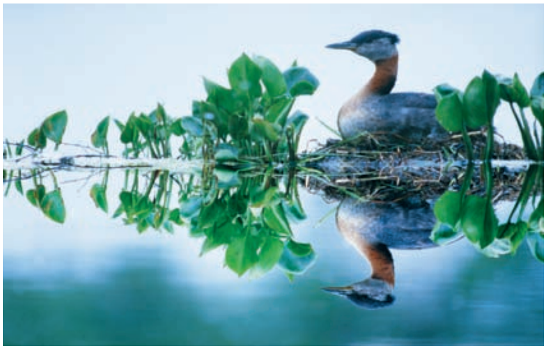
Typical of the Sullivan situation is the fact that numerous employees are fourth-generation employees at the Sullivan mine, and the number of children who have grown up, earned an education and gone on to other occupations either within the region or outside of it are too numerous to mention. Many individuals who got their start in Kimberley have achieved wide recognition, including some through the arts, others through athletics and many as business professionals..."

From an article on the Sullivan zinc mine at Kimberly, British Columbia, Canada
- www.teckcominco.com/enviro/articles/ki-sustainable.html

ZINC AND ENVIRONMENTAL PROTECTION

In contrast to man-made chemicals, zinc is a natural element that plays an essential role in the biological processes of all living organisms, including humans, animals and plants. For this reason, the environmental impact of zinc – and indeed of all essential elements – cannot be assessed in the same manner as man-made chemical compounds. In other words, 'less' is not automatically 'better' and reduction of zinc levels in the environment can be detrimental.

Organisms respond differently to deficiency and excess of essential elements like zinc and naturally regulate their uptake. The distribution and transport of zinc in water, sediment and soil depend on the type of zinc present and the characteristics of the environment. Zinc's *bioavailability* is affected by many factors, such as organism age and size, prior history of exposure, water hardness, pH, dissolved organic carbon and temperature. For these reasons, environmental assessment of zinc has to take these factors into account to be meaningful.



A comprehensive review of the environmental role of zinc was conducted in the framework of the International Programme on Chemical Safety, whose report was published in 2001 [1]. In 1995, the European Union began work on the risk assessment of zinc. This process brought forth a wealth of new scientific information about the role of zinc – and all essential elements – in the environment. In 2001, it was decided that further research was needed on the specific issue of bioavailability, before a clear scientific assessment could be concluded. A research program, funded by producers and users of zinc, was completed in 2003 and will now allow zinc's bioavailability to be predicted in a range of environmental conditions of water, sediment and soil.

Industrial emissions of zinc have been decreasing significantly since the 1970s, largely in response to better controls by industry. For example, estimates of zinc air emissions from zinc production facilities worldwide fell by 43% between 1983 and 1995 [2].

(1) *Environmental Health Criteria 221: Zinc.* WHO, 2001.

(2) *An assessment of global and regional emissions of trace metals to the atmosphere from anthropogenic sources worldwide.* J M Pacyna and E G Pacyna. Norwegian Institute for Air Research (NILU) – in publication 2002.

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"Zinc is an essential element in the environment. The possibility exists both for a deficiency and for an excess of this metal. For this reason it is important that regulatory criteria for zinc, while protecting against toxicity, are not set so low as to drive zinc levels into the deficiency area."

Environmental Health Criteria 221: Zinc. **World Health Organization, Geneva, 2001 www.who.int/pcs/ehc/summaries/ehc_221.htm**

Natural zinc levels in the environment

	Range
Air (rural) (µg/m3)	0.01 - 0.2
Soil (general) (mg/kg dry weight)	10 - 300
Rocks (ppm)	
• basaltic igneous	48 - 240
• granitic igneous	5 - 140
• shales and clays	18 - 180
• sandstones	2 - 41
• black shales	34 - 1500
Ore bodies (%)	5 - > 15
Surface waters (µg/l)	
Habitat-type:	
• Open ocean (surface)	0.001 - 0.06
• Coastal seas/inland seas	0.5 - 1
• Freshwater:	
– Alluvial lowland rivers rich in nutrients and oligo-elements (e.g. European lowland)	5 - 40
– Mountain rivers from old, strongly leached geological formations (e.g. Rocky Mountains)	< 10
– Large lakes (e.g. Great Lakes)	0.09 - 0.3 (dissolved)
– Zinc-enriched streams flowing through mineralization areas	> 200

Zinc in the Environment - An Introduction. International Zinc Association. 1997.

Zinc is a Sustainable Resource

Zinc Reserves

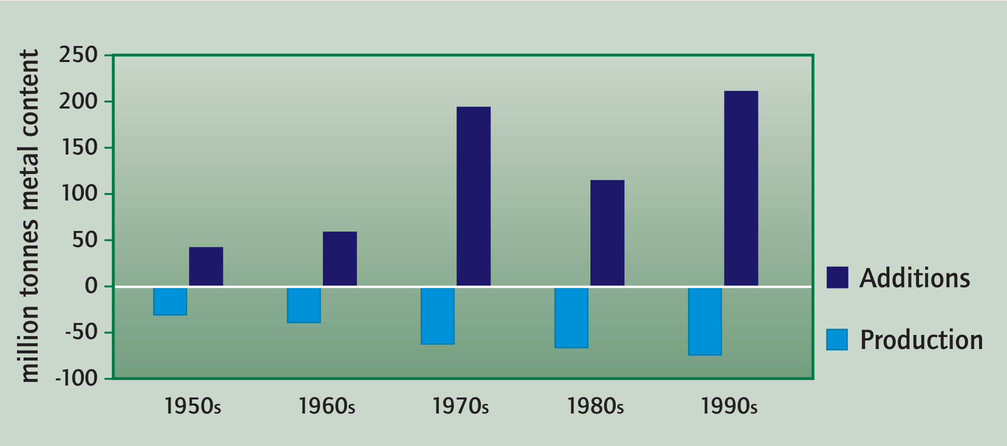
Zinc is the 27th most common element in the earth's crust. More importantly, zinc is fully recyclable. Zinc can be recycled indefinitely - without loss of its physical or chemical properties.

The world is naturally abundant in zinc. Even a cubic mile of seawater is estimated to contain 1 tonne of zinc. It is estimated that the first mile of the earth's crust under land contains 224,000,000 million tonnes of zinc, with a further 15 million tonnes in the seabed[2]. Such estimates, however, take no account of whether or not it is economic, or environmentally acceptable, to exploit these resources.

Reserves[1] of zinc – like those of any natural resource – are not a fixed amount stored in nature. Reserves are determined by geology and the interaction of economics, technology and politics. The term 'reserves' denotes only what has been mapped and measured today and what can be exploited using current technology. This is the reason why zinc reserves have increased significantly since the 1950s, as large new ore bodies have been discovered in many areas of the world. The sustainability of zinc ore supplies cannot therefore be judged simply by extrapolating the combined mine life of today's zinc mines.

Notwithstanding, zinc's true sustainability resides in its ability to meet society's need for sustainable materials – sustainable in terms of contributing to economic growth while protecting the environment and contributing to social progress – both for today and for future generations. Zinc meets this need.

Zinc: Production & Additions to the Reserve Base: 1950 to 2000[3]



[1] The term Reserves denotes the portion of resources that has been mapped and measured and which may be used, now or in the future. Thus, Reserves reflect the state of knowledge, technology and the value of a mineral at a given time. Moreover, Reserves have traditionally referred only to the mineral in the ground, ignoring the ever-increasing amount of zinc that is available from recycling every year.

[2] F Porter. *Zinc Handbook.* 1991

[3] P Crowson. *Use of Non-ferrous metal resources for economic growth.* Workshop on Sustainable Development, Nov30-Dec3, 1999. ILZSG, ICSG, INSG 1999.

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Zinc Recycling

At present, approximately 70% of the zinc produced worldwide originates from mined ores and 30% from recycled or secondary zinc. The level of recycling is increasing each year, in step with progress in the technology of zinc production and zinc recycling. Today, over 80% of the zinc available for recycling is indeed recycled.

Zinc is recycled at all stages of production and use - for example, from scrap that arises during the production of galvanized steel sheet, from scrap generated during manufacturing and installation processes, and from end-of-life products.

The life of zinc-containing products is variable and can range from 10-15 years for cars or household appliances, to over 100 years for zinc sheet used for roofing. Street lighting columns made of zinc-coated steel can remain in service for 40 years or much longer, and transmission towers for over 70 years. All these products tend to be replaced due to obsolescence, not because the zinc has ceased to protect the underlying steel. For example, zinc coated steel poles placed in the Australian outback a hundred years ago are still in excellent condition(3).

The presence of zinc coating on steel does not restrict steel's recyclability and all types of zinc-coated products are recyclable(4). Zinc coated steel is recycled along with other steel scrap during the steel production process - the zinc volatilises and is then recovered.

The supply of zinc-coated steel scrap for recycling is expected to double over the coming five years, as more zinc-coated vehicles enter the recycling stream. By 2005, half of world steel output is expected to come from electric arc furnaces (EAF). As a result, growing quantities of EAF flue dust with higher zinc contents will be treated and more recycled zinc will become available(5).

(3) G Thompson. *A Tribute to Zinc* - Australia's first international telegraph line. IZA. 1997.

(4) M Martin & R Wildt. *Closing the Loop* - An Introduction to Recycling Zinc Coated Steel. IZA 2001.

(5) The Waelz process is the leading technology for treating EAF flue dust and is continuously being optimized for energy input, product and offgas quality. In 1997, the Waelz process was used to treat over 1 million tonnes of EAF dust, representing 77% of world flue dust reprocessing capacity. K Mager et al. *Recovery of Zinc Oxide from Secondary Raw Materials* - New Developments of the Waelz Process. Published in Fourth International Symposium on Recycling of Metals and Engineered Materials. Edited by DL Stewart, RL Stephens and JC Daley, TMS 2000. ISBN 0-87339-494, p.329-344. See also Environmental Goals Based on the Example of the Steel Plant Dust Recycling Business Area - www.bus ag.de/index_e.html

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