About INSG

The International Nickel Study Group (INSG), established in 1990, is an intergovernmental organization whose members are governments of countries having an interest in nickel production, usage and trade. Representatives of nickel mining, smelting-refining, consuming, importing and exporting and recycling companies from both the private and public sectors participate in INSG work and meetings as industry advisers to government delegations.

The main objectives of the Group are:

- Collect and publish detailed statistics on global nickel markets including mining, smelting, refining, consuming, recycling, stocks and prices, with the aim of improving market transparency.
- Publish other information on nickel, such as data on industry facilities and environmental regulations.
- Provide a forum for discussions on nickel issues of interest to nickel producing and using (consuming) countries and their industries, including environmental issues.
- Undertake economic analysis of nickel markets and related topics.
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INSG OFFICERS AND SECRETARIAT

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INSG ACTIVITIES AND PUBLICATIONS

MEETINGS

The International Nickel Study Group meets twice a year usually in April and October. All INSG meetings are private and open only to government and industry representatives from member countries. Non-member countries with significant interests in nickel are occasionally invited to observe INSG meetings in order to encourage them to join. Permanent industry association observers and invited observing organizations may also attend.

PUBLICATIONS:

- World Nickel Statistics Yearbook
- World Nickel Statistics Monthly
- World Directory of Nickel Production Facilities
- Use of Nickel in Batteries 2018
- Nickel Factbook 2018
- World Nickel-based Alloys 2016
- Nickel Production in South East Asia: Trends and Perspectives 2016
- Primary Nickel Usage: New Frontiers in China 2015
- China’s Nickel Mine and Refined Nickel Production 2014
- Nickel – A Surface Technology Material - 2014
- Nickel Ore Market of Southeast Asia 2013
- Nickel Pig Iron Study 2012 (with statistical attachments)
- Joint Report on Mining and Smelting/Refining Waste 2018
- Social Acceptance of Mining 2016
- Study of By-Products of Lead, Zinc, Copper and Nickel and Directory 2015
- Cobalt as a By-Product of Copper and Nickel 2014
- Report on Taxation and Fiscal Incentives 2014
- Report on Risk Factors 2014
- By-Product Metals. Separate reports on for Bismuth, Germanium, Indium, Cobalt, Platinum Group Metals, Scandium, Molybdenum, Rhenium, Selenium, Tellurium and Rare Earth Metals
- Environment, Health and Safety (EHS) Regulations Relating to Nickel 2015
CHAPTER 1 NICKEL BASICS

Properties of Nickel Metal:

Name: NICKEL
Chemical Symbol: Ni
Atomic Number: 28
Atomic Weight: 58.71
Melting Point: 1453 °C
Boiling Point: 2730 °C
Curie Temperature: 253 °C
Density: 8.90 g/cm³ at 25 °C

- Magnetic at room temperature
- Deposited by electroplating
- Catalytic properties
- A lustrous, silvery-white metal
- Discovered in 1751
- Corrosion and oxidation resistance
- Very ductile
- Alloys readily
CHAPTER 2 NICKEL RESOURCES

Nickel occurs in nature principally as oxides, sulphides and silicates. Nickel is the fifth most common element on earth with its highest concentrations found in the core and the lowest in the earth’s crust. Nickel ores are mined in about 33 countries on all continents, and are smelted or refined in about 30 countries. Primary nickel is produced and used in the form of ferro-nickel, nickel oxides, NPI, nickel sulphate and other chemicals, and as more or less pure nickel metal. Nickel is also readily recycled in many of its applications, and large tonnages of secondary or "scrap" nickel are used to supplement newly mined ores.
Estimated World Nickel Ore Reserves

- Mineral reserves are between 90-100 million tons
- Mineral resources are around 200 million tons
- Huge potential for offshore resources
- Annual mining volume is around 2 million tons.

Source: USGS
Nickel Mine Production Countries

Number of Countries Producing Nickel Ore

- More and more countries have started to mine nickel ore
- Active exploration and mining activities recently took place
- Nickel creates jobs and wealth for many countries

INSG statistics show:
INSG statistics show nickel mine production:
- is taking place across the 5 continents
- in Africa is stagnant
- in Asia was mainly from Indonesia and the Philippines
World Nickel Mine Production Trends

- Increased from 2000 to 2013
- Was on a downward trend from 2014 to 2016
- Recovered in the year 2017

INSG statistics show that world nickel mine production:
- Increased from 2000 to 2013
- Was on a downward trend from 2014 to 2016
- Recovered in the year 2017
Aggregated World Nickel Usage 1995-2017

INSG statistics show:

- world nickel usage accumulation since 1995 is 31.898 million tons
- the usage accumulation provides resources for secondary use facilitated by the high recyclability of nickel
CHAPTER 3 NICKEL PRODUCTION

Nickel ores are smelted and refined into primary nickel in 30 countries across the world. Thanks to usage accumulation of nickel-containing materials and the high recyclability of nickel, more and more pure nickel or nickel alloys are being recovered from nickel-containing scraps.

INSG statistics show:
- world nickel mine production peaked in 2013
- world primary nickel and nickel usage continue to increase
- the growth of secondary nickel output
INSG statistics show that world primary nickel production increased sharply over the period of 2009 to 2013.

- Production has been stable since 2013.
World Primary Nickel Production Breakdown by Continent

INSG statistics show:

- World nickel production has moved to the East in line with the increased industrialization of Asia
- Africa is still a resource provider but is less involved in smelting and refining
INSG statistics show:

- output by the top 10 countries accounted for 85% of total world production in 2017. This is 1% higher than in 2016
- Indonesia witnessed a production growth of 86% in 2017, and advanced to become the second largest producing country in 2017 from its 6th ranking in 2016
- The Russian Federation retreated to 4th in the list in 2017 compared to its ranking of 2nd in 2016
CHAPTER 4 NICKEL USAGE

Nickel is used in over 300,000 products for consumers in form of over 3000 alloys.

It is also a high-end material used in construction, automobiles, petrochemicals, fabrication and welding, power and renewable energy, electronics, transportation and water sectors.

Major nickel containing materials include stainless steels, super alloys, low expansion magnetic and shape memory alloys, alloy steels, cast irons and cast alloys, copper alloys, pure nickel & other alloys, plating and electroforming, nickel chemicals.

The stainless steel industry is the biggest user of primary nickel and scrap nickel followed by alloys, special steel, plating, batteries and foundries. It is estimated that in 2017, the stainless steel industry accounted for approximately 75% of all primary nickel usage and also consumed nearly 900,000 tonnes of scrap nickel. The battery industry accounted for 3.7% with the remainder used by the other above-mentioned industries.
World primary nickel usage growth was interrupted in the lead up to global financial crisis.

World primary nickel usage growth has accelerated since 2010 and exceeded 2 million tonnes in both 2016 and 2017.
Asia: Engine for nickel usage growth; Africa: land of hope for future growth
P. R. China accounted for 53% of the total world primary nickel usage in 2017, 1% less than in 2016.
Usage growth is driven by Asia, with P.R. China contributing most of the increase.
America and Europe’s usage is stable.
Africa has the lowest usage growth.
Usage in Oceania currently amounts to only 2700 tonnes per annum.
INSG statistics show that Europe topped per capita nickel usage in 2017.
At 24kg/thousand people, the figure for Africa is 5% of that in Europe.
Primary nickel usage in Africa is very low relative to the size of its population.
Proportional usage varies by region.
Stainless Steel - A Nickel-Intensive Industry

- Around 75% of all primary nickel output was used in the production of stainless steel in 2017
- The continued growth of stainless steel output provides strong support for nickel demand
% Content Range of Nickel in Different Stainless Steel Grades

- 300 Series: 25%
- Duplex: 8%
- 200 Series: 1%
- 400 Series: 5.5%

negligible nickel content
Both 300 series stainless steel and duplex stainless steel production increased but the respective ratio relative to total production remains unchanged due to the growth in output of 200 series influenced by the relatively high cost of nickel.
Production of 300 series stainless steel has continued to increase. In 2015, the volume of increase slowed to half a million tonnes compared to more than 1 million tonnes in previous years. However, this slowdown was reversed in 2016 when production rose by a significant 2.4 million tonnes.
- Production of 200 series stainless steel has grown steadily and totalled 9.3 million tonnes in 2016.
- The rate of increase over the period 2011-2016 was 72.6% compared to 40.5% in the case of the 300 series.
Production of duplex stainless steel rose above 400 thousand tonnes in 2014 and remained in excess of this level in 2015. However, in 2016 production retreated to 370 thousand tonnes.
Nickel in Batteries

Nickel used in the battery sector is growing rapidly. Nickel is used in various types of battery including Nickel-cadmium, Nickel-metal-hydride, Nickel-iron, Nickel-zinc, Nickel-hydrogen and Lithium-ion batteries which are named for their active material but often contain nickel material in their cathodes. Nickel is currently the most widely-used metal after lead for off-grid energy storage batteries. With a high recyclability, the use of nickel in batteries is expected to continue to grow.
Nickel Plating and Coating

Nickel is used as a premium material for plating and coating on base metal materials to improve resistance to corrosion and wear, and enhance the property of hardness, superior strength and ductility. Different nickel plating processes also provide decorative effects for base metal materials with semi-bright and full-bright to matte, pearl, and satin finishes. Nickel can be plated on materials through electroplating or electroless plating independently and combined with other materials such as chromium, cadmium, tin, boron and palladium. Based on the finished effect, nickel plating can be categorized as bright nickel plating, black nickel plating or satin nickel plating.
Nickel in Nickel-Based Corrosion and High Temperature Alloys

High-temperature and super nickel alloys provide superior corrosion, heat resistance and strength for applications in extreme and critical circumstances as required in industries such as petrochemicals, aerospace, military, power and energy, etc.
CHAPTER 5: NICKEL MARKET AND TRADE

Nickel is a globally traded commodity. INSG collects, analyzes, and monitors the trade data of nickel ores and concentrates, matte, nickel oxide sinter and other intermediate products of nickel metallurgy, ferro-nickel, unwrought nickel, nickel powder and flakes, nickel chemicals as well as nickel and stainless steel scrap.

INSG monitors stock data in terms of nickel contained in primary nickel products held by nickel producers, users and commodity exchanges such as the LME and SHFE, traders and in government stockpiles.
Trade of Refined Nickel (Class I)

- Export volumes of refined nickel picked up in 2011 and were on a stable growth trend until 2015.
- Volumes turned downwards over the period 2015 to 2017 primarily due to increased usage in domestic markets.
Trade of Refined Nickel (Class I)

- INSG statistics show that import demand bottomed at the end of the financial crisis and moved upwards from 2010.
- After peaking at over 1 million tonnes in 2015, import volumes shrank in 2016 and 2017 due to tight market supply and increased prices.
The export origin up to the year 2010 shows that refinery capacity was located where nickel ore was mined, namely the Russian Federation, Canada, Australia and Norway.
Export Origin Comparison 2015 and 2017

- INSG statistics show that nickel warehouse host countries and trade hubs have recently emerged as major exporters
- Both Finland and Norway were among the top 5 Class I exporters in 2017
INSG statistics indicate that prior to 2010 imports were driven by industrial demand.

The US, Europe, China and Japan were the major destinations for refined nickel.
INSG statistics for 2015 show that warehouse host countries have become more involved in refined nickel imports.

In 2017, with the exception of the Netherlands, the top four importers were also major users of nickel.
Indonesia has been responsible for nearly 100% of the growth in exports since 2015 and has become the single largest exporter of charge nickel. Indonesia’s exports accounted for 39% and 63% of the total charge nickel exports in 2016 and 2017 respectively.
China is now the most important destination for charge nickel. China’s imports have been in excess of 50% of the world total since 2015 after a number of years of continuous growth.

China’s dominance is due to the wide use of NPI in the country’s stainless steel production.
World Nickel Exports

- Exports of refined nickel (class I) have grown steadily and surpassed 1 million in 2015 followed by consecutive falls in 2016 and 2017.
- Exports of charge nickel (class II) exceeded 1.5 million tonnes in 2017.
- The aggregated export volume of class I and class II nickel was above 2.24 million tonnes in 2017.
World Nickel Imports

- Imports of refined nickel (class I) topped 1.15 million tonnes in 2015 followed by consecutive falls in 2016 and 2017.
- Imports of charge nickel (class II) maintained their growth momentum and totalled over 2.43 million tonnes in 2017.
- The aggregated import volume of class I and class II nickel surpassed 3.33 million tonnes in 2017.
Since 2012, nearly all of the growth in charge nickel imports has been due to China.

Indonesia´s influence in the world charge nickel export market started in 2015.
Nickel Prices and Stocks

- The nickel price fell to its lowest level since 2006 in 2016 after reaching a peak in 2007.
- The nickel price stabilized and started to increase again in 2017.
Nickel prices and stocks

- Nickel stocks have accumulated in recent years and currently hang over the market.
- There was some reduction in inventories in 2016 and 2017 influenced by the recovery in the nickel price.
Nickel is an essential material for our daily life and a critical industry which has a potential impact on the environment and the health of people in the form of either nickel compounds or physical metal. Exposure to nickel can come from the processes of mining, smelting, refining, industrial utilization such as plating and alloy forming and the use of nickel-containing products and recycling.

The nickel industry and stakeholders are well advanced in addressing potential EHS issues in collaboration with regulators and academia by complying with existing regulations and developing even stricter standards compared with those set by regulators and academia.
Nickel: General Consideration for Metals

Metals are naturally present in the earth’s crust, which sets them apart from other materials such as organic chemicals. Because they are naturally occurring, metal risk assessment needs to consider the natural occurrence of metals in water, soil, and air, and to recognize that these concentrations will vary depending on the underlying regional geology and local conditions. Metals do have other characteristics that need to be taken into account, including their essentiality for humans and/or for plants. This means that a too high dose can be toxic, but a too low dose can also cause adverse effects, as the organisms need these essential metals to survive. Metals are also persistent and, as such, they are not consumed but merely used. Thanks to their persistent nature, metals can be recycled over and over again without loss of quality or properties, which again differentiates them from organic chemicals and other materials.

For regulatory purposes, metals are part of chemicals management systems around the world, such as EU and Korea REACH and US TSCA. As most of the approaches for international chemicals regulation were developed with organic chemicals in mind, they are not directly applicable to inorganic metal compounds. To this end, specific environmental and human health risk assessment guidelines have been developed with active involvement of the international metals industry and academia. These guidelines, HERAG (Health Risk Assessment Guidance for Metals) and MERAG (Metals Environmental Risk Assessment Guidance) have been recognized by the OECD and can also be found on the website of other regional organizations such as APEC. They provide guidance for regulators to assess risks associated with exposures to metals and metal compounds, taking into account the latest scientific developments in the area. These guidelines are very important when assessing nickel or nickel compounds because they ensure that the hazards and risks of metals are correctly understood, and that risk management measures, where necessary, are proportionate and do not lead to over or under protection.
Nickel and Workplace Exposure

Occupational exposure limit is an upper limit on the acceptable concentration of a hazardous substance in workplace air for a particular material or class of materials. It is typically set by competent national authorities and enforced by legislation to protect occupational safety and health. It is an important tool in risk assessment and in the management of activities involving handling of dangerous substances.

In general, workers are exposed to nickel and nickel compounds via inhalation and there are regulations as well as company policies in place to ensure that the workers are appropriately protected. HERAG guidelines provide insights to ensure that risks are properly assessed.

Nickel compounds are classified as human carcinogens since inhalation exposure to mixtures of nickel compounds encountered during the refining and processing of sulfidic nickel ores has been associated with increased risks of respiratory carcinogenicity and toxicity. Only the inhalation route and only the respiratory tract are of concern for carcinogenicity. Contrary to nickel compounds, nickel metal is not classified as a human carcinogen. There is general acceptance that nickel compounds are considered as carcinogens with a practical threshold, meaning that cancer risks only occur once the exposure level exceeds that threshold limit. Taking this into account, the Nickel Institute, representing the industry, recommends an exposure limit of 0.05 mg Ni/m³ (inhalable aerosol fraction) at the workplace, which is below the practical threshold for carcinogenicity and/or toxicity and therefore protective of the workers’ health.
Nickel and Environmental Exposure

Nickel is present in the environment from a range of natural and anthropogenic sources. Anthropogenic sources include those associated with the extraction, production, shipping, and use of nickel in downstream industries. Of equal importance are sources that are not associated with the direct use of nickel, including combustion of fossil fuels, the use of mineral fertilizers and biosolids on agricultural land, and effluents from municipal wastewater treatment plants. The combination of sources can result in nickel concentrations in the environment that cause adverse effects to ecosystems. As for most chemical substances, the regulatory approach for minimizing these situations is to set environmental quality standards. As long as environmental concentrations for a given substance like nickel are maintained below these concentrations, no effects to the environment should occur. The most common environmental quality standards focus on the water compartment. Other standards exist to identify appropriate clean-up goals for soil and sediments in contaminated sites that are undergoing remediation.

Many jurisdictions have also derived standards that set limits on nickel within ambient air. These limits are established to protect human health, and are most relevant for urban areas where smog occurs.
Nickel and Consumer Exposure

Nickel and nickel compounds are widely used in a variety of different applications, both in the home and the wider society. However, direct exposure to the public is relatively low.

Around 12-15% of women and 1-2% of men are known to be allergic to nickel. Nickel allergic contact dermatitis (NACD) is a rash or eczema on the skin of allergic people that manifests after direct and prolonged skin contact with a nickel-releasing item. It is not a life-threatening allergy though it can cause discomfort, itching, and a rash. The European Union has had a regulation in place since 1994, which restricts the release of nickel from items such as some types of jewellery, items worn in piercings or clothing fasteners, etc., as they may cause NACD in nickel-allergic people.

References


Data, information and pictures contained in this Factbook have been sourced from public channels such as the IMF, OECD and World Bank. Special thanks are extended to International Nickel Institute for their professional contribution to editing work, particularly on the EHS section. Special thanks are also given to the International Stainless Steel Forum for their contribution regarding world stainless steel production data. This Factbook serves as reference book for INSG’s member countries and the wider public to have a better understanding of nickel and its role as a critical material for peoples’ daily life. INSG, as an intergovernmental organization, welcomes the use of the information contained in the factbook with clear reference to INSG. As a not-for-profit organization, INSG bears no responsibility regarding the use of information contained in the Factbook.