SNAP CODE: **030309**

SOURCE ACTIVITY TITLE: **PROCESSES WITH CONTACT**
Secondary Copper Production

NOSE CODE: **104.12.10**

NFR CODE: **1 A 2 b**

1 ACTIVITIES INCLUDED

This chapter includes information on atmospheric emissions during the production of copper in secondary copper smelters. Secondary copper smelters produce about 40 % of the total copper production in the world (e.g. Pacyna, 1989). Pyrometallurgical processes are used to rework scrap and other secondary materials. As with primary copper production, final refining, where practised, is electrolytic. This chapter describes the methods to estimate emissions of atmospheric pollutants during the secondary copper recovery (e.g. Parker, 1978; UN ECE, 1994).

2 CONTRIBUTIONS TO TOTAL EMISSIONS

There are several trace elements which can be emitted during the secondary copper production. However, these emissions are not very significant on a global scale. Nriagu and Pacyna (1988) concluded that the secondary copper production contributes well below 1 % of the total atmospheric emissions of copper, lead, antimony, selenium, and zinc. Similar contribution of atmospheric emissions during the secondary copper production was estimated for the European emissions in the beginning of the 1980's (Pacyna, 1983). However, a secondary copper smelter or refinery can be an important emission source of trace element contamination on a local scale.

The contribution of emissions released from secondary copper production to total emissions in countries of the CORINAIR90 inventory is given as follows:

Table 1: Contribution to total emissions of the CORINAIR90 inventory (*28 countries*)

Source-activity	**SNAP-code**	**Contribution to total emissions [%]**							
		SO_2	NO_x	NMVOC	CH_4	CO	CO_2	N_2O	NH_3
Secondary Copper Production	030309	0	-	0	-	0	-	-	-

0 = emissions are reported, but the exact value is below the rounding limit (0.1 per cent)
- = no emissions are reported

3 GENERAL

3.1 Description

A secondary copper smelter is defined as any plant or factory in which copper-bearing scrap or copper-bearing materials, other than copper-bearing concentrates (ores) derived from a mining operation, is processed by metallurgical or chemical process into refined copper and copper powder (a premium product).

The recycling of copper is the most comprehensive among the non-ferrous metals. The copper metal scrap can be in the form of:

- copper scrap, such as fabrication rejects, wire scrap, plumbing scrap, apparatus, electrical systems, products from cable processing,
- alloy scrap, such as brass, gunmetal, bronze, in the form of radiators, fittings, machine parts, turnings, shreddar metals, and
- copper-iron scrap like electric motors or parts thereof, plated scrap, circuit elements and switchboard units, telephone scrap, transformers, and shreddar materials.

Another large group of copper-containing materials is composed of oxidised materials, including drosses, ashes, slags, scales, ball mill fines, catalysts as well as materials resulting from pollution control systems.

The copper content of scrap varies from 10 to nearly 100% (UN ECE, 1994). The associated metals which have to be removed are mainly zinc, lead, tin, iron, nickel and aluminium as well as certain amounts of precious metals.

Depending on their chemical composition, the raw materials of a secondary copper smelter are processed in different types of furnaces, including:

- blast furnaces (up to 30% of Cu in the average charge),
- converters (about 75% Cu), and
- anode furnaces (about 95% Cu).

The blast furnace metal (“black copper”) is treated in a converter, the converter metal is refined in an anode furnace. In each step additional raw material with corresponding copper content is added.

In the blast furnace , a mixture of raw materials, iron scrap, limestone and sand as well as coke is charged at the top. Air which can be enriched with oxygen is blown through the tuyeres, the coke is burnt and the charge materials are smelted under reducing conditions. Black copper and slag are discharged from tapholes.

The converters used in primary copper smelting, working on mattes containing iron sulfide, generate surplus heat and additions of scrap copper are often used to control temperature. The converter provides a convenient and cheap form of scrap treatment, but often with only moderately efficient gas cleaning. Alternatively, hydrometallurgical treatment of scrap, using ammonia leaching, yields to solutions which can be reduced by hydrogen to obtain copper powder (e.g. Barbour et al., 1978). Alternatively, these solutions can be treated by solvent extraction to produce feed to a copper-winning cell.

Converter copper is charged together with copper raw materials in anode furnace operation. For smelting the charge, oil or coal dust is used , mainly in reverberatory furnaces. After smelting, air is blown on the bath to oxidise the remaining impurities.

Leaded brasses, containing as much as 3% of lead, are widely used in various applications and recycling of their scrap waste is an important activity. Such scrap contains usually much swarf and turnings coated with lubricant and cutting oils. Copper-containing cables and motors contain plastic or rubber insulants, varnishes, and lacquers. In such cases, scrap needs pre-treatment to remove these non-metallics. The smaller sizes of scrap can be pre-treated termally in a rotary kiln provided with an after-burner to consume smoke and oil vapors (so-called Intal process). There are also various techniques available to remove rubber and plastic insulations of cables (e.g. Barbour et al., 1978; UN ECE, 1994).

Atmospheric emissions of various pollutants are generated during all three types of processes employed in the secondary copper industry.

3.2 Definitions

Secondary copper production: - production of copper from materials other than ores.

3.3 Controls

Controls in secondary copper production should include effective dust collecting arrangements for dust from both primary exhaust gases and fugitive dust emissions. Fabric filters can be used reducing the dust emissions to below 10 mg/ m^3 (UN ECE, 1994).

4 SIMPLER METHODOLOGY

Application of general emission factors with appropriate activity statistics can be regarded as a simpler methodology for estimation of emissions from secondary copper production. However, it should be noted that the chemical composition of input scrap is one of the most important factors affecting the amount of emissions. The chemical composition of input scrap varies considerably from one plant to another and so do emission factors.

5 DETAILED METHODOLOGY

In this case, different emission factors for various production technologies should be used. An account of the effect of emission controls should be considered. The different emission factors will have to be evaluated through measurements at representative sites.

6 RELEVANT ACTIVITY STATISTICS

Information on the production of copper in secondary smelters is available from the UN statistical yearbooks. This information is satisfactory to estimate emissions with the use of the simpler estimation methodology. However, in most cases, no information is available from the statistical yearbooks on the quantities of the metal produced by various types of industrial technologies employed in the secondary copper industry. Therefore, the application of detailed estimation methodology may be complicated unless the statistical data are availbale directly from a given smelter.

7 POINT SOURCE CRITERIA

Secondary copper smelters should be regarded as point sources if plant specific data are available.

8 EMISSION FACTORS, QUALITY CODES AND REFERENCES

Table 2 contains fuel related emission factors for secondary copper production based on CORINAIR90 data [g/GJ]. Technique related emission factors, mostly given in other units (e.g. g/Mg product, g/m^3), are listed in footnotes. In the case of using production statistics the specific energy consumption (e.g. GJ/Mg product) has to be taken into account, which is process and country specific. Within CORINAIR90 a range for the specific energy consumption of 38.5 up to 100 GJ/Mg product has been reported.

Table 2: Emission factors for secondary copper production[7]

				Emission factors						
		Type of fuel	NAPFUE code	SO_2[2] [g/GJ]	NO_x[3] [g/GJ]	NMVOC[4] [g/GJ]	CH_4 [g/GJ]	CO [g/GJ]	CO_2 [kg/GJ]	N_2O [g/GJ]
l	oil	residual	203	495-1,470[1]	150[1]	30[1]	30[1]	15[1]	76-78[1]	2[2]
l	oil	gas	204	94-1,410[1]	100[1]	1.5[1]	1.5[1]	12[1]	73-74[1]	2[1]
g	gas	natural	301	0.28[1]	100[1]	4[1]	4[1]	13[1]	57[1], 60[5], 59[6]	1[1]
g	gas	liquified petroleum gas	303	0.04[1]	100[1]	2.1[1]	0.9[1]	13[1]	65[1]	1[1]

[1] CORINAIR90 data, point sources

[2] SO_x: (EPA, 1990)	750	g/Mg charged	Scrap dryer (rotary)
	6,400	g/Mg charged	Wire burning, incinerator
	250	g/Mg charged	Crucible and pot furnace, charged with brass and bronze
	15	g/Mg charged	Electric arc furnace, charged with brass and bronze
	15	g/Mg charged	Electric induction furnace, charged with brass and bronze
	2,182	g/Mg product	Refining
	17,209 · S	g/m³ fuel	Secondary metal production, process heaters NAPFUE 204, S = sulphur content of fuel
	19,006 · S	g/m³ fuel	Secondary metal production, process heaters NAPFUE 203, S = sulphur content of fuel
[3] NO_x: (EPA, 1990)	850	g/Mg charged	Wire burning, incinerator
	40	g/Mg charged	Reverberatory furnace, charged with brass and bronze
	300	g/mg charged	Rotary furnace, charged with brass and bronze
	2,397	g/m³ fuel	Secondary metal production, process heaters, NAPFUE 204
	6,591	g/m³ fuel	Secondary metal production, process heaters, NAPFUE 203
[4] VOC: (EPA, 1990)	2	g/Mg charged	Scrap dryer (rotary)
	300	g/Mg charged	Wire burning, incinerator
	60	g/Mg charged	Sweating furnace
	223,500	g/Mg coke free charge	Cupola, charged with insulated copper or brass and scrap copper
	90	g/Mg charged	Cupola, charged with scrap copper or brass and scrap copper
	2,600	g/Mg charged	Reverberatory furnace, charged with copper / charged with brass and bronze
	1,200	g/Mg charged	Rotary furnace, charged with brass and bronze
	3,350	g/Mg charged	Crucible and pot furnace, charged with brass and bronze
	1,950	g/Mg charged	Electric arc furnace, charged with copper
	0	g/Mg charged	Electric arc furnace, charged with brass and bronze
	0	g/Mg charged	Electric induction furnace, charged with copper or brass and bronze
	24	g/m³ fuel	Secondary metal production, process heaters, NAPFUE 204
	34	g/m³ fuel	Secondary metal production, process heaters, NAPFUE 203
	44,851	g/Mm³ fuel	Secondary metal production, process heaters, NAPFUE 301

[5] CO_2: Locally contaminated scrap input, brass production (Bremmer, 1995)

[6] CO_2: Strongly contaminated scrap input, brass production (Bremmer, 1995)

[7] It is assumed, that emission factors cited within the table are related to combustion sources in secondary copper production. Footnotes may contain emission factors for total emissions (fuel and process related).

A list of emission factors for several trace elements emitted from secondary copper smelters is presented in Table 3. Results of measurements and estimates carried out in various countries are presented. However, in some cases the factors originate from the same sources.

Information available from the above mentioned measurements and estimates does not allow for further differentiation of emission factors with respect to neither various industrial processes involved in the secondary copper production or different production technologies used at present. Therefore, the factors in Table 3 can only be used in a simpler emission estimation methodology.

Table 3: Compilation of emission factors for secondary copper production (in g/tonne Cu produced)

Element	Estimates by Pacyna (1986)	Estimates in Canada (Jacques, 1987)	PARCOM program (PARCOM, 1992)	Estimates in the U.K. (Leech, 1993)	Estimates in Austria (Schneider, 1994)	Suggested
Arsenic					2	2
Antimony	3					3
Cadmium	4		5	5	2	2-4
Copper	150	200-400			20	20-150
Lead	50-200	230	130	130	50	50-130
Nickel		1				1
Zinc	500-1600		500	500	250	250-500
Control	ESP, ca. 99% efficiency	Based on question-naires. Most plants use ESPs with 99% efficiency	Unspecified	Based on emission factors by Pacyna and PARCOM	Unspecified	Common ESPs with 99% efficiency

9 SPECIES PROFILES

At present no reliable information exist on physical and chemical species of trace elements emitted during the secondary copper production. It can be assumed that the majority of trace elements volatilized from scrap and other copper-containing materials enter the atmosphere on fine particles.

10 UNCERTAINTY ESTIMATES

It is difficult to assess current uncertainties of emission estimates for pollutants emitted during the secondary copper production. Recently it was concluded that up to 50 % of uncertainties can be assigned for the emission estimates of most of the trace elements emitted from major point sources in Europe (Pacyna, 1994). Even bigger uncertainty can be assigned for emission estimates of these compounds from the secondary copper production. Information on emission factors and statistics is more limited for the secondary copper smelters than for major point sources, such as primary smelters and power plants.

11 WEAKEST ASPECTS/PRIORITY AREAS FOR IMPROVEMENT IN CURRENT METHODOLOGY

Improvement of emission factors is necessary in order to obtain more accurate emission estimates for the secondary copper production. This improvement should focus on preparing individual emission factors for major industrial technologies currently employed in the copper industry. In this way, a detailed methodology for emission estimates can be applied. Obviously, it will be necessary to obtain relevant statistical data on the production of copper in various secondary copper furnaces.

12 SPATIAL DISAGGREGATION CRITERIA FOR AREA SOURCES

Not applicable.

13 TEMPORAL DISAGGREGATION CRITERIA

The secondary copper production is a continuous process. No temporal disaggregation is needed.

14 ADDITIONAL COMMENTS

15 SUPPLEMENTARY DOCUMENTS

The following supplementary document can be suggested:
UN ECE State-of-the-Art Report on the Heavy Metals Emissions, the UN ECE Task Force on Heavy Metals Emissions, Prague, the Czech Republic, June 1994.

16 VERIFICATION PROCEDURES

At present no specific verification procedures are available for estimation of atmospheric emissions from the secondary copper production. Estimated emission factors could be best verified by measurements at plants using different industrial technologies.

17 REFERENCES

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18 BIBLIOGRAPHY

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