

RAUTOMEAD UPWARDS VERTICAL CASTING MACHINES

COPPER CATHODE FEEDSTOCK

Introduction

Rautomead upwards vertical casting machines have been designed to accept copper cathode as the feedstock in production of oxygen-free copper rod and certain copper alloys. In all but the smallest models, the cathode sheets are fed (without pre-cutting) into the machine and are melted and cast in a single furnace.

Where a manually operated cathode feed is specified, the cathodes must be stacked vertically adjacent to the machine and from that position they are lifted by pneumatically-operated gripper jaws suspended from an electric hoist, advanced and lowered into the furnace crucible under the control of the operator.

Where an automatic cathode feed system is specified, the pallets of horizontally stacked cathodes are loaded into a cathode stacking bin on the floor at rear of the operating platform from where they are fed automatically to the casting machine without manual attention.

Quality

The Rautomead process is metallurgically a very clean system and is designed to remove residual oxygen from the copper. On the other hand, the process is not a refining one. Thus, it is important that the specification of the cathode used is carefully considered, having regard to the properties required in the cast rod.

Grade A Cathode

It is **strongly recommended** that only cathode conforming to the London Metal Exchange (LME) 'Grade A' **electrolytically refined** specification is used. This material specification conforms to British Standard BS EN 1978:1998. The cathode grade designation is Cu-CATH-1. See chemical composition Appendix I. The equivalent American standard is ASTM B 115-72.

Units of Quantity

Cu-CATH-1 is available in lots of 25 tonnes. Individual bundles are of not more than 4 tonnes.

COPPER CATHODE FEEDSTOCK (cont'd)

Cathode Sizes and Weights

Cathode sheets vary in dimensions and weight. Most cathodes are nominally 1.0 metres square, though this can range from 0.9 metres up to 1.2 metres. Cathodes larger than 1.1 metres in either dimension are not recommended for use with the automatic cathode feed system. Cathode weight varies from approx. 50 kgs up to approx. 160 kgs, cathodes within this weight range may be used with either cathode feed system.

Electrolytically Refined versus Electro-won (SXEW) Cathode

Care must be taken to specify electrolytically refined cathode. Electrolytically refined cathodes may be either ISA Process type or "full deposit" type.

ISA Process

Copper Refineries Pty Ltd, a subsidiary of MIM Holdings Ltd of Queensland, Australia developed the ISA Process, of plating copper on to a stainless steel sheet as an improved cathode production process.

The ISA Process is used in both electrorefining and solvent extraction (SX Electrowon) cathode manufacture.

Though it is still grouped under the generic term 'Grade A', the electro-refined ISA process produces a particularly pure type of copper cathode - see examples of chemical compositions compared with Standard (copy follows).

The individual copper cathode sheets are thinner and lighter (typically approx. 60 kgs) than traditional "full deposit" cathode. They have no suspension lugs and are relatively smooth surfaced.

Brands

A listing of cathode brands and cathode type (ER or EW) follows. This includes the ISA Process brands (see above). It should be noted that not all Grade A cathode brands are ISA process electro-refined cathodes.

Availability

The LME maintains warehouse stocks throughout the world. Rautomead can assist with introductions to cathode brokers and suppliers around the world.

COPPER CATHODE FEEDSTOCK (cont'd)

Recommendations

1. Rautomead strongly recommends the use of electro-refined Grade A cathode produced by the ISA Process in all applications. This recommendation is made on the basis of:

chemical composition	simpler automatic handling
reputation	consistency
smooth unoxidised surface	free of suspension lugs with their attendant problems of trapped electrolyte
convenient size	
lower trapped impurities	

2. Other types of electro-refined Grade A cathode are also suitable, but care must be taken to ensure that metallic contaminants or heavy oxidation are not present on the surface and that moisture is not trapped either in surface “bubbles” or in the suspension lugs.
3. Careful attention should be paid to levels of impurities in different brands of Grade A cathode. Conformity with the standard specification does not represent an adequate guarantee of success in drawing to fine wire. The presence of bismuth, tellurium, selenium or sulphur, even in small amounts is detrimental to performance.
4. The automatic cathode feed system is suitable for use with either ISA process or full deposit electro-refined cathodes :

Maximum cathode size : 1100 x 1100mm square

Maximum cathode weight : 160 kgs

Typical cathode weight : 45 – 100 kgs

Cathode surface to be dry, clean, bright, flat, unoxidised and free from electrolyte nodules. Lugs (electro-refined) must be removed from cathodes prior to stacking bin.

5. **Gas Inclusions**

Gas inclusions in certain brands of copper cathode can cause explosions when the copper is melted and can be a serious **THREAT TO LIFE**.

Explosions caused by gas expansion within the melt will progressively weaken the graphite crucible and will cause premature structural failure.

COPPER CATHODE FEEDSTOCK (cont'd)

Recommendations (cont'd)

6. **Moisture**

In all cases, greatest care and attention must be given to avoid moisture being introduced to the furnace with the cathodes. Moisture risks causing hydrogen gas porosity in the cast rod, represents an explosion hazard and can be a serious THREAT TO LIFE. "Bumps" and "pops" occurring as small explosions within the melt will progressively weaken the graphite crucible and will cause premature structural failure.

Surface moisture can be caused by cathodes being transported or stored in the open, or by condensation on the surface of the sheets. Cathodes should be protected in transport and stored under cover. Storage for 5-7 days in proximity to the casting machine is normally sufficient to avoid surface condensation. Operators should be alert to the possibility of finding condensation within a pack of tightly packed cathode sheets.

Internal moisture can be caused by trapped electrolyte under the surface of the copper and around the suspension lugs of full deposit cathode sheets. Brands with trapped electrolyte should not be used.

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Cu-CATH-1 Chemical Composition

Element	Symbol	Specification	ISA Brands (typical)		Typical Rautomead Rod – Customer A	Typical Rautomead Rod – Customer B
			Grade A ppm	JB ppm		
Bismuth	Bi	<2.0	<0.8	<0.2	0.24	0.04
Selenium	Se	<2.0	<0.3	<0.3	---	1.5
Tellurium	Ti	<2.0	<1.0	<0.2	0.05	<0.3
group		<3.0	<2.1	<0.6		
Arsenic	As	<5.0	0.8	0.1	0.86	<0.2
Cadmium	Cd		0.1	<0.1	0.05	<0.1
Chromium	Cr		<0.5	<0.1	0.01	<1
Manganese	Mn		0.4	<0.1	0.005	<1
Phosphorous	P		<0.3	<0.1	0.04	<2
Antimony	Sb	<4.0	<1.0	<0.1	---	<0.5
group		<15.0	<3.0	<0.5		
Lead	Pb	<5.0	2.0	<0.1	0.28	0.5
Sulphur	S	<15.0	6.9	<4.0	8.0	5.9
Cobalt	Co		<0.5	<0.1	0.01	<2
Iron	Fe	<10.0	2.0	<0.7	0.7	1.5
Nickel	Ni		1.3	<0.1	0.19	0.4
Silicon	Si		0.6		0.62	
Tin	Sn		<0.3	<0.1	0.01	0.2
Zinc	Zn		<1.5	<0.1	0.09	0.2
group		<20.0	<6.0	<1.0		
Silver	Ag	<25.0	12.0	<5.0	9.3	7.4
Oxygen	O				1.8	<2
Carbon	C				<0.4	
Aluminium	Al				0.11	
Boron	B				0.01	
Total		<65.0	<32.0	<15.0		

COPPER CATHODES 2005

Country	Brands	Producer	Capacity Tonnes	ISA Process	Type	Registered	URL	See Also	Comments
Argentina		Various Argentina			Fire refined				
Australia	ISA	Copper Refineries			Electrorefined	LME			
		Girilambone Copper			Electrowon				
		Matrix Metals			Electrowon				
	ISA	Mount Isa Mines Ltd		yes	Electrorefined		http://www.mimpt.com.au		Now Owned by XSTRATA
	OLYDA	WMC (Olympic Dam Corporation) Pty Ltd			Electrorefined	LME	http://www.wmc.com/		Now owned by WMC
		WMC (Olympic Dam Corporation) Pty Ltd			Electrowon				
		Pasminco							
		Port Kembla Copper			Electrorefined				
		Straits Resources			Electrowon				
		Western Metals			Electrowon				
Austria	BRX	Montanwerke Brixlegg Aktiengesellschaft			Electrorefined	LME			
Belgium	OLEN	Umicore Copper N.V.		yes	Electrorefined	LME	http://www.umicore.com		
	SME	Metallo-Chemieque International NV			Electrorefined	LME			
Brazil	Cbm	Caraliba Metais SA			Electrorefined	LME			
Bulgaria		Union Miniere			Electrorefined				
Canada	FKA	Falconbridge Ltd			Electrorefined	LME			
	NORANDA (produced after October 1999)	Noranda Inc.			Electrorefined	LME			
	ORC	Inco Ltd			Electrorefined	LME			
Chile	ABRA	Sociedad Contractual Minera El Abra			Electrorefined	LME			
	AE	Corporacion Nacional del Cobre de Chile			Electrowon	LME			
	AE SX EW	Corporacion Nacional del Cobre de Chile			Electrorefined	LME			
	CCC	Corporacion Nacional del Cobre de Chile			Electrowon	LME			
	CCC-SBL	Corporacion Nacional del Cobre de Chile			Electrorefined	LME			
	cCo-SX-EW	Corporacion Nacional del Cobre de Chile			Electrowon	LME			
	CDA	Compania Minera Carmen de Andacollo			Electrowon	LME			
	CHUQUI-P	Corporacion Nacional del Cobre de Chile			Electrowon	LME			
	CMCC	Compania Minera Cerro Colorado Ltda			Electrowon	LME			
	COLLAHUASI (produced after December 1998)	Compania Minera Dona Ines De Collahuasi SCM			Electrowon	LME			
	ENM	Empresa Nacional de Mineria			Electrorefined	LME			
	ESOX (produced after April 1999)	Minera Escondida Limitada			Electrowon	LME			
	LBF	Comp. Minera Falconbridge Lomas Bayas			Electrowon	LME			
	MET	Minera El Tesoro			Electrowon	LME			
	MIC-P	Minera Michilla S.A			Electrowon	LME			
	MIC-T	Minera Michilla S.A			Electrowon	LME			
	MB	Empresa Minera de Mantos Blancos SA			Electrowon	LME			
	MV	Empresa Minera de Mantos Blancos SA			Electrowon	LME			
		Cerro Dominador			Electrowon	LME			
		Codeico - Caletones			Fire Refined				
		Codeico - El Teniente			Electrowon				
		Codeico - Radomiro Tomic			Electrowon				
		Explotadora de Minas			Electrowon				

COPPER CATHODES 2005

Country	Brands	Producer	Capacity Tonnes	ISA Process	Type	Registered	URL	See Also	Comments
China		Min. Disputada de las Condes			Electrowon				
		Min. Disputada de las Condes - Los Bron			Electrowon				
		Min. Pudahuel			Electrowon				
		Min. Pudahuel - Lo Aguirre			Electrowon				
		Compania Minera Quebrada Blanca S.A.			Electrowon	LME			
		Min. Rayrock			Electrowon				
		Sociedad Punita del Cobre			Electrowon				
	ZALDIVAR	Compania Minera Zaldivar			Electrowon				
	QING FENG	Anhui Chi Zhou Nonferrous Metal			Electrorefined	SHFE			
	TG	Anhui Tongdu Copper Stock Co. Ltd			Electrorefined	SHFE			
	IBIS	Baiyin Nonferrous Metals			Electrorefined	SHFE			
		Changsha Nonferrous Metals			Electrorefined	SHFE			
		Changzhou Orientmet			Electrorefined	SHFE			
	DA JIANG	Daye Nonferrous Metals			Electrorefined	SHFE			
		Gejiu Copper			Electrorefined	SHFE			
		Guangdong Shilu Copper			Electrorefined	SHFE			
	ZHUJIANG	Guangzhou Zhujiang Copper Co			Electrorefined	SHFE			
	HX	Huludao Zinc Refinery			Electrorefined	SHFE			
	TIAN HENG	Jiangsu Tai Cang Copper			Electrorefined	SHFE			
	GUIYE	Jiangxi Copper Company Ltd.		150,000	no	LME SHFE		http://www.jxcc.com/english/enjigs/enindex.htm	
GUIYE	Jiangxi Copper Ind			Electrorefined	LME SHFE				
JIN TUO	Jinchuan Nonferrous Metals			Electrorefined	SHFE				
JINTUN/Jinlong	Jinlong Copper Co Ltd			Electrorefined	LME SHFE				
JINTUN (produced after 31/8/97)	Jinlong Copper Co Ltd		100,000		LME SHFE				
	Kunming Smelter			Electrorefined					
	Local Authority - Anyang/Tongbai			Electrorefined					
JIN GUANG	Local Authority - Baotou			Fire Refined	SHFE				
	Local Authority - Chengdu			Electrorefined					
	Local Authority - Chongqing			Electrorefined					
	Local Authority - Fuchuijiang			Electrorefined					
	Local Authority - Harbin			Electrorefined					
	Local Authority - Shaowu			Fire Refined					
	Local Authority - Tieling			Electrorefined					
	Local Authority - Tonghua			Fire Refined					
	Local Authority - Urumqi			Fire Refined					
	Local Authority - Wuhan			Electrorefined					
	Local Authority - Xiaoshigou			Electrorefined					
	Local Authority - Zhejiang Aluminium			Electrorefined					
PEONY	LuoYang Copper Fabricating			Electrorefined	SHFE				
JIN YAN	Mei Zhou Jinyan Industry Group			Electrorefined	SHFE				
	Mouding Copper			Electrorefined					
JU JING	Nanhai Shi Taipinyang			Electrorefined	SHFE				
JIN TIAN	Ningbo Jintain Copper Industry			Electrorefined	SHFE				
SHANG YE	Shanghai Xinye Copper Co			Electrorefined	SHFE				

COPPER CATHODES 2005

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	TIGER	Shanghai Da Chang Copper Co			Electrorefined	SHFE			
		Shenyang Smelter			Electrorefined				
	ZHONG DING	Shenyang Xinxi Copper			Electrorefined	SHFE			
		Shuikoushan Mining Bureau			Electrorefined				
	DA TONG	Taiyuan Copper Industrial			Electrorefined	SHFE			
	TONG GUAN	Tianjin Da Tong Copper			Electrorefined	LME SHFE			
		Tongling Nonferrous			Electrorefined				
		Various China			Electrorefined				
	JING JING PAI	Wuhu Heng Xin Copper			Electrorefined	SHFE			
	SAN JIAN PAI	Yantai Nonferrous Metals Group			Fire Refined	SHFE			
	TIE FENG	Yunnan Copper Corp Ltd	?	no	Electrorefined	LME SHFE	http://www.yunnan-copper.com/ehtml/main.htm		
	JIN XIN	Yuyao Shi San Cheng Nonferrous			Electrorefined	SHFE			
	TONG DING	Zhangjiagang Lianhe Copper			Electrorefined	SHFE			
	ZHONG TIAO SHAN	Zhongtiaoshan			Electrorefined	SHFE			
		Zhuzhou Smelter			Electrorefined				
Cyprus		Hellenic Copper			Electrowon				
Egypt		Various			Fire Refined				
Finland		OM Group			Fire Refined				
Germany	OKM	Boilden Harjalvalta Metals Oy			Electrorefined	LME			
		KM Europa Metal			Fire Refined				
		Mansfelder Kupfer			Electrorefined				
	HK	Norddeutsche Affinerie AG			Electrorefined	LME Comex			
	NA-ESN	Norddeutsche Affinerie AG			Electrorefined	LME Comex			
India	BIRLA COPPER	Hindalco Industries Limited			Electrorefined	LME			
		Hindustan Copper - Malanjhand			Electrowon				
		Hindustan Copper - Ghatsila			Electrorefined				
		Hindustan Copper - Khetri			Electrorefined				
	BIRLA COPPER	Indo Gulf Fertilisers & Chem			Electrorefined				
	STERLITE	Sterfite Industries (India) Ltd			Electrorefined				
Indonesia	GRESIK	PT Smelting	200,000	Yes	Electrorefined	LME	http://www.smelting.co.id/	Mitsubishi largest shareholde	
Iran		NICICO - Sarcheshmeh			Electrorefined				
Italy		NICICO - Sarcheshmeh			Electrowon				
		Europa Metall			Fire Refined				
		Simar			Electrorefined				
		Tramet			Fire Refined				
Japan	DOWA	Dowa Mining Co Ltd	72,000	No	Electrorefined	LME Comex	http://www.dowa.co.jp/english/index.htm		
	TAMANO	Mitsui Mining & Smelting Co Ltd			Electrorefined	LME Comex			
	HM	Nippon Mining and Metals Co Ltd	180,000	Yes	Electrorefined	LME Comex	http://www.nikko-metal.co.jp/english/index.html		
	MITSUBISHI	Mitsubishi Materials Corporation			Electrorefined	LME Comex			
	OSR	Mitsui Mining & Smelting Co Ltd			Electrorefined	LME Comex			
	SR	Onahama Smelting & Refining Co Ltd			Electrorefined	LME Comex			
	SUMIKO N / SUMIKO T	Nippon Mining and Metals Co Ltd			Electrorefined	LME Comex			
	TAMANO	Sumitomo Metal Mining Co Ltd			Electrorefined	LME Comex			
		Mitsui Mining & Smelting Co Ltd							

COPPER CATHODES 2005

Country	Brands	Producer	Capacity Tonnes	ISA Process	Type	Registered	URL	See Also	Comments
	CHANGHANG	LG-Nikko Copper Inc.							
	ONSAN	LG-Nikko Copper Inc.							
	ONSAN II	LG-Nikko Copper Inc.							
Kazakhstan		Kazakhmys JSC - Balkhash			Electrorefined				
	CDM	Cobre de Mexico			Electrorefined	Comex			
		Mexicana de Cananea			Electrowon				
		Mexican de Cobre			Electrorefined				
		Erdenet			Electrowon				
Mongolia									
Myanmar	MONYWA S&K	Myanmar Ivanhoe Copper Company Ltd			Electrowon	LME			
Norway	FHG	Falconbridge Nikkelverk AS			Electrowon	LME			
Oman	OMCO	Oman Mining Co LLC			Electrorefined	LME			
Peru		BHP Tintaya							
		Metatoraya			Electrorefined				
	SMCV	Sociedad Contractual Minera Cerro Verde			Electrowon	LME Comex			
	SPCC-ILO	Southern Peru Copper Corporation			Electrorefined	LME Comex			
	SPCC-SXEW	Southern Peru Copper Corporation			Electrowon	LME Comex			
Philippines	PASAR	Philippine Associated Smelting and Refining Corporation			Electrorefined	LME Comex			
Poland	HMG-B	KGHM Polska Miedz SA			Electrorefined	LME			
	HMG-S	KGHM Polska Miedz SA			Electrorefined	LME			
	HML	KGHM Polska Miedz SA			Electrorefined	LME			
Romania		Allied Deals			Electrorefined				
		Romanian Ministry of Mining			Electrorefined				
Russia		Kyshtym			Electrorefined				
		Mednogorsk			Electrorefined				
		Norlisk			Electrorefined				
		Severnicket			Electrorefined				
		UralsElectromet			Electrorefined				
Serbia		RTB Bor			Electrorefined				
Slovakia		Kovohuty Krompachy			Electrorefined				
South Africa	PMC	Palabora Mining Company Ltd			Electrorefined	LME			
		Various			Electrowon				
South Korea	CHANG HANG	LG-Nikko Copper Inc.			Electrorefined	LME			
	ONSAN	LG-Nikko Copper Inc.			Electrorefined	LME Comex			
	ONSAN II	LG-Nikko Copper Inc.			Electrorefined	LME			
	ERCOSA	Elmet SL			Electrorefined	LME			
Spain	FMS	Atlantic Copper SA			Electrorefined	LME			
Sweden	BK	Boliden Mineral AB			Electrorefined	LME			
Turkey		Er-Bakir			Electrorefined				
		Hendik Bakir			Electrorefined				
		HES			Electrorefined				
		Sarkuysan			Electrorefined				
USA	ATR	ASARCO Incorporated			Electrorefined	LME Comex			

COPPER CATHODES 2005

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	RAY	ASARCO Incorporated			Electrowon	LME Comex			
	BHP COPPER***	BHP Copper Inc.			Electrowon	Comex			
	BHP COPPER/SXEW****	BHP Copper Inc.			Electrowon	LME Comex			
	CB * CC	Cyprus Amax Minerals Company/Phelps Dodge			Electrowon	LME Comex			
	CMCMER	Cyprus Amax Minerals Company/Phelps Dodge			Electrowon	LME Comex			
	CTB	Cyprus Amax Minerals Company/Phelps Dodge			Electrowon	LME Comex			
	KUC	Kennecott Utah Copper Corporation			Electrowon	LME Comex			
	KUE *	Kennecott Utah Copper Corporation			Electrowon	LME Comex			
	MAGMA **	BHP Copper Inc.Ä							
	MSEW **	BHP Copper Inc.							
	P * D	Phelps Dodge Sales Co IncorporatedÄ							
	RAY	ASARCO Incorporated			Electrowon	LME Comex			
		BHP Copper Miami			SXEW				
	BHP COPPER	BHP Copper San Manuel			Electrowon				
	BHPX	BHP Copper San Manuel			Electrowon	LME Comex			
	LMC	Cerro Copper Products			Electrowon	Comex			
	SANTA RITA	Chino Mines			Electrowon	Comex			
	WHITE PINE COPPER (WPC)	Considar			Electrowon	Comex			
		Equatorial Mining Mineral Park			Electrowon				
		Equatorial Mining Tonopah			Electrowon				
		Nord Resources			Electrowon				
	CMCMC	Phelps Dodge Miami			Electrowon				
	PDSS & PDMI	Phelps Dodge Morenci SXEW			Electrowon	Comex			
	PD*GO	Phelps Dodge Stargo, Morenci			Electrowon				
	BCCC	Phelps Dodge Tohono			Electrowon				
		Phelps Dodge Tyrone			Electrowon	Comex			
		Silver Bell Mining			Electrowon				
	CDS	Southwire			Electrowon	Comex			
		Wamantou Resources			Fire Refined				
Uzbekistan		Almalyk Mining & Met			Electrowon				
Zaire		Gecamines - Lulu			Electrowon				
		Gecamines - Shituru			Electrowon				
Zambia	MCM	Mopani Copper Mines Plc			Electrowon	LME COMEX			
	REC	ZCCM (SmelterCo) Ltd			Electrowon				
		Avrmin			Electrowon				
		First Quantum			Electrowon				
		Konkola Copper Mines			Electrowon				
Zimbabwe		Bindura Nickel			Electrowon				
		Empress Nickel Refinery			Electrowon				
		Mhangura Copper Mines			Electrowon				
		Munyati Mining			Electrowon				
		Smelterco			Electrowon	LME COMEX			