The Manufacture of Semi Finished Brass Rod for Forging & Machining Applications

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Description

This process and plant described is intended to produce semi-finished brass rods and sections at an net output rate of up to around 150 tonnes per month, using either virgin metals or scrap brass feedstock.

The plant is designed for production of bars up to 4m long; 15mm - 45mm diameter and hexagon sections 15mm - 40mm across flats.

It is assumed that feedstock comprises 100% brass scrap, including in-house scrap arisings in the form of machining swarf and bar ends and reject machined components or forgings. Bought-in scrap of a similar nature to a known composition can also be used. Minor additions of virgin zinc and lead are added as required.

Process Route

1) **Feedstock preparation**, storage and feeding to melting furnace.

2) **Induction melting** of feedstock using a 1000Kg capacity 400 Kg/hr maximum coreless steel shell melting furnace.

3) **Metal transfer** via a refractory lined heated (normally by gas fired burners) launder.

4) **Continuous casting** of two strands of rod by a Rautomead RT850 Horizontal Continuous Casting Machine.

5) **Cut to length** (typically 3m - 4m) using a hand held powered bandsaw.

6) **Rod pointing** to reduce diameter of bar at one end to allow feed into shaving bench.

7) **Hydraulic shaving**, shaving straight lengths up to 4m long, removing up to a maximum depth of 1mm using a hydraulic shave bench with 3 shave dies..

8) **De-Tagging saw** to remove pointed end and cut to length.

9) **Bar straightening** using a 2 roll bar straightener.

10) **Storage and racking**.

11) **Quality control & testing**.

A typical factory layout demonstrating the equipment layout to achieve above process route is shown in drawing RD5147-4 attached at appendix C.

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Equipment

1. Feedstock Preparation, Storage and Feeding to Melting Furnace

Scrap from manufacturing processes such as reject components, swarf and bar ends where the composition is known is ideally suited to this process. This requires to be reasonably clean, dry and free from oil. Excessive amounts of cutting lubricant result in high levels of gaseous emissions. The subsequent weight loss also contributes to a net reduction in yield.

Solid reject components from in house manufacturing process are usually relatively clean and dry and do not require special cleaning or drying. Storage is normally in bins or hoppers, which can be lifted directly onto the melting furnace platform.

Fig. 1 Swarf Drying Equipment

Swarf and bar ends require to be dried by centrifuging. Storage can again be in bins or hoppers but a feature of swarf is that it can be transported, by conveyor, to the furnace and fed directly, using a vibratory table. In this case any sold scrap can be added manually to the vibratory table as the swarf/bar ends are charged. This approach is particularly recommended where the cost of labour is high.

Bought in scrap should be treated with caution. Quality scrap to the correct composition may be available from known sources, whereas trade scrap from unknown sources often contains ferrous and other impurities, making it unsuitable.

A swarf drying and handling system can be tailored to suit a particular installation but a basic system would typically consist of: -

a) A screw conveyor fed by tipper bins which raise the swarf/bar end mixture to a bar end separator. The bar ends and any random components are separated from the swarf and fed directly to a separate output storage hopper. This is loaded directly onto the melting furnace platform by crane or forklift truck.

b) The swarf is fed to a centrifuge, which separates the soluble oil, producing dry swarf of approximately 1-2% W/W soluble oil content. The oil is stored in a collection tank.

Fig 2 Swarf Tipper and Spiral Lift

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c) The hopper of dried swarf is moved by fork lift to a swarf elevating and feeding system, where it is tipped into the feed of a spiral elevator. As the swarf bar ends exit the spiral elevator, the material passes through a rotary self-cleaning magnetic separator to extract any contaminating ferrous materials.

Fig 3 Spiral Lift Exit feeding Rotary Magnetic Separator

Fig 4 Vibrating Table feeding Swarf into Furnace

d) The swarf is then fed in a controlled fashion into the furnace using an 80 m^3/hr vibratory hopper feeder (rate controlled by the operator). At this stage the bar ends and any solid scrap are added manually.

If a conveyor/vibrating feed table is not used, then there are two other basic approaches to the storage and feeding of the scrap to the furnace.

I. The scrap may be stored remotely from the furnace. The charges are weighed into specially designed feed hoppers, which are transported to the furnace by overhead crane to be fed directly into the furnace.

Fig 5 Feed Hooper for use with Overhead Crane

Fig 6 Storage Hoppers and weighing Station of Furnace Platform

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II. Buffer stores of swarf/bar ends and solid scrap hoppers may be located on the furnace platform along with buckets and weighing scales. Operators charge the materials into buckets by shovel for feeding into the furnace. This is labour intensive, but avoids the need for an overhead crane. The hoppers are loaded onto the platform by forklift truck.

Regardless of the feeding method employed, a stock of virgin zinc and lead along with weighing scales must be located on the melting furnace platform. Some manual assistance, using a "puddling" pole, may be required to ensure the charge is pushed through the surface of the melt.

2. Induction Melting

350 kW, 1000Kg capacity, medium frequency coreless steel shell melting furnace with hydraulically operated trunion tilted fume hood and hydraulic integral lid.

The furnace includes hydraulic power pack, load cell weighing system with digital readout, computerised melt manager and a recirculating closed circuit water cooling system.

Fig 7 Induction Premelting and RT850 Installation

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The melting furnace is designed to pour batches of 400Kg in a 60minute period leaving a heel of 600Kg in the crucible to facilitate the melting and alloying of each succeeding batch. This would allow for sufficient time to perform the following cycle:

1) Pour 400Kg into the RT850 continuous casting furnace,
2) De-slag the surface including scraping the side walls,
3) Charge new material into the premelting furnace.
4) Sample molten metal.
5) Prepare sample on lathe and analyse with the spectrometer.
6) Adjust the chemistry of the molten brass and repeat analysis
7) Repeat steps 5), 6), and 7) as required.
8) Check and adjust molten metal temperature.

3. Metal Transfer

The closed and heated metal transfer launder is provided to transfer liquid metal from the melting furnace to the RT850 continuous casting machine crucible. The launder consists of a steel shell fabrication lined with a suitable refractory. The launder is heated, typically using gas fired burners.

Fig 8 Brass being transferred to Rautomead Casting Machine

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4. Continuous Casting

A 105 kVA resistance heated furnace designed to cast two strands of brass bar in sizes ranging from 15mm to 45mm diameter. The technology is based around a graphite crucible to contain the brass, graphite resistance heating elements and graphite dies cooled with copper coolers. Crucible capacity is approx. 750 kg.

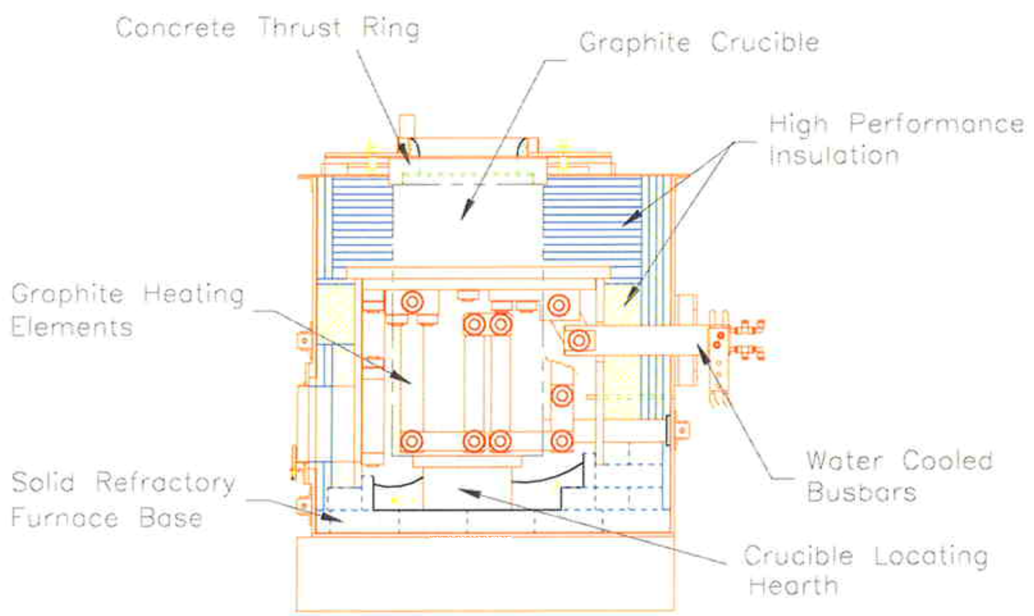

Fig 9 Section through RT850 Furnace Body

The furnace construction is shown in Fig 9 above.

Graphite bus bar and heating elements operating at an inherently safe low voltage provide the resistance heating. A 105 kVA air cooled transformer and thyristor complete the power pack.
The casting furnace is supplied with the following equipment: -

a) Fume hood over the casting machine and side taphole. This is to be connected to a fume extraction system.

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b) Two rod strand withdrawals, each comprising a robust steel frame with two pairs of fully articulating shafts. The lower pair of shafts has a manual height adjustment whilst the clamping force is provided by pneumatic cylinders on the upper shafts. Drive to the withdrawal is by an AC servomotor with touchscreen controls, giving operator access to the withdrawal motion parameter settings.

c) Control cabinets housing furnace, withdrawal and fluidics instrumentation and controls utilising touch screen operator interfaces.

d) Platform tailored to each installation, but typically 7.5m x 5.1m x 1.95m high including access steps, handrails and kickboards

Fig 10 Rautomead Brass Rod Casting Installation. Note Fume extraction Hoods and hand Held Powered Bandsaw

e) Primary Water cooling system comprising a dual pumps module (one operation, one standby) providing 15 m^3/hr cooling water to the casting furnace. A plate cooler, sized to suit local ambient conditions, is used to cool the water. All mounted on a common skid complete with interconnecting pipework to furnace. Customer to supply cooling water to the heat exchanger, normally from standard atmospheric cooling tower system.

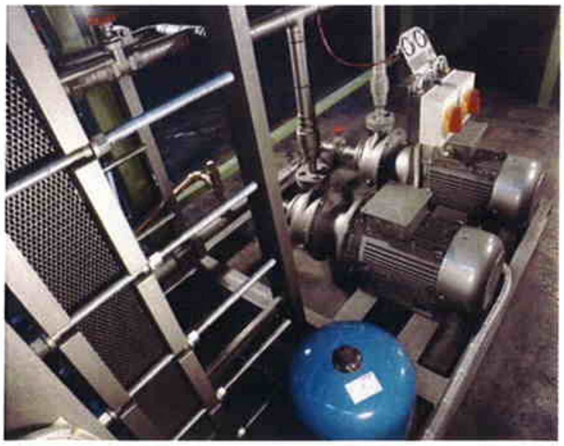

Fig 11 Pump Module with dual pumps and heat exchangers

f) Secondary sparge cooling providing water spray cooling to the rod on exit from the casting dies. Comprises a stainless steel tank, circumferential water sprays, air wipes to contain the spray within the tank and collection tank with heat exchanger and recirculating pump.

g) Rod guides and run out tracks to suit sections sizes to be cast.

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5. Cut to Length

For the size range 15mm to 45 mm, a hand held electric powered bandsaw is suitable for cutting the strands during the casting process. Cut length is typically 3m to 4.0m.

6. Rod Pointing

The cut bars require one end to be turned down to the finished size to allow the bar to be entered into the shave bench dies. This is achieved using either a multi tool turning machine or a push type pointer.

Operation of these machines is manual. If several sizes are to be cast then the pointing is done on a batch basis. The furnace operator can often do this when not directly working on the casting furnace.

7. Hydraulic Shaving

A 30 tonne hydraulic shave bench capable of shaving up to 1mm depth over a maximum length of 4m. Approximately 15m overall length including a 3.5m loading table.

The loading table is designed to hold a 1 tonne bundle of rod, which is manually descrambled and loaded into the die assembly manually.

Fig 12 30 Tonne Hydraulic Shave Bench

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The die assembly comprises a guide die and two shave dies clad in an acoustic hood to minimise noise.

During operation the operator will push the pointed end of the rod through the shaving die assembly into the jaws and activate the shave cycle. The shave bench will shave the bar and eject into the collection trough with the jaws returning to the start point to accept the next rod.

An acoustic hood is provided over the machine to reduce noise from the shaving operation to acceptable levels.

8. Detagging Saw

Once shaving is complete the turned down "pointed end" must be removed and the bar cut to the desired length. This can be simply accomplished using a standard circular saw and length gauge. This is a manual operation again carried out in batches.

9. Bar Straightening

The process of casting followed by shaving may put a slight curve into the bars, which can cause difficulties if the bar is to be used in automatic feed machinery. The bars can be straightened using a standard two roll straightening machine.

Fig 13 Straightening Machine

10. Storage and Racking

If several sizes are manufactured and stored storage racking would be required. This is normally manufactured locally. Size of racking should allow for manual handling if single bars are to be moved or for forklift access, if bundles are to be handled.

Fig 14 Typical Storage Rack Arrangement for Brass Rod

Standards

Relevant standards are:

material	standards	Physical properties		
		requirements		typical values
Forging rod	BSEN CuZn40Pb2 C 37700	UTS N/mm^2 (min)	350	400
		Elongation (min)	25%	30%
Machining rod	BSEN CuZn36Pb3 C 36000	UTS N/mm2 (min)	400	450
		Elongation (min)	20%	25%

11. Quality Control and Testing

During the melting and casting sequence, frequent samples of the molten metal need to be analysed for chemistry. This is done using an analytical emission spectrometer. It is important that the laboratory should be positioned close to the melting and casting shop. Additional quality control checks of the finished bar include a tensile test, elongation and microstructure of the rod.

Equipment needed for a typical laboratory would be:

a) Optical emission spectrometer with factory calibration samples and software programmes for each brass alloy to be manufactured.

b) Lathe with chuck capable of holding up to 45mm diameter rod metal samples for spectrometer and microstructure preparation.

c) Tensile test machine.

d) Hardness testing machine.

e) Sample preparation equipment for microstructure.

Fig 15 Spectrometer

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f) Microscope

Fig 16 Microscope magnification x50, x100, x 200, x 500

Fig 17 Grinding and Polishing machine for Micrograph Preparation.

Additional Equipment
In addition to the equipment described above the following equipment would normally be sourced by the customer: -

a) **Materials handling equipment**
All equipment to transport the raw materials and finished products. This would include cranes, forklift trucks, hand operated trolleys, storage bins, hoppers and racks.

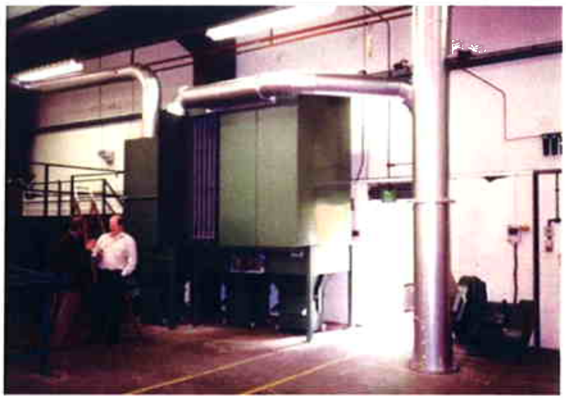

Fig 18 Fume Extraction system comprises Spark Arrestor, Bag Type Filter House, Fan and Chimney.

b) **Fume extraction system**
Requirements are subject to local regulations, but a minimum system to provide fume extraction from the melting furnace and casting machine is a centrifugal fan and ducting to provide airflow of 24,225 Nm^3/hr, exhausting via a 14m high 360mm diameter chimney.

In addition it is recommended that either a wet deduster or filter bag filter is used to collect the fumes extracted. This could also incorporate a dust monitoring system comprising an in-duct sensor and microprocessor controlled combined monitor and data logger.

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c) **Secondary cooling water system**
A water supply to provide cooling water to the melting furnace and casting machine primary water systems is required. A specification is provided to suit local ambient conditions. This normally comprises a dual pump system (one operational, one standby) circulating the specified volume of cooling water which has been cooled by a standard atmospheric cooling tower. In hot climatic condition additional refrigerant cooling may be required.

Fig 19 Cooling Tower, water storage tank and secondary water pumps

Capital Cost

The overall capital cost of such a system (excluding buildings) is influenced by many local factors, such as quality of feedstock materials available, degrees of automation used, existing equipment available, opportunities for inclusion of adapted used equipment, etc, that it is not possible to provide an accurate capital cost to suit all circumstances. Nevertheless, a budget figure of £500,000 to £750,000 (Euro 800,000 to Euro 1,200,000) would be a reasonable approximation.
See appendix B for a list of used machinery dealers.

Operating Cost

Direct operating costs include melting, casting and bar shaving. Shaving removes the surface of the cast bar and also involves the loss of the tag end of each bar, resulting in a reduction in net yield. The amount of brass melted and cast must be grossed up to compensate for this reduction in yield.

Detailed calculations of the direct costs are shown at appendix B, which takes 30mm diameter bar as the example. These calculations exclude labour cost, as this varies so widely between countries. The spreadsheet is available on disk, enabling users to insert their own known local factor costs and operating schedules, to measure the effect on operating cost.

In the example shown, the direct operating cost, excluding labour, is £81.09 per tonne.

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The Economic Case

In most market conditions, the addition of the direct operating cost, plus labour and overheads to the market value of the scrap and swarf will show a significant reduction in the cost of the semi-finished rod, compared with the price at which brass rod can be bought in the market. This will also show an attractive return on the investment required.

Rautomead will always be pleased to assist customers on a confidential basis, in the analysis of the business case for such an investment, having regard to local prevailing costs and market conditions.

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May 2002

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Appendix A

MODEL RT 850 HORIZONTAL CONTINUOUS CASTING MACHINE
ROD CASTING - MOLTEN FEED, INCL. MELTING AND SHAVING COST

Direct Operating Costs

Assumptions

	item		units		selectable value		item	units	selectable value
	material				brass		power cost	£/kwh	£0.045
	density		gm/cc		8.4		nitrogen cost	£/cu.m	£0.45
	melting (molten or integrated)				molten				
	melting furnace		kW				shifts		3
	rated power		kW		105				
	rod size	OD	mm		30.0				
	rod size	ID	mm	n/a			melting furnace refractories	£/tonne	3.00
	wall thickness		mm	n/a					
	bar weight per meter		kg	5.9					
	strands		no		2				
	desired casting speed		mm/min		570				
	die life		hours	396			crucible price	£	£10,650
							kit of spare parts	£	£18,505
schedule:							graphite flake price	£/kg	n/a
		hours per day			24		availability	f.	0.85
		days per week			5.5		working time per year	weeks	48

notes: Labour not included:
One operator for melting furnace; one operator for casting machine; one operator for shaving bench.
Enter tooling prices at appendix C. Calculations assume bars of same size.

Output

net operating time/year		hours		**5,386**
theoretical kg/strand/hr		kgs	203	
theoretical gross output per hour		kgs	406	
output restricted as below:				
achievable casting speed		mm/min		**561**
achievable max.kg/strand/hr		kgs		**200**
achievable gross output/hour		kgs		**400**
achievable net output/week		tonnes		**45**
achievable net output/year		tonnes		**2,154**

Direct Operating Costs per Tonne

		appendix	
Power		A	**£23.25**
Nitrogen		B	**£1.66**
Tooling		C	**£6.56**
Crucible		D	**£0.91**
Spares & Consumables		E	**£7.30**
subtotal			**£39.67**
grossed up for shaving losses	21.03%		**£50.24**
cost of shaving (appendix F)		F	**£30.86**
Total Direct Cost per Tonne		**£**	**£81.09**

note: While cost information provided by Rautomead is given in good faith and is based on factual experience, Rautomead offers no warranty that these or any other figures will be achieved in any given installation.

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Appendix A (cont'd)

Appendix A										
									RT850	
Power Cost										
									per tonne	per hour
serial								kg		406
									kW	kW
A	**Steady State Operation**									
				no. of	**kW**	**loading**	**kW**			
		stand-by losses:								
		12%	of		105				10	3
		operating losses :								
		18%	of		105				56	15
		melting burden	("350" if molten feed)						350	94
		ancillary motors								
		- rod withdrawal		2	2.2	75%	3.3			
		- saw		1	2	20%	0.4			
		- water pumps		1	7.5	75%	5.6			
		- motors sub-total					9.3		35	9
		cooler efficiency (86%)								
		72.06	kW						66	27
		totals							517	147
		cost at £	0.045	kWh					£23.25	

Appendix A (cont'd)

Appendix B							
						RT850	
Nitrogen Cost							
						per tonne	per hour
serial					kg		406
A	**Weekly Schedule -**						
	168	hours @	0.85	availability			
						weekly	
						tonnes	cu.m.
	132	hours production					
	406	kg/hour	1.00	cu.m./hr		46	132
	36	hours standby					
			1.00	cu.m./hr			36
		totals				46	168
B	**Nitrogen Cost per tonne Produced**						
	cost at	£0.45	£/cu.m.		£	£1.66	
* Cost of gas at £0.45/cu.m is based on UK charges for rental of liquid nitrogen gas tanks.							
If nitrogen gas supplied by nitrogen gas generator, cost of gas is reduced to £0.08/cu.m							

Appendix A (cont'd)

Appendix C									
								RT850	
Tooling Cost									
								per tonne	per hour
serial							kg		406
A	**Casting Die Tooling Used per Year**								
	qty	item		price					
				unit	total				
			size						
			mm	£	£				
	2	super coolers		£1,734.00	£3,468.00				
	2	super cooler holders		£1,080.00	£2,160.00				
	2	nitropackers		£96.06	£192.12				
	27	casting inserts	30.0	£205.00	£5,576.00				
	27	packer inserts	30.0	£80.00	£2,176.00				
	81	insulating washers		£0.60	£48.60				
	4	water hoses		£125.63	£502.52				
		totals per year			£14,123.24				
B	**Tooling Cost per Tonne Produced**						£	£6.56	

Appendix A (cont'd)

Appendix D									
								RT850	
Crucible Cost									
								per tonne	per hour
serial							kg		406
						£			
A	**Basic Assumption**								
	- crucible life - 60 months continuous operation								
		crucible cost:							
		RT850			£10,650				
		x weeks' usage per annum/260				£1,966			
B	**Cost per Tonne Produced**						£	£ 0.91	
Appendix E									
								RT850	
Spares and Consumables Cost									
								per tonne	per hour
serial							kg		
					tonnes/year	2,154			
A	Basic Assumptions					£			
	melting furnace refractories & spares								
	@	£ 3.00	per tonne	3		£6,463			
	RT850	spare parts kit			18,505				
		annual usage approx. 50% of above				£9,253			
	RT850	graphite flake @		1.25	kg/tonne				
		total spares & consumables				£15,715			
B	**Spares and Consumables**								
	Cost per Tonne Produced						£	£ 7.30	

Appendix A (cont'd)

Appendix F							
COST OF SHAVING BRASS							
	bar diam	30	mm				
	density	8.4	gm/cc				
	weight/m	5.94	kg				
	length	4000	mm				
	bar weight	23.76	kg				
	bars/hour	20					
	meters per hour	80					
	weight per hour	475.2	kg				
	power	30	kW				
	operators	1					
	tag	500	mm				
	tag loss	2.97	kg				
	diam reduction	1.5	mm				
	weight/m	5.36	kg				
	length	3500	mm				
	weight finished	18.76	kg				
	weight finished per hour	375.26	kg				
	shaving losses	21.03%	%				
				%	kWh	rate	cost
						£ per hour	
	power	30	kW	0.4	12	0.045	0.54
	dies re- grind at	500	meters	0.16		15.00	2.40
	die replacements at	5000	meters	0.016		540.00	8.64
	total						11.58
						£ per tonne	
	cost per tonne of finished bar						30.86
	(excl. labour)						

Appendix B – List of Used Machinery Dealers

Goodwin Machinery Ltd Excalibur House, 630 Liverpool Road, Irlam, Manchester, England M44 5AD Tel: +44 161 775 6172 Fax: +44 161 775 7230 E-mail: goodwinltd@compuserve.com Web: www.goodwinmachinery.co.uk	**Mathiasen Machinery, Inc.** 450 Town Street East Haddam, CT 06423 USA Phone: (860) 873-1423 Fax: (860) 873-8866 Email: mmi@mathiasen-machinery.com Web: www.mathiasen-machinery.com
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B.M.S. Rue du Stade 69290 Grézieu la Varenne (Lyon) FRANCE **Tel:** +33 4 78 57 46 46 **Fax:**+33 4 78 57 07 53 E-mail: bms@bms-france.com Web: www.bms-france.com	**QUEINS & CO. GMBH** Industriestr.12 D-52156 Monschau Germany Tel : (+49) 2472 8080 Fax : (+49) 2472 3014 E-mail: info@queins.com Web: www.queins.com

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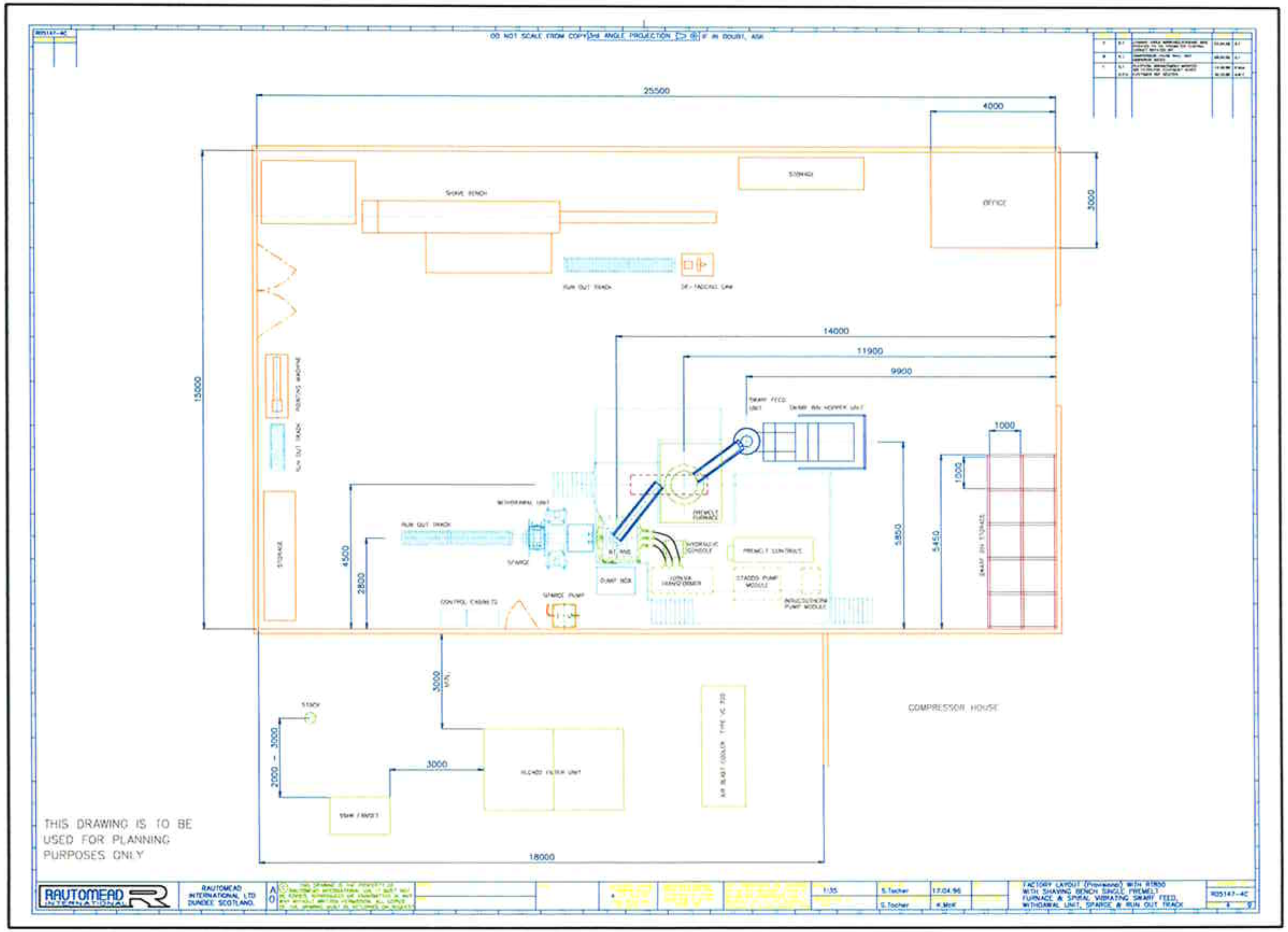
Appendix C



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