

Water-cooled cables

Water-cooled cables technical catalogue

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THEORETICAL CURRENT DENSITY

The admissible theoretical current density is 4,5 Amps/mm^2.
For furnaces in which current variations are verry little (ferroalloy reduction furnaces for istance), this current density can be increased up to 8 to 9 Amps/mm^2.

BENDING RADIUS

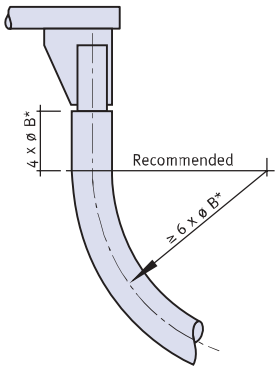
The minimum bending radius of the cable is around 6 times the inner diameter of the water hose (see cables chart at page 5 and 6).
A lower value of bending radius may lead to an undesirable wear of the water hose.

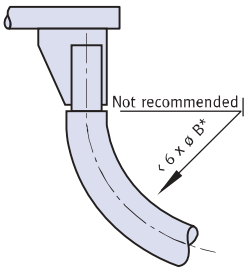
POWER LOSSES, REACTANCE, GMR

In order to limit the power losses and the reactance of the secondary circuit, the GMR (geometric mean radius) of each phase must be the maximum.
If the number of cables per phase is given, there are two ways of improving the GMR value: by increasing either the GMR of each cable or the distance between the cables of the phase.

Cables definition: choice criteria

Brar proposes, for a given cross section, several GMR values, in order to optimize the cost of cables as a function of the cost of energy and the reactance value. Brar utilizes advanced computer techniques to calculate the flexible circuit reactance and the energy losses based upon the furnace geometry and the cable design. These calculations may be provided upon request.





NOTE:
Diameter B is the inner diameter of the water hose (see chart page 5 and 6)

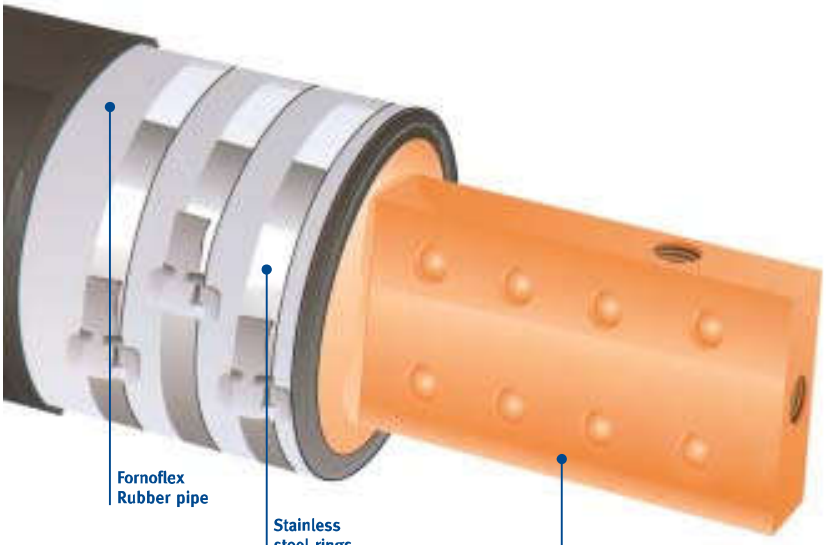
Star cables

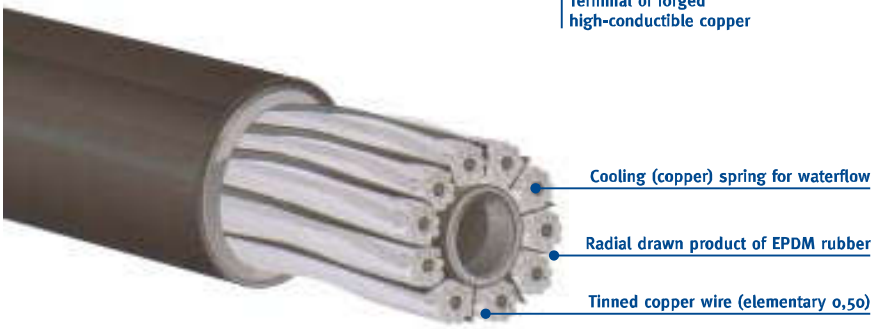
Our AC cables are manufactured with Star Lay design.
The construction details of the Star cables are mentioned hereunder:

Fornoflex hose
The Fornoflex hose is made of synthetic rubber, reinforced by rayon plies. Its mechanical characteristics allows it to withstand severe operating conditions:
- service pressure of about 4 to 10 bars
- torsion, traction and shearing stresses due to the furnace movements
- mechanical shocks inside and outside, due to electromagnetic stresses
- heat radiation from the liquid steel bath
- projection of molten metal
- voltages up to 1200 V.

The Fornoflex is a special tube made with a particular anti-abrasive vulcanized external strip that doesn't need the bumper.
Up to request other several protection can be added to this, such as:
- vulcanized glass fibre, aluminium-glass fibre sleeve (against radiation), silicone glass fibre sleeve (against projections)
- reinforcing sleeve, to strengthen the ends against shearing stress.

Of course, all our hoses are insulating, and their insulation is tested before use. Until now, a service voltage of 1000 V is sufficient in many cases, but the hoses are already designed for service voltages as high as 2000 V, covering the future needs of power increase.





Copper conductor
The conductor is made of electrolytically refined tough pitch copper, with guaranteed conducity.
Each wire is tinned plated to avoid the copper oxidation and get a longer medium life of the cables and it has a diameter of 0,5 mm.
Inside at each copper rope a copper spring is located to assure the water flow in the rope and to have the best copper cooling.

Rubber core
The core is made of synthetic rubber. It is here to support the conductors.

Star profile
The difference between the Star cable and the others is the inner star profile where the copper rope are adapted.
This support not only avoid the abrasion between the ropes, but also guarantees the best water flow in each cable position.

Fixing bands
Made of non-magnetic stainless steel (for protection against eddy currents), they ensure a very tight clamping by means of stainless steel locking buckles.

Copper terminals
Made of the same material as the copper conductors, they are connected to it by low temperature brazing, which allows to use them again when the cable is damaged.
Their dimensions are calculated to ensure a good contact area (contact density = 0.7 A/mm² maximum).



Aluminium glass fibre sleeve



Silicone glass fibre sleeve



Vulcanized glass fibre cover

Cables range

We make the rope by ourselves, for this reason we can make every section and lenght. Therefore the list given hereunder only mentions the most common references, but almost any other combination is possible, upon specific requirement. Rope Lay cables are also available if necessary.

Low impedance star cable for electric arc furnaces

Code	Section	Wires for each cable	Wire section	GMR	Resistance t= 30°C DC µ Ohm/m	Water l./min.	Bending radius mm.	ø Fornoflex tube	ø Fornoflex tube with rotating terminal
STM 1	900	6	150	30	20	1,01	400	80 x 112	80 x 112
STM 2	1200	6	200	32	15	1,37	400	80 x 112	80 x 112
STM 3	1500	6	250	37	12	1,72	500	100 x 134	100 x 134
STM 4	1800	6	300	39	10	2,08	500	100 x 134	100 x 134
STM 5	2100	6	350	45	8,5	2,48	500	100 x 134	100 x 134
STM 6	2400	6	400	47	7,5	3,00	650	130 x 172	130 x 172
STM 7	2700	12	225	58	6,6	3,60	700	140 x 184	140 x 184
STM 8	3000	12	250	60	6,0	4,18	760	152 x 199	152 x 199
STM 9	3300	12	275	62	5,4	4,74	760	152 x 199	152 x 199
STM 10	3600	12	300	67	5,0	5,26	810	163 x 210	163 x 210
STM 11	3900	12	325	68	4,6	5,38	810	163 x 210	168 x 215
STM 12	4200	12	350	69	4,2	5,94	810	163 x 210	168 x 215
STM 13	4500	12	375	72	4,0	6,58	840	168 x 215	168 x 215
STM 14	4800	12	400	74	3,7	7,20	950	190 x 238	190 x 238
STM 15	5100	12	425	76	3,5	7,70	950	190 x 238	190 x 238
STM 16	5400	12	450	86	3,3	8,10	1015	203 x 253	203 x 253
STM 17	5700	12	475	88	3,1	8,50	1015	203 x 253	203 x 253
STM 18	6000	12	500	90	3,0	8,90	1015	203 x 253	203 x 253
STM 19	6300	12	525	100	2,8	9,10	1015	203 x 253	210 x 270
STM 20	6600	12	550	105	2,7	9,50	1050	210 x 270	210 x 270
STM 21	6900	12	575	110	2,5	10	1100	220 x 270	220 x 270

The cooling water quantity is calculated for a cable 1 m. length, at a specific load 4,5A / mm^2 with a cooling water temperature difference of Δt = 5°C.

Uniflex rope Lay cables

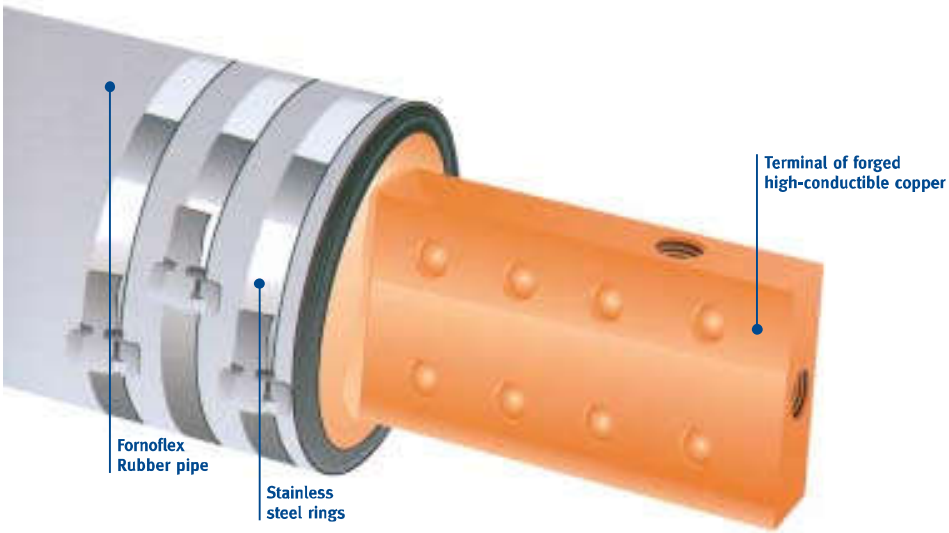
Water hose
The water hose of the Rope Lay cables is identical to that of the Star cables, which is described in detail on page 4.

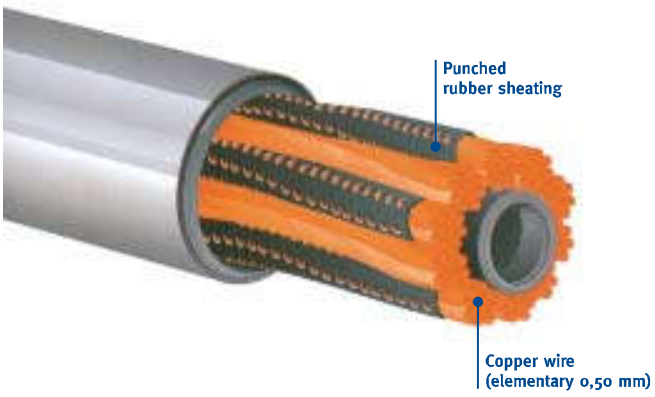
Copper conductor
The copper material is the same as for Star cables, and the conductor structure is Concentric Lay too. However, the copper distribution is different, and for a given section (and number of strands), there are more layers than in AC cables, again because of the absence of skin effect.

Copper conductor
The conductor is made of electrolytically refined tough pitch copper, with guaranteed conducity.
Each wire as diameter of 0,5 mm.

Fixing bands
Made of non magnetic steel, they ensure a very tight clamping by means of stainless steel locking buckles.

Copper terminals
Made of the same material as the copper conductor, they are connected to it by low temperature brazing, which allows to use them again when the cable is damaged.
Rather than cast or forged, they are made by machining different parts that are silver brazed together.
Their dimensions are calculated to ensure a good contact area (contact density = 1.1 A/mm² maximum).





Low impedance Uniflex cable for electric arc furnaces

Code	Section Sqmm	Wires for each cable	GMR	Resistance at 30°C DC µ Ohm/m	Water l/min	Bending radius mm	ø rubber tube	
CR10	1000	6	24	18	1.13	400	80	104
CR15	1500	6	28	12	1.72	500	102	131
CR20	2000	6	30	9	2.65	500	102	131
CR25	2500	8	35	7.2	3.20	630	127	163
CR30	3000	8	37	6	4.18	630	127	163
CR35	3500	8	44	5.1	5.10	700	140	177
CR40	4000	8	46	4.5	5.57	750	152	189
CR45	4500	8	55	4	6.58	750	152	189
CR50	5000	10	58	3.6	7.36	900	180	218
CR55	5500	10	66	3.3	8.23	950	190	229
CR60	6000	10	69	3	8.90	950	190	229

The cooling water quantity is calculated for a cable 1 m. length, at a specific load 4,5A / mm² with a cooling water temperature difference of $\Delta t = 5°C$.

WI cables

BRAR CAN SUPPLY WATER COOLED CABLES FOR LOWER CURRENT APPLICATIONS REQUIRED IN THE SECONDARY METALLURGY.

Water hose
The water hose is made of synthetic rubber, reinforced by textile plies.
Those hoses are designed for a range of frequencies up to 10 kHz.
Of course those hoses can be supplied with/without thermal protection (up to 370° C with the protection).

Copper conductors
FULL CORE CABLES WI UR:
The conductor is made with a single rope. This structure is used for low frequency applications (up to a maximum of 1000 Hz)
HOLLOW CORE CABLES WI B & WI RL:
WI B: the conductor is manufactured with a braid fitted on a spring core
WI RL: in this case the conductor is manufactured with a layer of elementary ropes wound around a spring core.
This structure is especially recommended for medium frequencies (up to 10 kHz).

Terminals
These parts are C.N.C. machined from a copper bar (also available in brass & bronze).
For WI UR: conductor & terminals are crimped with a heavy tool for an optimal connection.
For WI B & WI RL: the conductor and the spring core are brazed into the terminals. This good process allows to reuse them when the cable is damaged.

Spring core for WI B & WI RL
The core is made of a spring which allows water to flow also through the centre of the cable. As the sprirals are not contiguous the copper is cooled directly and the cooling effect is optimal.

Fixing bands
Made of non magnetic steel they ensure a very tight clamping by means of stainless steel locking buckles.



WI UR
FULL CORE CABLE

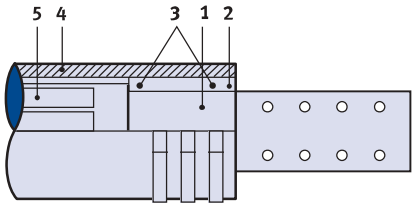
WI B
HOLLOW CORE CABLE

WI RL
HOLLOW CORE CABLE

Rotating terminals



water-cooled cable with rotating terminal



1 Forged SeCu copper terminal
2 Rotating bush
3 o-rings gaskets
4 External rubber tube
5 Flexible copper ropes

Patent nr. MN91U000014

General features

It is a new product in the field of flexible electric connections conceived in response to the problems noted by the users. We all know that, at the opening of the furnace, the electrode bearing arms rotate around their vertical axis and twist of the cable is proportional to the opening width of the arms.

Such movement is bad for the rubber tube and requires a strong effort to the structures of the furnace. As a result, BRAR's experts devoted themselves to the design and construction of a feed cable with a ROTATING terminal.

Now we can meet the needs of Arc Furnace manufactures and users having optimised the operational conditions of the cable without modifying the electrical characteristics and the flexibility of typical BRAR cables. The tests carried out in our factory by means of adequate instrumentation were able to prove that the difference in twist resistance between the two system is around 80%.

Since 1991, when the ROTATING terminal has been launched, more than 80% of our customers are successfully using our device.

Technical features

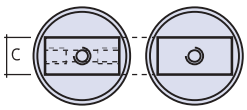
Thanks to its great functional and technical features, the ROTATING terminal allow:

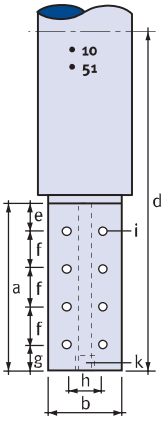
- Increasing of the medium lifetime of the rubber pipe;
- Reduction of the mechanical stress upon the structure;
- Considerable assembling easiness of the cable;
- Time reduction of the maintenance stop;

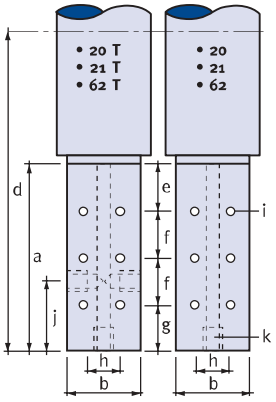
Copper terminals

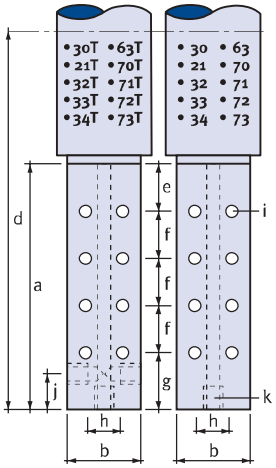


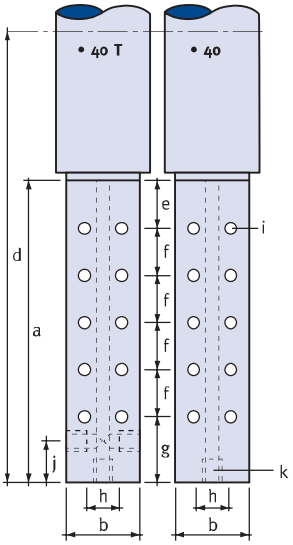
Upon request:
- different shapes
- silvered contact surfaces











Cable terminals

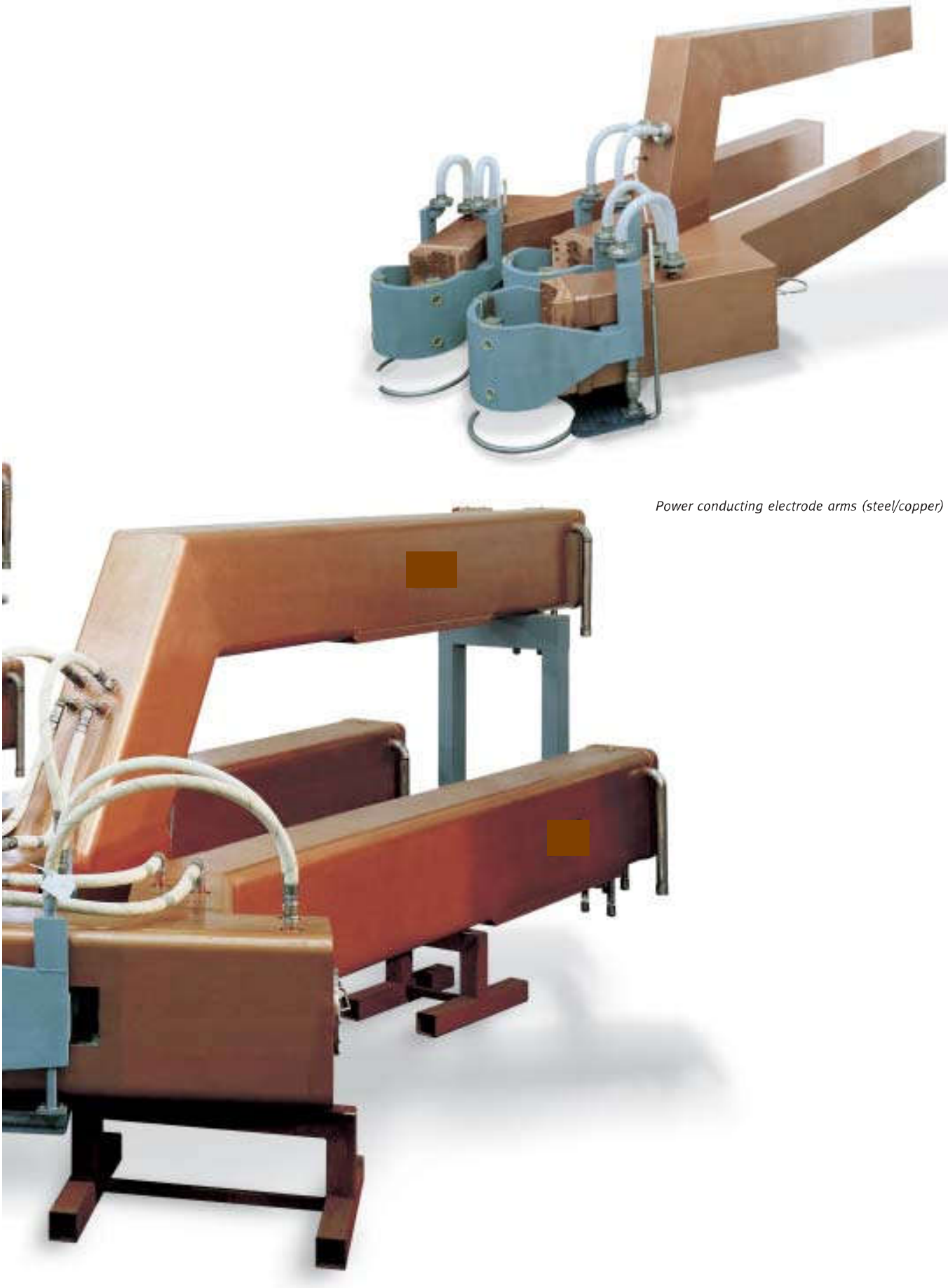
Ref.	a mm	b mm	c mm	d mm	e mm	f mm	g mm	h mm	i mm	j mm	k “
• 10	185	70	30	260	35	40,5	28,5	46	11		1/2”
• 20	200	85	30	330	50	50	50	45	14	75	1/2”
• 21	200	85	40	330	50	50	50	45	14	75	1/2”
• 30	265	100	50	395	55	50	60	65	14	30	1”
• 31	305	115	50	435	50	65	60	75	20	30	1”
• 32	305	130	50	435	50	65	60	75	20	30	1”
• 33	318	140	50	483	63	65	60	75	20	30	1”
• 34	330	150	60	495	70	65	65	75	20	30	1”
• 40	360	170	60	495	50	65	50	75	24	25	1”

Electrode arms

General features
We design and manufacture the traditional electrode arms and also the most advanced conductive arms made of copper/steel or aluminium.

Anyway we always take care to provide a turn key job, from the engineering to the manufacturing, the assembling and assistance on site.





Power conducting electrode arms (steel/copper)

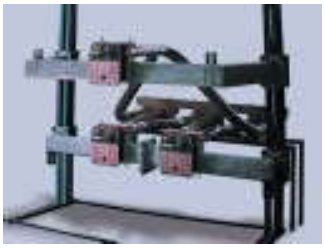
Delta closures

General features

The supply normally includes:

- SE-CU copper or aluminium water or air cooled pipes;
- Machined SE-CU copper plates for the cables and flexible connection;
- Water cooled non-magnetic steel structures;
- Insulating materials;
- Nuts and bolts;
- Flexible connections for the cooling circuit;
- Copper flexible connections for the to the transformer.

Therefore we have the capability to provide a turn key job, starting from the engineering to the building, the assembling and assistance on site.







High current busbars

General features
We design and manufacture copper or aluminium high current system (water cooled or air cooled) for induction furnaces, ferro-alloys electric arc furnaces, galvanic plants worldwide.
The complete system is calculated to optimise the operational and energy specifications requested by the project.
The conductors can be rigid (water or air cooled tubes or bars) or flexible (water cooled cables, braided connections or laminated shunts).



High current connections for ferro alloys furnace



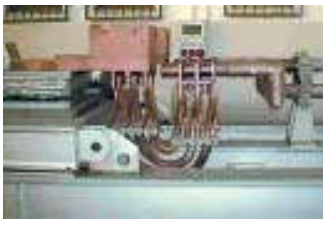
Secondary busbars for DC Electric Arc Furnace



High current connections for ferro alloys furnace



Aluminum water cooled



Copper busbars and flex

Contact pads and electrode holders

A very large range of electrode holders and contact pads can be supplied, either cast in high purity copper or forged in oxygen free copper.



Cast electrode clamps



Cast electrode holder: particular



Forged contact pads

Flexible connections

This type of connections are suitable for all industrial applications where high currents are required.

They're made of copper or aluminium laminated that allows a big flexibility, they are used to colmpensate:

- thermal expansion of busbars;
- transmission of the vibration;
- small movement.





Press-welded shunts



Rivetted shunts



Electron beam shunts



Flexibles braids

General features

HANDLING

Cable handling should be carried out with a lifting ring, available upon request by Brar. This ring is screwed on the water holes on the cable terminal.

If this lifting ring is not available, the cables should be handled with textile slings, put on the bumpers or on a rubber piece which protects the hose, **but never directly on the water hose.**

It is advisable not to handle the cables if the temperature is below 0°C.

STORAGE

The spare cables should be kept closed in their original packaging, away from source of heat, and under cover.

Temperature of storage: 0 to 55°C.

TERMINALS ASSEMBLING

The connection of the terminals, on both furnace and transformer sides, shall be done with stainless steel bolts. Tight clamping is essential and this must be checked periodically.

Any accidental loosening may result in temperature rise, with the risk of damaging the contact surfaces and high power losses.

The contact pressure must be over 15 N/mm².

It is recommended to use Brar special bolts.

BUMPERS ASSEMBLING

Bumpers of cables of the same phase must face each other, to avoid any contact with the water hose.

If in the extreme positions (tapping and roof opening), the bumpers get in touch with the hose, it may be necessary to use additional bumpers in these positions.

Also if the bumpers move or wear themselves, it will be necessary to replace them.

Brar can supply the equipment necessary to fit the bumpers.

COOLING WATER CIRCUIT

Cables should hang freely and not be allowed to come into contact with any fixed equipment (piping, walls...). A rapid wear can be caused by the limitation of the free movement of the cables caused by these obstructions.

Cables are cooled, individually or two by two, by parallel circuits.

Water pressure: service pressure has to be 4 to 5 bar, test pressure: 9 bar.

Water flow: the flow is determined as a function of the admissible temperature ΔT in the cables. The outlet temperature should not exceed 55°C.

Water quality: the cooling water should be filtered, with a low rate of calcium and sodium chloride. It should not contain any solid particle.

A closed water circuit rather than an open circuit is preferred.

Circuit control: each circuit must be permanently controlled by a flowmeter, and, if possible by a system to measure temperature.

This cable protecting system should trip the unit in case of failure (very low water flow, excessive temperature rise).

PREVENTION

The wear of the cables depends mostly on the type of unit (furnace geometry and movements, electric power...) and on the number of operation cycles.

Our directions for use should minimise the wear of the cables. However, some supplementary precautions will help to schedule the cable replacement:

- **VISUAL CHECKING OF THE WATER HOSE**

  Should be done periodically, the period dependant upon the wear already noticed. Any abnormal shape should be reported to Brar specialists.

- **CHECKING OF CONDUCTOR**

  Measurement of ohmic resistance: the cable, once removed, is subject to DC current. The voltage drop is measured, to give an indication of the resistance. When it is around 150% of the resistance of a new cable, the cable replacement should be scheduled.

  - Remove the cable.
  - Measure the voltage drop with a DC power supply.

  Brar advises all users to follow up the cable lifetime by recording the dates of erection and removal of each cable. This will help to reduce the shutdown time of the furnace, thanks to a preventive maintenance.

SPARE CABLES

It is advisable to have a stock corresponding to one phase, in order to avoid the risk of unavailability of spares.