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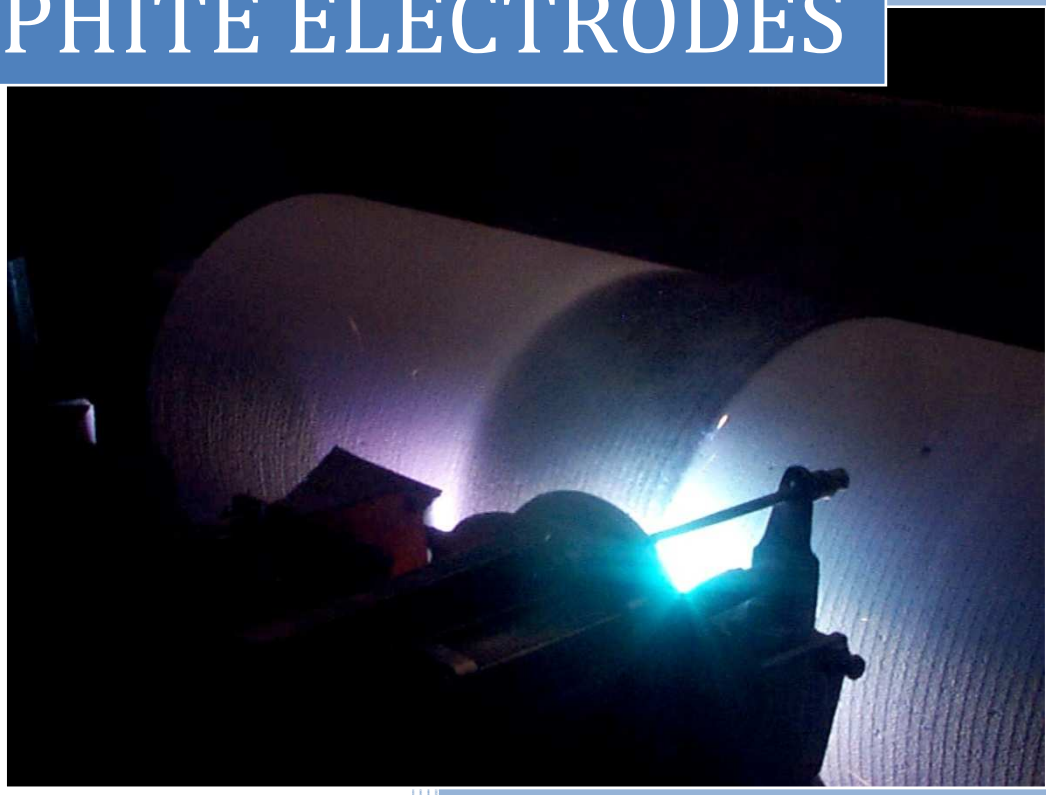
PROTECTIVE COATING FOR GRAPHITE ELECTRODES



SUPER UHP ELECTRODES

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Reducing the specific graphite consumption is one major issue for electric steel plants and can be achieved in several ways, particularly by protecting the electrode surface from oxidation or at least delaying the start of the oxidation process. For more than 40 years, the most efficient technique applied in electric steel production is the special Graphite Cova protective coating for graphite electrodes. All over the world, Graphite Cova is the only producer of this type of coating which is used in metallurgy (electric steel production) as well as in the production of non-metal and mineral products by electric arc treatment (mineral wool, corund, silicium, etc.). The production of protective coating is a high-tech process made on machines designed especially for this purpose.

On EAFs, where water spray cooling is applied for reducing the specific graphite consumption, a further reduction of 10 to 15% can be achieved by using coated electrodes. On LFs, however, the specific graphite consumption can be reduced by up to 30% by using coated electrodes (depending on the operation conditions of the furnace).

The Graphite Cova coating process has been improved continuously during the last 20 years and is available today in two main types: "white coating" and "black coating". The latest patent for the technological development of coating dates from the year 2000.

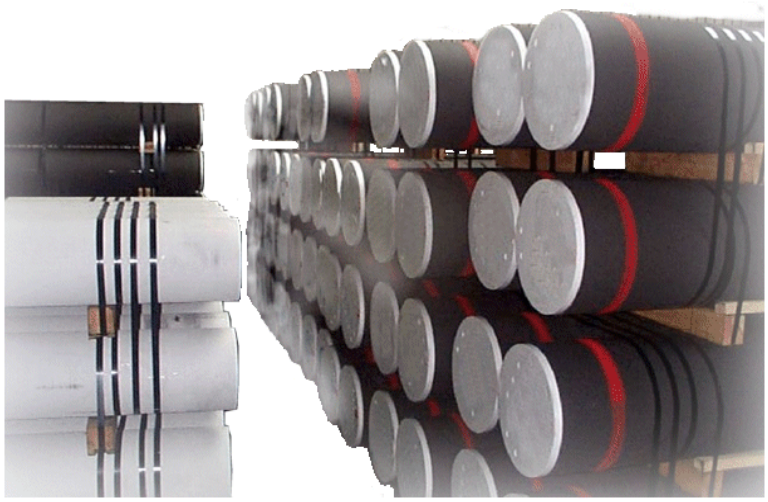

FIG. 1: „WHITE" AND „BLACK" COATING

TECHNOLOGY FOR THE PRODUCTION OF PROTECTIVE COATING

The classic coating consists of three layers applied on the electrode surface consecutively ("white coating"). The first two of them consist of aluminium alloys with an aluminum content of more than 75%. The third layer consists of pure aluminium.

The newly patented coating contains two further layers of metal and graphite ("black coating"). The total thickness of coating is 0,5 to 0,8 mm.

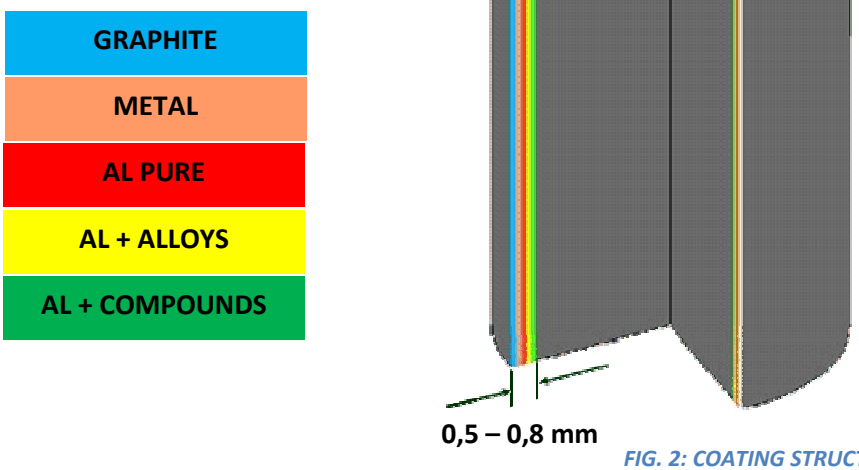

FIG. 2: COATING STRUCTURE

PROPERTIES OF THE PROTECTIVE COATING

Graphite Cova coating is the only anti-oxidation protection meeting all demands required for protective coating:

- high temperature stability in an oxidizing atmosphere
- corrosion stability against dust, slag, metal splashs, etc.
- ideal adhesion: mechanical and chemical connection on the electrode surface
- thermal shock resistance
- absolute gas impermeability
- excellent electrical conductivity
- abrasion resistance
- no negative influence on steel.

Parameter	Unit	Value
Thickness of the Coating	mm	0,5 – 0,8
Specific Electrical Resistivity	Ω.µm	0,07 – 0,10
Gas Impermeability at 900 °C	h	above 50
Temperature when Decomposition Process starts	°C	above 1850
Delay of Graphite Surface Oxidation	h	10 – 20

FIG. 3: PROPERTIES OF THE COATING

The aluminium layer of the protective coating melts at a relatively low temperature – at about 600 °C. It thus remains on the graphite surface as a liquid film with a constant thickness, guaranteeing excellent gas impermeability and resulting in increased resistance of the coating towards changes in temperature and thermal shocks.

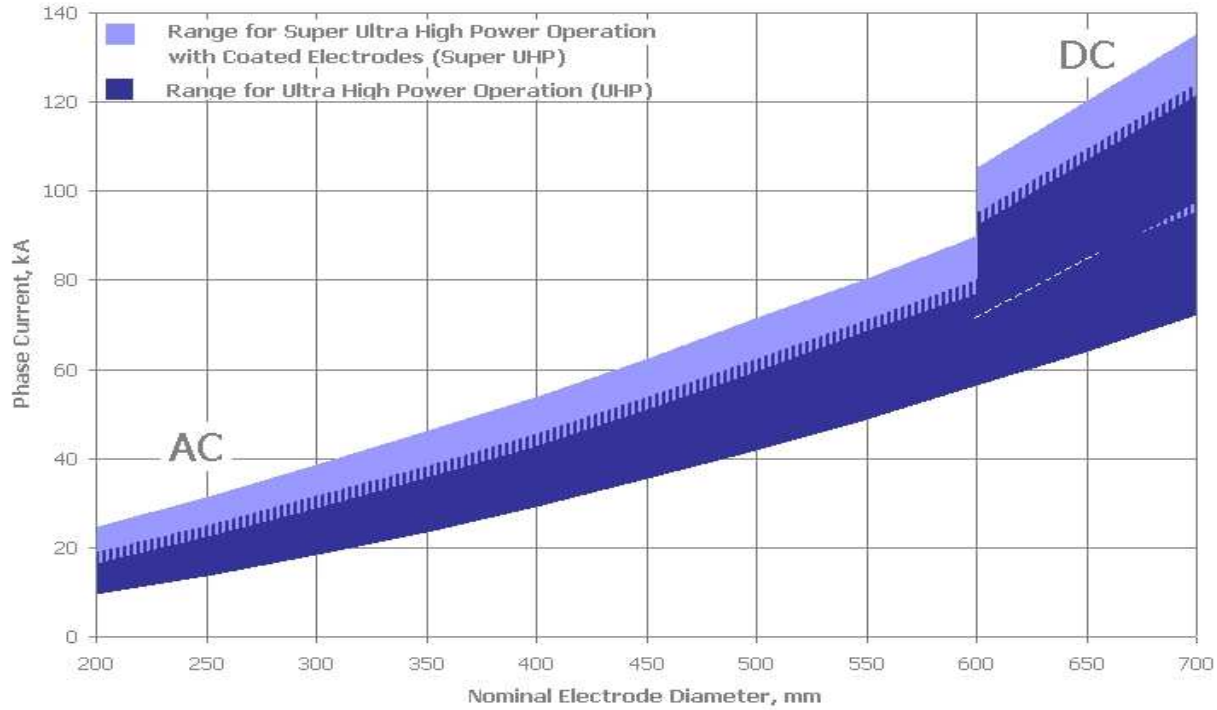

FIG. 4: CURRENT CARRYING CAPACITY FOR ELECTRODES

20 to 35% of the current run through the protective coating due to its very high electrical conductivity (40 to 80 times higher compared to graphite). Thus, the current carrying capacity of the electrodes can be increased respectively.

Higher current carrying capacity of an electrode with protective coating decreases the probability of butt losses and breakages.

PROPERTIES OF COATED ELECTRODES

Coated electrodes show reduced side oxidation when they are in operation. The protective coating delays the start of the oxidation process unless it oxidizes itself. Afterwards, the oxidation process in the lower part of the electrode column, meanwhile without coating, continues the same way and with the same speed as the one of an uncoated electrode.

CHARACTERISTICS OF THE ELECTRODE CONSUMPTION

The electrode consumption depends on the following four factors varying according to the furnace type:

- consumption due to side oxidation - 30 - 65%
- tip consumption - 30 - 60%
- consumption due to tip losses - 3 - 10%
- consumption due to breakages - 1 - 10%

Electrode producers normally sum up the first three elements and consider this sum as technological consumption. Technological consumption plus consumption due to breakages are the gross consumption.

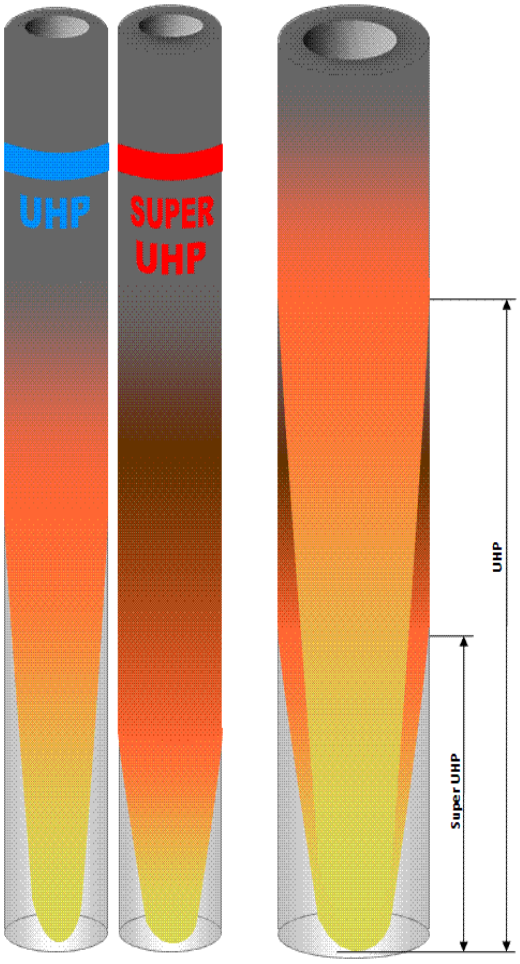

FIG. 7: COMPARISON OF OXIDATION CONES OF COATED AND NON-COATED ELECTRODES

With the other conditions remaining unchanged, consumption due to side oxidation is proportional to the surface subject to oxidation. Protective coating reduces the length of the oxidized surface by 35 to 50%. The oxidation cone is reduced, the tip diameter is increased by 25 to 35 mm. Thus, the tip consumption as well as the consumption due to tip losses is reduced as the walls of the socket at the tip are thicker. As a consequence, savings in specific graphite consumption of up to 30% can be achieved.

The effect of the coating can be clearly seen if a non-coated and a coated electrode are assembled in one column. Within the same temperature range, the oxidation process of the coated electrode in the connection starts much later.

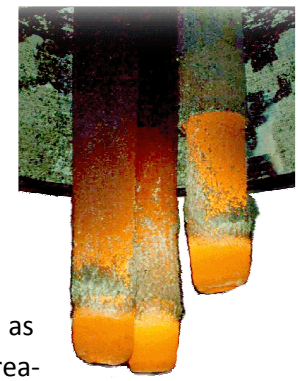

FIG. 5

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FIG. 6 + 7: NON-COATED AND COATED ELECTRODES IN OPERATION IN ONE COLUMN

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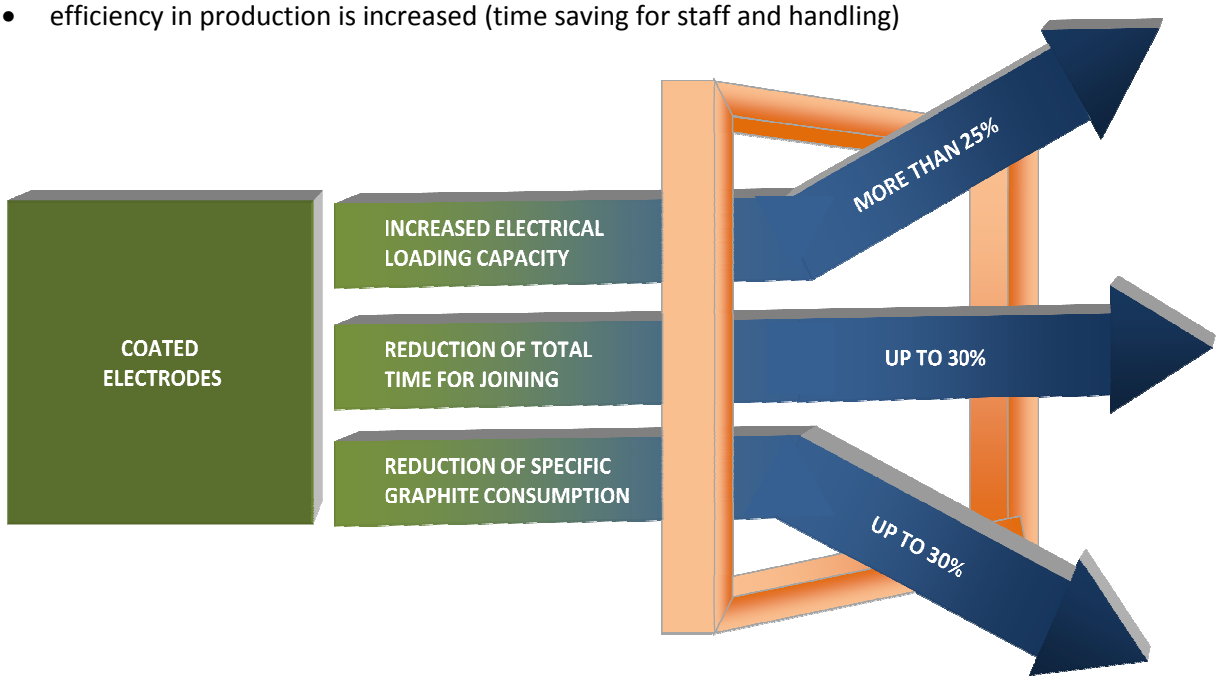
FIG. 6

ADVANTAGES OF COATED ELECTRODES

The following targets can be achieved by using electrodes with Graphite Cova coating:

- electrode quality is improved (durability and conductivity)
- specific graphite consumption in steel plants is reduced by up to 30%
- graphite costs in electric steel plants are reduced
- efficiency in production is increased (time saving for staff and handling)



RECOMMENDATIONS FOR USING COATED ELECTRODES

No changes on the furnace are required for using coated graphite electrodes. In order to guarantee best operation conditions and a good current transfer in the contact surfaces, following requirements should be fulfilled:

- keep the contact surfaces of the electrodes and clamps clean and in good condition
- keep the recommended clamping forces of the electrode systems
- keep the contact clamps and the electrode spray cooling system intact

GRAPHITE INSERTS

In case the electrode clamps cannot be kept as clean as required, they may be provided with graphite inserts with the corresponding radius and a thickness of 20 to 25 mm. Graphite inserts reduce the costs for repairs/maintenance of the contact clamps considerably and extend its life by a multiple. As the copper contact surfaces are protected by the graphite inserts, they are kept clean and in good condition. Depending on the furnace's operational conditions, the life of these inserts is one to three months. Due to their mechanical abrasion, they must be replaced afterwards.

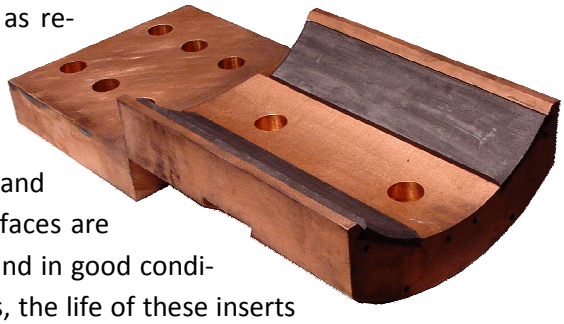


FIG. 8: ELECTRODE CLAMP WITH GRAPHITE INSERTS

CERAMIC AIRCOOLED ECONOMIZER

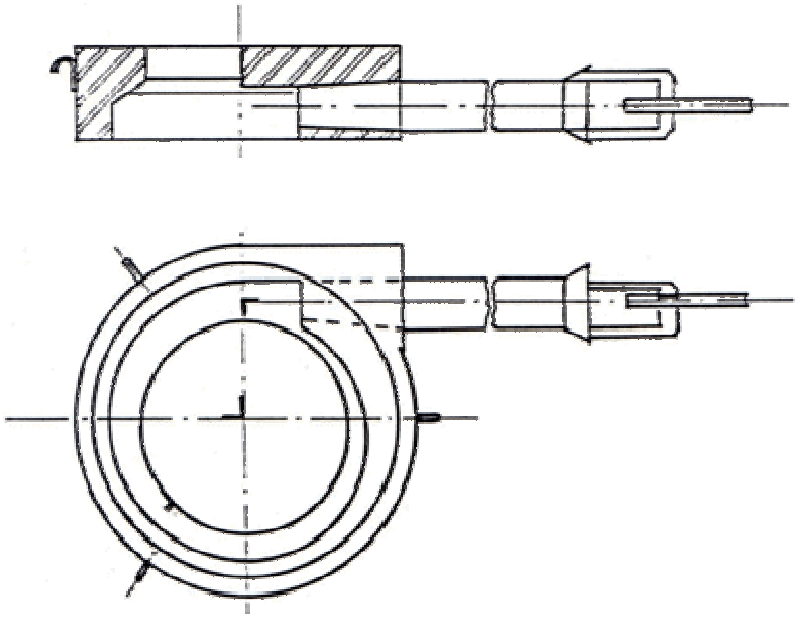


FIG. 9: FORM OF A CERAMIC AIRCOOLED ECONOMIZER

Coated graphite electrodes can be used in combination with the ceramic economizer for electrode roof holes which is based on the "air blast" principle and flame emission through the electrode openings in the furnace roof is prevented 100%. Compressed air is blown into the injector tubes, sucking this air quantity approx. another 15 times from the factory hall and streaming into the electrode holes over a spiral inside chamber of the economizer. In this chamber, the air pressure is slightly higher than the one created by gases and flames emanating from the furnace.

The consumption of compressed air for every economizer is 40 to 50 Nm^3/h at a required pressure of 0.3 to 1.5 bar. Life varies between 15 and 50 days, depending on the furnace operational conditions. The installation of economizers is only useful if coated electrodes are in operation as the injected air would intensify the oxidation process of a non-coated electrode considerably.

Advantages of economizers:

- no deposition of furnace dust oxides on the coating, life is extended
- reduction of the specific graphite consumption by another 2%
- reduction of number of electrode joints and/or of replacements of electrode columns
- improvement of working conditions of the clamps
- no creation of low pressure in the furnace area
- considerable reduction of air pollution in the furnace hall
- life extension of the furnace roof

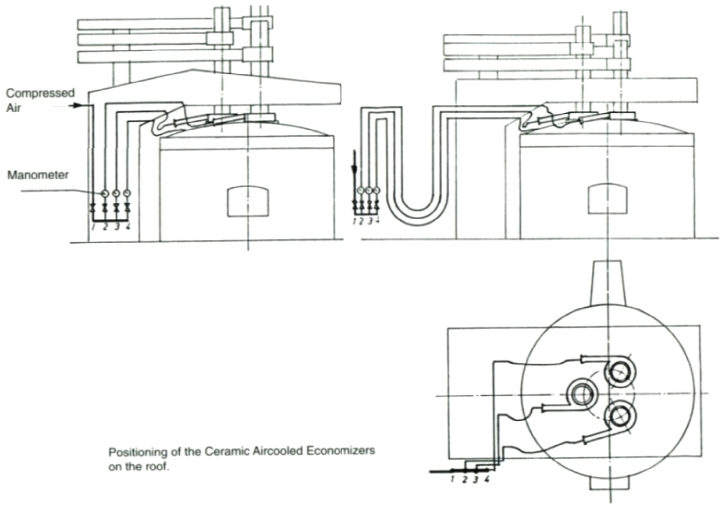


FIG. 10: ASSEMBLY OF THE ECONOMIZER ON THE FURNACE ROOF

RESULTS WITH COATED ELECTRODES

The coating can be applied on all electrode brands. The different results in the savings in the electric steel plants are due to the individual working conditions of the electric arc furnaces as well as the varying electrode qualities.

Electrode Diameter [mm]	Customer	Country	Heat Weight [mt]	Phase Current [kA]	Reduction in Specific Graphite Consumption [%]
300	A	Germany	70	24	24
300	B	South Africa	80	22-27	18
350	C	Denmark	90	22-27	25
350	D	Italy	80	22-27	26
350	E	Sweden	95	22-27	20
350	F	Turkey	80	22-27	18
350	G	Germany	81	25	30
400	H	Italy	100	33	28
400	I	Germany	90	29	21
400	J	France	165	31	20
400	K	USA	100	30	20
400	L	USA	120	28-30	25
400	M	USA	165	32	18
400	N	USA	125,5	29	17
450	O	France	165	35	18
500	P	Great Britain	165	35	18
600	Q	Finland	90	51-70	12
600	R	Spain	115	65	17
700	S	Germany	130	90-100	10

FIG. 11: EXAMPLES FOR SAVINGS IN ELECTRIC STEEL PLANTS (NAMES OF STEEL PLANTS NOT INDICATED)