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PLANNING, INSTALLATION, START UP AND OPERATION OF TIN PLATE LINES IN BRAZIL [1/]

by

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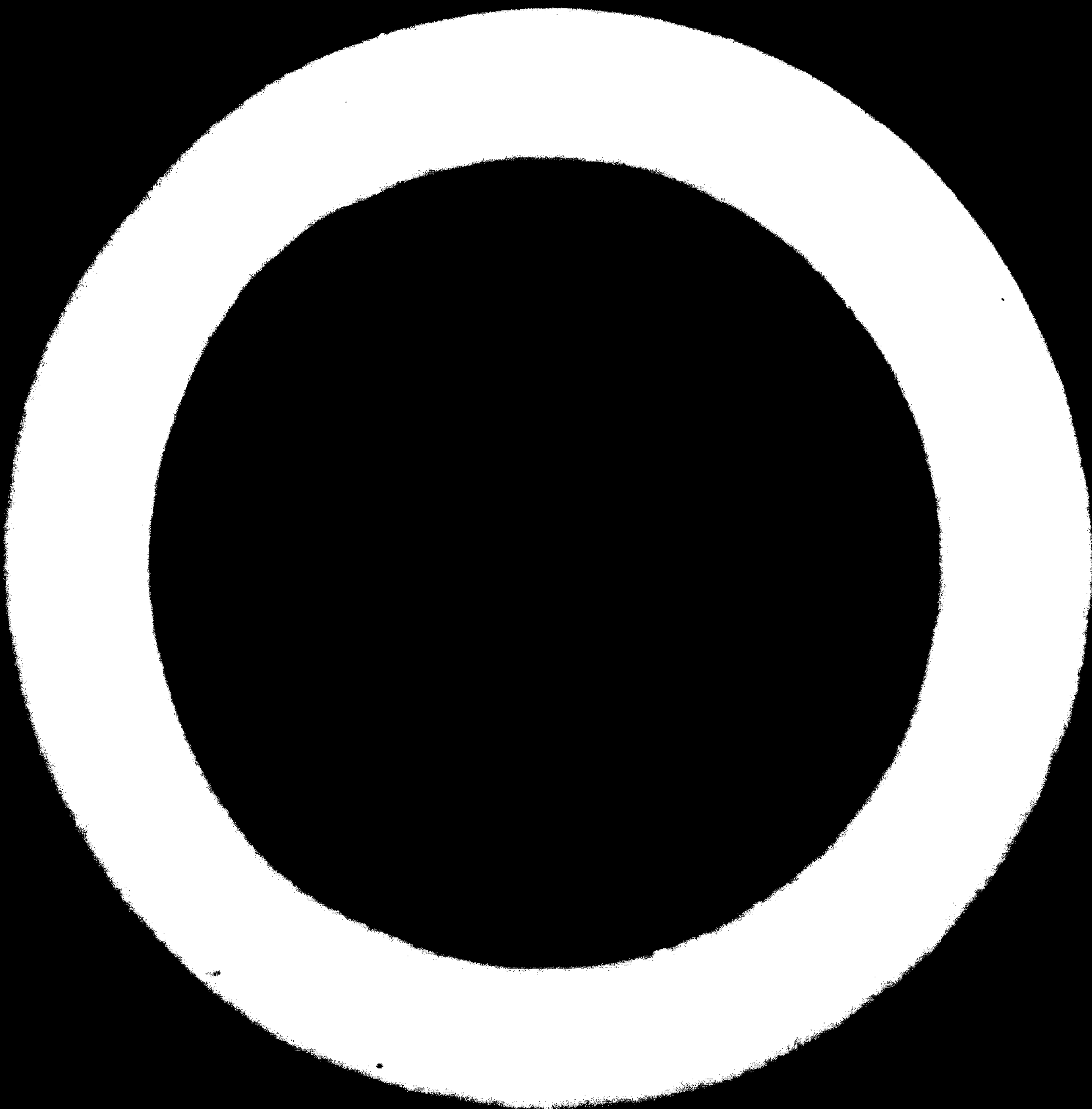


I - GENERAL

1. LOCALIZATION

All tin plate produced in Brazil is manufactured in the President Vargas Plant of the Brazilian National Steel Company. The Plant is located in Volta Redonda city, Rio de Janeiro State, 120 kilometers away from Rio de Janeiro and 350 kilometers from São Paulo city.

2. CONSIDERATIONS ABOUT TIN PLATE IN THE WORLD

The quality problems and high production cost of the old hot dip coating process for the production of tin plate prompted searchers to investigate other methods of production. Electrolytic coating was studied because the potential for uniform tin coatings in a continuous process presented the opportunity to produce a superior product at a lower cost. It seems that Germany was the first country that produced electrolytic tin plate trying acid and basic electrolyte, with good results.

However, the American literature says that tin plate was not of good quality, was high cost, low production, rates and operation with many difficulties.

In 1930, at least, two experimental lines were coating coils 6" to 8" wide by the electrolytic process. The first line to produce electrolytic tin plate in commercial sizes was the Gary Tin Mill, USS, in 1937.

The acid process using phenolsulfonic acid and sulfone in its electrolyte was patented by United States Steel Corporation with the name of FERROSTAN.

In 1941 a shortage of tin developed in USA might loose a great part of their supplies. This possibility contributed to the rapid commercial development of the electrolytic process and research was accelerated to improve the quality.

The electrolytic tin coated sheets were initialy used to can non-corrosive dry products. The use of electrolytic tin rapiddly expanded into the more corrosive products as the quality improved.

The development of lacquers contributed to increase the uses of electrolytic tin sheets.

After 2nd world war, the electrolytic coating process was further developed and in 1947 the production in U.S.A. was approximately 2 millions tons, almost the same tonnage of hot tin plate.

Since 1947 the production of electrocoated sheets and coils has been growing and surpassing the hot dipped coated sheets.

II - PLANNING - HOT DIP AND FERROSTAN LINES

The Brazilian National Steel Company started production of hot dip tin plate in 1948. The decision to produce tin plate in Brazil was based on market potential, import levels and investment cost. Six hot dip coating machines were installed; five were 64 inches wide and one 75 inches wide. Production increase from 1948 and reached a peak of 55,248 tons in 1956.

The demand for tin plate grew faster than the production capacity and in 1956, the Brazilian National Steel Co. started the first FERROSTAN line.

Coating weights of .25 lb/bb and .50 lb/bb were produced by the new process compared to 13.7 kg/ton or 1.50 lb/bb by the hot dip process.

The start up of the complex electrolytic coating line was not easy but as the equipment problems were solved it became obvious that the quality requirements for the strip to be coated by electrolytic process were for more demanding than the quality requirements for the sheets which were hot dip coated. Defects such as box annealing oxides, rust, slivers, scale and roll marks which were covered by the hot dip process could not be tolerated in strip for electrolytic coating. Improvements in equipments, operation and quality control through the entire process sequence of hot rolling, continuous pickling, cold reduction, cleaning, annealing, temper rolling and electrolytic coating led to the improvement of product quality of electrolytic tin plate. The number of unsatisfactory coils which were previously diverted to the hot dip process declined and in 1966, the Brazilian National Steel Co. produced 30,121 tons of hot dip tin plate and 140,505 tons of electrolytic tin plate for a total production of 170,626 tons of tin coated products.

In 1967 we started the second FERROSTAN line and in the following year stopped production of hot dip tin plate. Studies were stablished to convert three hot dip tin machines to produce long terne-plate for the automobile market. In 1969 the production reached 550 tons, mainly 18 and 20 gages, .0478" and .0359" thickness.

As the Brazilian tin plate market is growing and exerting demanding pressure intersted in being supplied with tin plate having smaller thickness 75 lb, 65 lb or even less and to reach the goal of 450,000 tons it is planned to install in the next three years, the third FERROSTAN line. This next expansion program will include one continuous annealing line and one combined double cold reduction temper mill, equiped with AGC. The continuous annealing will make it possible to increase productivity and produce a more uniform annealing. The product will be known as the internationally recognized TU, used in place of T-4 and T-5 types. The combined mill will permit rolling as a Temper Mill or as a Double Cold Reduction Mill.

The future program expansion aims to reach 600,000 tons per year and includes the fourth electrolytic tinning line. This expansion program is based on the production of cut sheets but, in order to attend to future, possible requirements of the market we will be able to install in one FERROSTAN line two coilers and one uncoiler to produce coils tin coated.

III - INSTALLATION

1. HOT DIP MACHINES

a) PICKLING

The equipment installed would not permit a continuous operation.

The charge and discharge of the sheets to be pickled was manual and sheets piled inside steel boxes to be transported and stored.

b) TINNING MACHINE

The installation would permit a continuous operation and consists of 5 principal parts: Poole Feeder with magnetic roll to feed machine automatically; Tin pot with tin machine 64" or 75" wide that permit to process two or three sheets paralel; Washing Tank, Branner and Pilers.

2. FERROSTAN LINES

a) LINES DATA

NO. 1 LINE

Coil weight	13,6 ton	(30,000 lb)
Coil I.D.	50 cm	(20")
Coil O.D.	167,64 cm	(60")
Maximum strip thickness	0,394 mm	(.0155")
Minimum strip thickness	0,168 mm	(.0066")

Maximum strip width	96 cm	(38")
Minimum strip width	35, 56 cm	(14")
Sheared lengths	42, 72 cm to 95, 25cm	(18" to 37 1/2")
Line speed	304, 8 m/minute	(1000 FPM)

NO. 2 LINE

Coil weight	15 ton	(33, 000 lb)
Coil I. D.	50 cm	(20")
Coil O. D	183 cm	(72")
Maximum strip thickness	0, 607 mm	(. 0239")
Minimum strip thickness	0, 152 mm	(. 006")
Maximum strip width	96 cm	(38")
Minimum strip width	40 cm	(16")
Sheared lengths	50 cm to 116, 84 cm	(20 to 46")
Line speed	457 m/minute	(1500 FPM)

b) The FERROSTAN Lines can be divided in three principal sections:

Entry sections that includes two uncoilers, pinch rolls, double cut air shear, welder machine, entry bridle rolls, looping pit or tower, steering rolls, drag bridle rolls.

Intermidiate section or process that includes electrolytic cleaning tanks, electrolytic pickling tanks, water rinse tanks, water rinse scrubbers tank, plating tanks, dragout tanks, wring rolls, steam dryers, hot air dryers, differential coat roll marker, resistance melting tower, quench tank, chemical treat tanks, electrostatic oiler and drive bridle rolls. This section also includes the circulating-storage solution tanks, pipes, coolers and evaporator.

Exit section consists of Pin hole detector, X or β ray, gauge control, flying shear, leveller, run-out tables, sheet counters, sheet classifiers and packaging conveyor.

UNCOILERS

Both lines with two uncoilers and coil holder to handle coils and permit a continuous operation. See Photo no. 1.

PINCH ROLLS

To lead the head of strip to the double cut shear.

Photo no. 1 - UNCOILERS

DOUBLE CUT AIR SHEAR

This shear cuts the ends of coils to be welded.

WELDER MACHINE

Attaches the coil of the uncoiler to the tail of the preceding coil.

NO. 1 FERROSTAN uses over lap double seam welder and No. 2 narrow lap seam welder. The sheets with weld are automatically rejected by automatic micrometers. However to garantee sheets bundles absent of weld marks, during welding operation is made a small hole at the front of weld region and the tin plate welded is also rejected by the pin holes detectors. See Photos No. 2 and 3 - Narrow lap seam welder.

ENTRY BRIDLE

Feeds strip to looping pit no. 1 Line or looping tower (see photo no. 4) no. 2 Line. Looping pit and tower - The looping pits and tower contain enough strip to permit continuous operation of the lines at reduced speed between 300 and 500 FPM while the new coil is being welded to the one in the Lines. It was adapted to the tower top deflector rolls a brake system, compressed air operated, that stops all no. 2 Line during weld strip brake.

Photo no. 2 - WELDER MACHINE

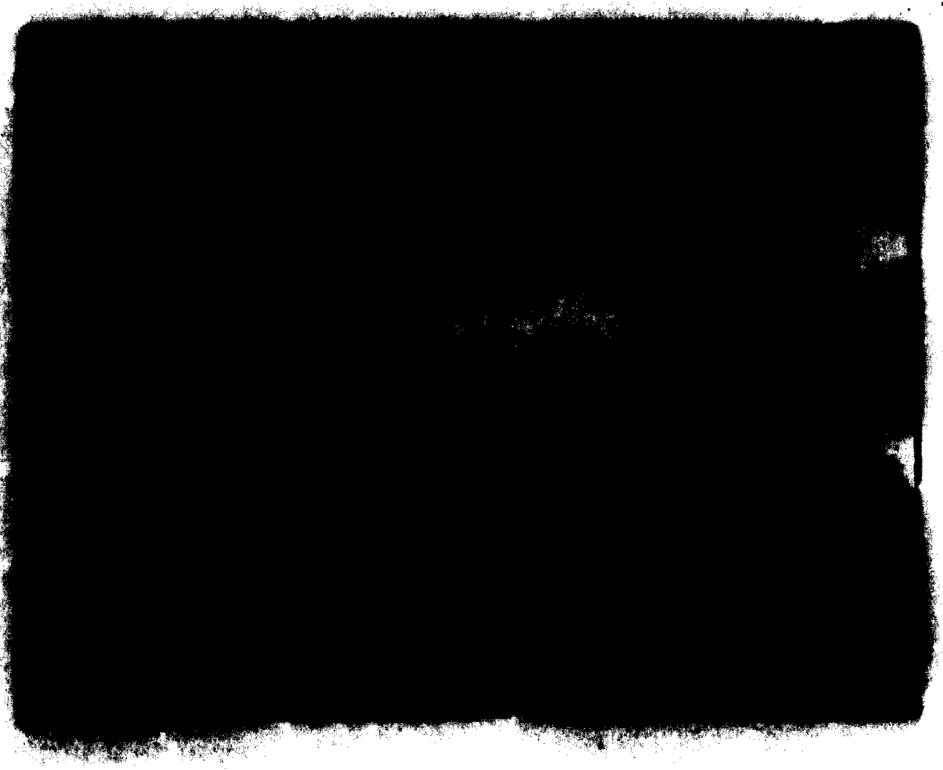


Photo no. 3 - WELDER MACHINE

Photo no. 4 - LOOPING TOWER

STEERING ROLL ASSEMBLY

Is used in no. 2 FERROSTAN Line to maintain automatically, through photo cels, the strip centered during operation. The movable rolls are hydraulically operated. See Photo no. 5.

DRAG BRIDLE ROLLS

Provides the desired strip tension to permit tracking the strip through the Lines.

ELECTROLYTIC CLEANING TANKS

Through this alkaline cleaning tanks, the strip is electrolytically cleaned to remove grease, oil and dirt. Because of the extremely short time available for cleaning the strip, the chemical cleaning action of the alkaline solution is electrolytically aided. Temperature of the cleaning solution through a heater reservoir storage tank to which additions of water and cleaning compound are made as required.

No. 1 Line has one electrolytic tank with one entry cleaning generator and one delivery cleaning generator with total 7.500 A and 24 V. It is possible to work as cathodic or anodic cleaning in order to keep the stainless electrode clean.

No. 2 Line has one electrolytic tank and one alkali dunk tank. The top tanks bodies is one unit. They operate with silicon rectifiers. Two silicon rectifiers, total current 15,000 A and 24 V. It is possible to work with cathodic-anodic, anodic cathodic, both cathodic or both anodic passes.

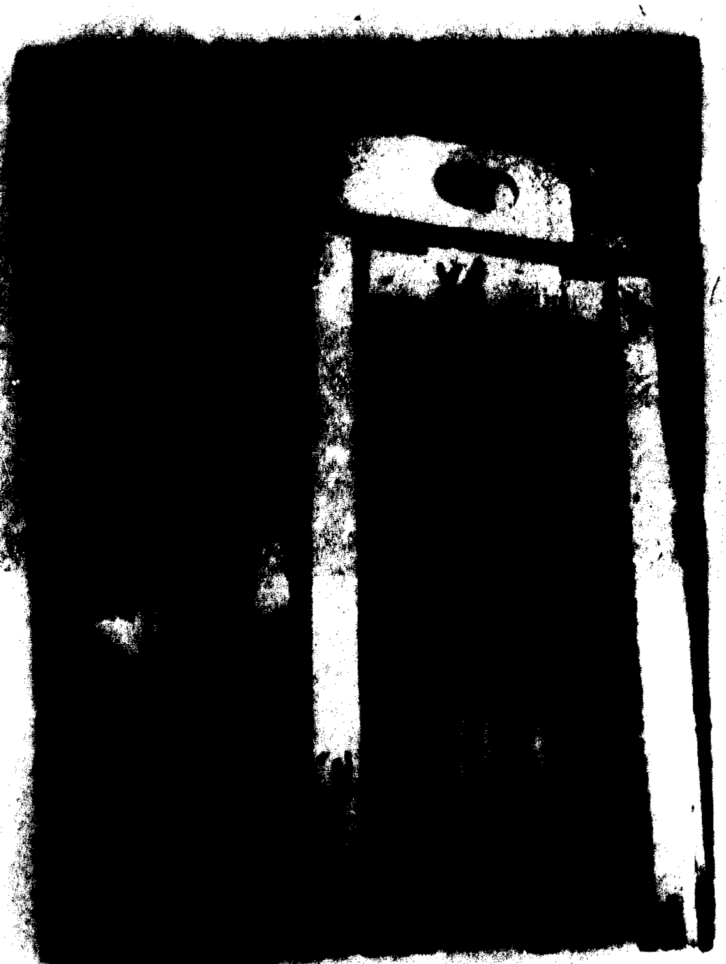


Photo no. 5 - STEERING ROLL ASSEMBLY

ELECTROLYTIC PICKLING TANKS

Although the strip as it leaves the cleaner rinse should be free of surface soil, oxides formed during the various stages of steel processing are not removed by the cleaner. The purpose of the acid pickle is to remove these oxides and lightly etch the strip, thus presenting as clean a steel surface as possible to the plating solution. As is true of the cleaner, the short times available for pickling also require the use of electrolytic to achieve the most benefit. Addition of sulfuric acid in both FERROSTAN Lines is by gravity.

No. 1 FERROSTAN Line pickling may be cathodic or anodic through a single tank, without solution circulation. Two generators with 7,000 A and

15 V (See photo no. 6).

No. 2 FERROSTAN Line pickling may be cathodic-anodic, anodic-cathodic, both cathodic or both anodic through two tanks. Four silicon rectifiers 30,000 A and 24 V. (See photo no. 7).

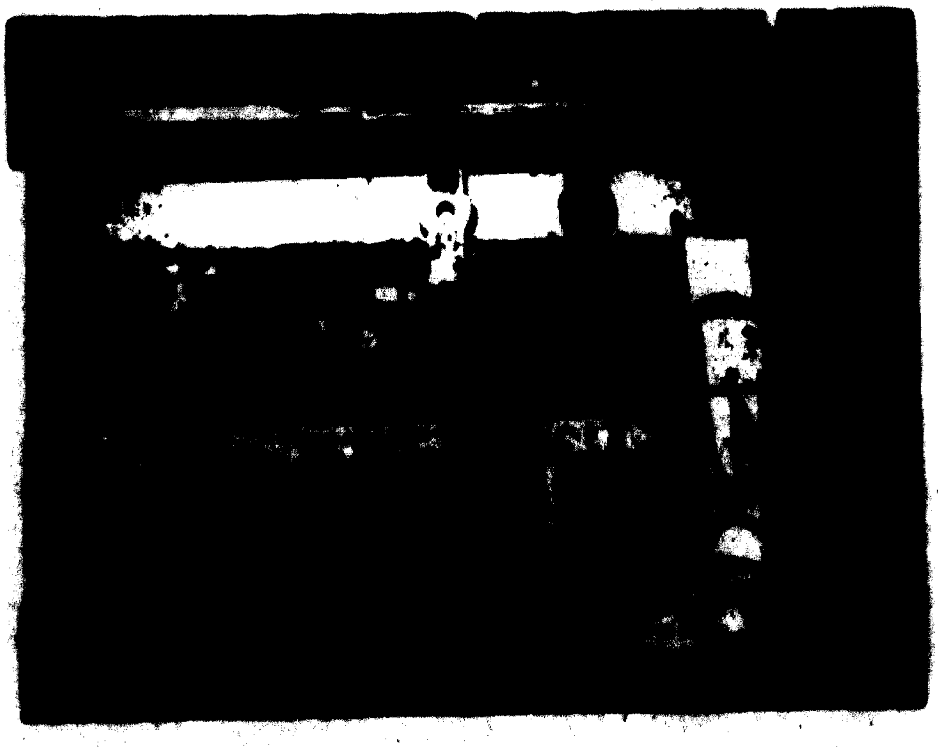


Photo no. 6 - PICKLING TANK

Photo no. 7 - PICKLING TANKS

WATER RINSE TANKS

Cleaning rinse shall be as through as possible to prevent contaminations and neutralisation of the pickle acid by the cleaning solution. This rinsing in both Lines is by water sprays. Pickling rinse is very important. Although the plating electrolyte can tolerate some sulfate ion, excessively high concentrations of sulfate ion are deleterious to electrolyte function.

WATER RINSE SCRUBBERS TANKS

The production of double reduced tin plate will require modifications of this unit: The two scrubbers tanks of no. 2 FERROSTAN Line will be removed and installed in alkaline cleaning lines, to improve strip cleaness after cold reduction.

PLATING TANKS

The plating section in both Lines consists of several vertical tanks arranged in tandem so that any point on the strip passes into each tank consecutively and the tin coating thickness is thus increased in successive plating. The tank is rubber-lined steel construction and contains a rubber-covered sink roll that is driven in no. 2 FERROSTAN Line. In addition to the sink roll, two chrome-plated copper conductor rolls, with vapor-blast finish, are associated with each tank. Each conductor roll is fitted with a rubber covered hold-down roll to maintain tight strip contact with the conductor roll.

Current is transferred from the conductor rolls to the strip so that the strip becomes cathodic to tin anodes that are hung from bus bars (bridges) into the plating electrolyte. The anodes are pure tin and made by mold casting (66" long, 3" wide and 2" thick). See photo no. 8.

Photo no. 8 - TIN ANODE 66" x 3" x 2"

Contact between the Anode bridge and the anode is made by hanging the anode over the bridge by means of a hook formed in the anode during casting.

No. 1 FERROSTAN Line plating consists of 5 tanks and 10 generators (5 top and 5 bottom) for 65,000 A and 15 V. See photo 9.

No. 2 FERROSTAN Line consists of 8 plating tanks (the top tanks body is one unit) with silicon rectifiers for 96,000 A and 24 V, 48,000 A top and 48,000 A bottom. For differential coatings it is possible to switch on top 64,000 A and 32,000 A bottom. See photo 10.

Photo no. 9 - PLATING TANKS

DRAGOUT TANKS

The function of this step in the process is to prevent or reduce the loss of plating electrolyte that adheres to the strip as it leaves the last plating tank. A large percentage of this electrolyte is squeezed off by the hold-down roll on the exit conductor roll.

The drag-out can be reduced to 1 or 2 cc per square foot of strip area at normal speeds. At high speeds the pumping action of the strip results in a thicker liquid film between the conductor roll and the strip. More carry-over and splashing of the electrolyte is also experienced, so every effort should be made to recover as much of it as possible. Even 1 to 2 cc per square foot represents the loss of a considerable volume of solution, approximately 25 to 50 gallons per hour at line speed of 600 FPM. To recover at least a part of this, the strip is washed with a dilute PSA solution. This is accomplished in both FERROSTAN Lines by passing the strip through rubber-lined tanks containing the recovery solution. Because its higher speed, no. 2 Line is provided with a second drag-out recovery unit to increase the dilution ratio. The make-up water is provided by steam condensated. See photo no. 11.

Photo no. 10 - PLATING TANKS

Photo no. 11 - DRAG OUT TANKS AND WRINGER ROLLS

WRINGER ROLLS

On leaving the recovery unit, the strip passes through two pairs of wringer rolls so that the net result is the removal of the original film of strong electrolyte and the replacement of it with a film of dilute electrolyte.

STEAM DRYERS - HOT AIR DRYERS

The drying is accomplished by passing the strip through a series of steam jets in no. 1 Line and hot air jets in no. 2. Hot air dryers are more efficient than steam dryers.

DIFFERENTIAL COAT ROLL MARKER

Soon after the introduction of heavy-coated (1.0 lb/bb) electrolytic tin plate, it was recognized that for many applications no more than 0.25 lb/bb tin on the exterior of the can was required. Because a light coating on one side of the sheet and a heavy coating on the other would result in a satisfactory product for many uses with resultant savings to the customer. It was apparent that such a product would be useful only if the light-coated side could be readily distinguished from the heavy-coated side to avoid using the light side on the inside of the can. In no. 2 FERROSTAN Line, that is proper to produce differential coating, the heavy-coated side is marked on top side of strip by one sodium dichromate solution printed on plated strip in a pattern of parallel lines.

No. 2 Line is equiped with a Pannier marker, developed by the Pannier Corporation, 207 Sandusky St. Pittsburgh 12, Pa., in which the strip is contacted with a patterned roll that has been dampened with a 2 to 3 % sodium dichromate solution prior to melting.

RESISTANCE - MELTING TOWER

The tin coating, as it is deposited on the strip, has a dull matte appearance. To give it a bright lustrous surface, the strip is heated to above 450º F (the melting point of the tin) and then quickly cooled to solidity the coating before it contacts a roll. Both FERROSTAN Lines of Brazil use the method called resistance melting. This method consists in passing a 60 cycle alternating current through the strip while it passes in an inverted loop between two conductor rolls connected to the transformer. Both FERROSTAN Lines of Brazilian National Steel Co. have two conductor rolls at the bottom of the melting tower and two isolated deflector rolls of heat-resisting rubber with shaft water cooled at the top of tower. The second conductor roll is located in a tank through which fresh water flows to quench the hot strip. The loop between the two conductor rolls is surrounded by an inslutated muffle to reduce heat losses from the strip. It should be noted that the two melting conductor rolls are insulated from ground. There are two other conductor rolls that are grounded. Thus there is a second, undesired path for the alternating current to flow from the two conductors to the strip and to ground. This is called the ground current; and to reduce it to a low value, choke cores are provided in the entry leg and exit leg of the melting tower. These consist of a larger number of silicon steel laminations through which the strip passes, and they serve to induce a back EMF in the strip opposing the flow of the ground current. They are effective in reducing the ground current to about 2 % of the total melting current. No. 2 FERROSTAN Line was designed with a 60' strip pass from conductor to conductor roll suitable for the application of 3,000 KVA of power, two transformer 1,500 KVA, 6.900-195 V.

No. 1 Line designed with two transformers and 1,000 KVA. The luster of the melted coating depends on a large number of factors, but the quality of the electrodeposit, the degree of fluxing, and the quench water temperature are the primary ones that must be regulated for optimum results. If the plating conditions are controlled so as to maintain the plating-current density, electrolyte temperature, and solution composition within the proper operating range, there should be no trouble in obtaining bright melting. The dragout recovery solutions serves as a very good fluxing agent if it contains 2 to 4 g/l stannous tin and enough acid (phenolsulfonic) to prevent hydrolysis.

The strip is at about room temperature as it leaves the first conductor roll of the melting furnace, but its temperature continuously increases as it passes up and over the top deflector roll and until reaches the quench tank. The melting current is adjusted so that the strip temperature reaches the melting point of the tin coating just slightly before the strip reaches the quench tank. For certain products, specially differential or heavy coated items, a slightly higher current than this may be used to improve the appearance of the product. However, this practice is not recommended since it increases the iron-tin alloy weight. The first conductor roll is dry and the second is immersed in the quench tank.

QUENCH TANK

The second conductor roll is immersed in the quench-tank and the strip reaches this roll with tin solidificated by action of cold water. The quench water is not recirculated. However, the fresh water is clean to minimise conductor roll pick up. It is not heated, but the flow in both FERROSTAN Lines is adjusted to maintain the temperature in the overflow tank between 120 and 160 º F.

In no. 1 FERROSTAN Line, the inlet consists of 1 1/4" pipe manifold with 1/16 inch holes drilled on 1 inch center, located on each side of the strip just below the water level. Additional cold water may be controlled by one manual valve and the inlet is in the bottom of quench tank for quick temperature corrections.

In no. 2 FERROSTAN Line the cold water is pumped from the inlet in the bottom of tank to the pipe manifolds located on each side of strip. The temperature control of quench tank is critical, cold quench water produces a rough melted coating and too high a temperature produces of narrow white irregular lines called quench stains.

CHEMICAL TREAT TANKS

The oxide film normally present on tin, although protective to some degree, readily grows to such an extent that discoloration of the surface is easily discernible. This oxidation and the accompanying discoloration, commonly called jellow stain, can occur during storage in warehouses under humid conditions or during the baking operation that follows lacquering or enameling. However, it is not only the change in the appearance of the tin plate that is objectionable, the oxide film formed during warehouse storage may prevent the proper adherence of some lacquers and lithographing inks to the tin surface may mar the appearence of lithographed cans or caps where the tin surface is used as a background for the lithograph design, and may cause difficulties. To minimise these difficulties, the tin plate of both FERROSTAN Lines in Brazil are stabilised electrochemically using dichromate solution. No. 1 Line has one cathodic generator producing 3,000 A, 18 V and one anodic generator producing 400 A, 8 V.

No. 2 Line has silicon rectifiers: one cathodic producing 4,000 A, 18 V and other anodic producing 2,000 A, 18 V. After Chemical Treating, the strip is rinsed and dried to remove soluble dichromate and sludge from the tin surface. See photo no. 12.

Photo no. 12 - CHEMICAL TREAT TANKS

ELECTROSTATIC OILER

After the tin plate has been treated, rinsed and dried, a thin film of lubricant is applied to the tin plate. The function of this film of lubricant is to minimize subsequent damage by abrasion, to facilitate assorting, handling, mechanical feeding and fabricating operations, and to aid in the lacquering and printing operations. In both FERROSTAN Lines at Volta Redonda, cotton seed oil is drawn from the reservoir and is broken up into fine particles by atomizing nozzles in the fog generating chamber. The fog floats through the chamber and enters the oiler inclosure through slots adjacent and parallel to the strip. As the oil fog rises parallel to the strip, it enters the electrostatic field, receives an electrostatic charge, and the particles are attracted to the strip. It is essential that the pass line through the oiler be vertical. The electrostatic field between the electrodes and the strip is obtained from high-voltage power supply, about 50 KV in both FERROSTAN Lines. See photo no. 13.

Photo no. 13 - ELECTROSTATIC OILER

DRIVE BRIDLE ROLLS

These rolls are rubber covered, motorized and drives the strip through the Lines.

CIRCULATING AND [illegible] PLATING SOLUTION (STORAGE TANKS, [illegible] EVAPORATOR)

In both FERROSTAN Lines plating solution inlet in the plating tanks is controlled automatically by regulating the flow of cold water through the coils of heat exchangers.

No. 1 Line circulating system works with one 9,000 gallons tank and two 6,000 gallons storage tanks and one evaporator to concentrate solution.

No. 2 Line works with one 12,000 gallons circulating tank, two 9,000 gallons storage tanks and two evaporators. All tanks are equiped with level indicator and circulating tanks are controlled automatically. See photo no. 14. - EVAPORATOR SYSTEM.

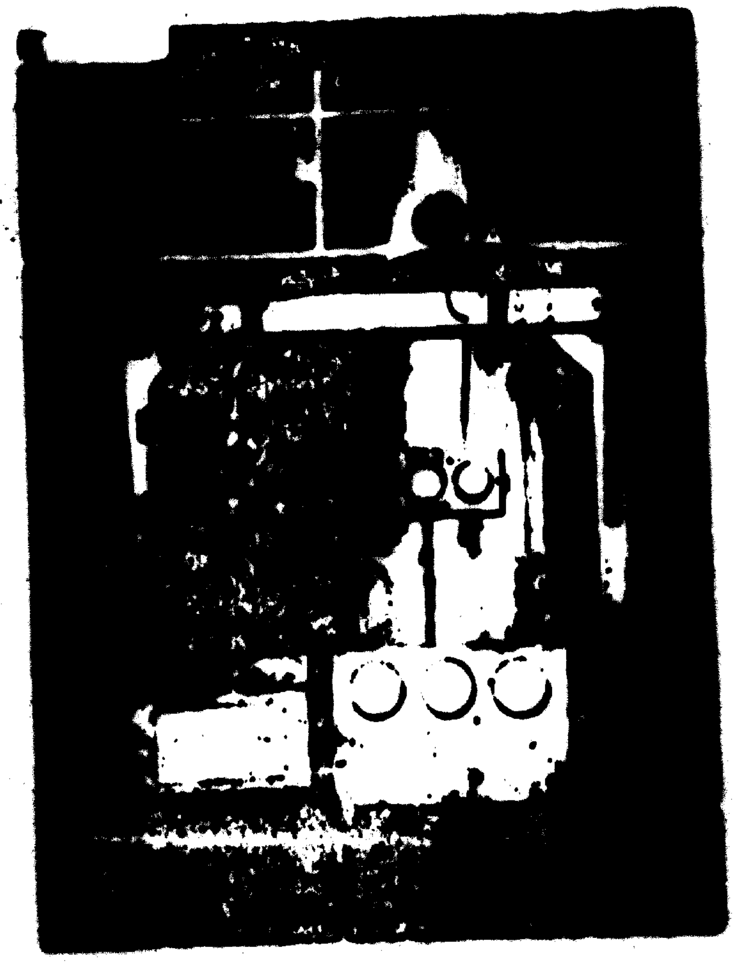


Photo no. 14 - EVAPORATOR SYSTEM

PIN HOLE DETECTOR, X OR β RAY GAUGE CONTROL

In order to detect holes in the strip both Lines are equiped with Pin Hole detectors and they act on the classifiers. The same is extensive to the gauge automatic controls micrometers β or X ray (no. 1 or no. 2 Line). See photo no. 15. PIN HOLES DETECTORS.

Photo no. 15 - PIN HOLE DETECTORS

FLYING SHEAR, LEVELLER, RUN-OUT TABLE, SHEET COUNTERS, SHEET CLASSIFIERS AND PACKING CONVEYOR

To complete the Tinning installation both Lines are equiped with Halden flying shear to cut strip, leveller to improve flatness, run-out tables, sheet counters, sheet classifiers and continuous packing conveyor.

No. 1 Line has 3 pilers and no. 2 Line, 4 pilers. See photos no. 16, 17, 18 and 19.

IV - START UP

To start up both FERROSTAN Lines, all cleaning and pickling tanks were washed by circulating hot water. The Plating tanks were washed by a 5 % sulfuric acid solution. This operation must be done carefully to avoid damages to the conductor rolls. This sulfuric acid solution circulation was done with the Line stoped and without strip. The plating anodes were grounded to various thickness from 2.0 inches to 0.9 inches. All preplating, plating and treatment solutions were prepared in storage tanks. To start no. 2 Line plating solution was pumped from storage tanks of no. 1 Line to circulating tank of no. 2 Line. After this, the strip was manually passed through the Line and started up Line carefully, in order to syncronize all different Line sections.

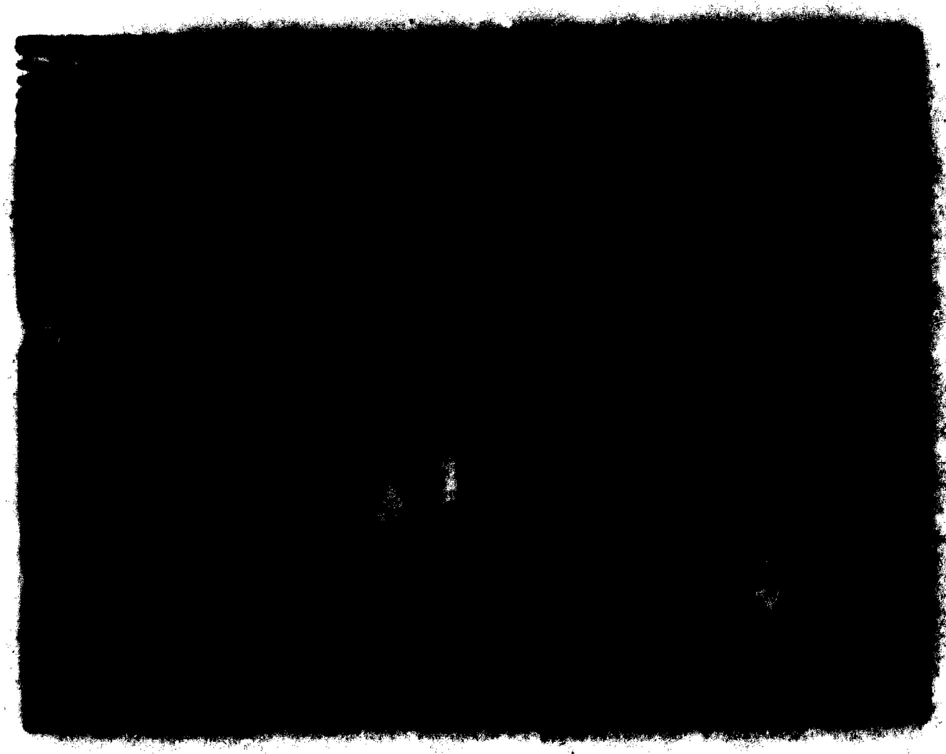


Photo no. 16 - FLYING SHEAR

Photo no. 17 - CLASSIFIERS

Photo no. 18 - PACKING CONVEYOR

Photo no. 19 - TIN PLATE STORAGE AREA

V - OPERATION

CLEANING

The coiled black plate as received from the side trimming line is usually slightly contaminated with rolling oils and mill dirt. Because successful tin deposition requires that the steel surface be free of these contaminants, it is important that the cleaning cycle be as thorough as possible.

No 1 and no. 2 Lines use solution of sodium metasilicate 80 % and caustic soda 20 %, according recommended operating conditions.

Concentration	-	14 to 22 gr/l
Temperature	-	over 83 º C
Amperage	-	7,000 A

When cleaning solution concentration is under 14 gr/l a new addition made:

X = (A-B) D
X = amount to be added.
A = desired concentration.
B = concentration determined by laboratory.
D = volume in liters.

Temperature of cleaning solution is maintained by circulating the solution through a heated reservoir storage tank to which additions of water and cleaning compound are made as required.

PICKLING

Although the strip as it leaves the cleaner rinse should be free of surface soil, oxides formed during the various stages of the steel processing are not removed by the cleaner. The purpose of the sulfuric acid pickle is to remove these oxides and lightly the strip, thus presenting as clean a steel surface as possible to the plating solution. A good average acid concentration is 10 weight per cent. The solution is not heated, the temperature is ambient.

The sulfuric acid and water additions are continuous and controlled by manual valves.

Recommended conditions:

Concentration	-	50 to 150 gr/l
Iron	-	1 to 7 gr/l
Amperage	-	7,500 A

PLATING

The plating electrolyte consists essentially of phenolsulfonic acid (PSA), stannous sulfate, and dihydroxy diphenyl sulfone (sulfone). The phenolsulfonic acid makes the solution highly conductive and also inhibits oxidation of stannous tin to stannic tin.

Additions of PSA to the electrolyte are required to compensate for dragout losses. The stannous sulfate provides an initial source of tin ions in solution, however, additions of stannous sulfate to the electrolyte should be required after initial make up because the cathode efficiency should be sufficiently less than the anode efficience to compensate for tin dragout losses.

Sulfone is the primary addition agent and is used to permit the deposition of a coherent deposit that will melt bright. In FERROSTAN Lines of Brasil, in order to improve plating solution, is used sulfone 25 % and phenolene supra 75 %. This phenolene supra is liquid from which any insoluble materials present in the solid grade is removed, reducing blocking up coolers and pipes.

The phenolene supra presents the following advantages:

Absense of sludging, giving a much clear bath liquor.
Direct additions can be made to the bath.
Activity is at least 20 % higher than sulfone.

Satisfactory operation over a substantially wider current density range, particularly towards the low current density region.

Greater flexibility of operation, for example, readily changes over one extreme of plating weight to another.

In addition to sulfone monobutyl plenyl phenol sodium monosulfonate (Areskap) is sometimes used as a secondary addition agent to broaden the plating current density and temperature range. It is specially effective at high operating temperatures (above 120º F).

Phenolsulfonic acid specification:

PSA is supplied as a 65 % by weight water solution.
Free sulfuric acid: 5 % absolute maximum, 2,5 % desirable.
Free Phenol: 5 % absolute maximum, 2 % desirable maximum.
Iron: as low as possible.
Sulfur dioxide: less than 0,01 %
Stannous sulphate: stannous sulphate is supplied as a powder and should be of a least technical grade purity.
Dihydroxy diphenyl sulfone: sulphone is suppled as a flesh-colored

powder that consists of a mixture of two isomers, the 4-4' isomer and the 2-4' isomer. The product as supplied should be essentially tar-free and should contain 50 to 80 % of 4-4' isomer and 50 to 20 % of the 2-4' isomer.

A mixture of 70 % of 4-4' isomer and 30 % 2-4' isomer has proved to be quite satisfactory in service.

ELECTROLYTE MAKE-UP

The electrolyte used for starting no. 2 Line was obtained from no. 1 Line already in operation. For starting no. 1 Line it was made-up from the basic constituents. Whenever possible, it is desirable to start a new line with electrolyte obtained from a operating line. This procedure will probably reduce the break in time required for optimum performance of a freshly prepared electrolyte.

New electrolyte is make-up in batches in an electrolyte mixing tank. The size of the tank determine the number of batches that must be mixed. For start-up purposes, the electrolyte should contain 30 g/l stannous tin (added as stannous sulfate or stannous phenolsulfonate), 15 g/l PSA and 6 g/l sulphone.

Acid concentration:

$X = (A1 - A2)\ V/P$, where
X = PSA required (gallons)
A1 = Acid concentration desired (grams per liter)
P = Acid concentration of PSA (grams per liter)
V = Volume of electrolyte (gallons)
A2 = Acid concentration present (grams per liter)
(A2 = 0 for making-up a new electrolyte)

Thus. if the mixing tank holds 200 gallons of electrolyte, the desired acid concentration is 15 g/l and acid concentration of the PSA is 265 g/l; the addition of PSA required is: $X = 15 \times 200/265 = 11.3$ gallons.

Tin concentration:

$Y = (S1 - S2)\ V/1.2\ F$, where
Y = Stannous sulphate required (pounds)
S1 = Tin concentration desired (grams per liter)
V = Volume of electrolyte (gallons)
F = Fraction of Sn^{+2} in $SnSO_4$ (usually 54 %)
S2 = Tin concentration present (grams per liter)
(S2 = 0 for making-up a new electrolyte)

Thus, if the mixing tank holds 200 gallons of electrolyte, the desired tin (Sn^{+2}) concentration is 30 g/l, and the fraction of Sn^{+2} in $SnSO_4$ is 54 %, the amount of $SnSO_4$ to use is:

Y = 30 x 200/1.2 x 54 = 926 pounds.

Sulphone concentration:

Z = DV/120, where
Z = Amount of sulphone required to be added.
D = Amount of sulphone disired (pounds)
V = Volume of electrolyte (gallons)

Thus, if the mixing tanks holds 200 gallons of electrolyte and the desired sulphone concentration ie 6 g/l, the amount of sulphone required would be:

Z = 6 x 200 x 120 = 10 pounds.

Sulphone should be added as a water solution. It is preferably dissolved in boiling water and the rate of solution may be increased by previously adding of 1 gallon of PSA to 50 gallons of water. Normally is used condensate water that is demineralised. Sulphone is an addition agent that is essential to the production of smooth, coherent, fine-grained deposits. It is consumed during electrolysis and quantities are also lost by dragout, therefore, it must be constantly or periodically replenished. The amount of sulphone required for optimum operation is most dependent on temperature. Ordinarily a concentration of 6 g/l is sufficient to insure a bright plating range of 50 to 500 asf.

Areskap concentration:

Although Areskap is a powder, it is usually sold as a 50 % water solution designated as Areskap 50. It should not ordinarily be necessary to add more than about 5 pounds per 8 hour operating period. The formula used for calculating sulphone additions may also be used to calculate Areskap additions.

Recommended plating operating conditions:

PSA	10	to	20 g/l (desired aim 15 g/l)
Sulphone	6	to	8 g/l
Sn^{++}	25	to	40 g/l (desired aim 32 g/l)
Areskap	0.1	to	0.2 g/l
Iron	2,0 g/l maximum		
Sn^{++++}	1 g/l maximum		

Sn^{++} g/l	TEMPERATURE
30 to 34	46 to 48º C

31 to 35	44 to 46º C
32 to 36	42 to 44º C
33 to 37	40 to 42º C
34 to 38	38 to 40º C

Dragout

Sn^{++}	2,0 g/l max.
PSA	4,0 g/l max.

Anode and cathode efficience:

The difference between anode and cathode efficiency is sufficient to maintain tin concentration at the desired level without additions of stannous sulphate.

Weight of coating:

Tin coating weights are expressed in terms of weight per unit area. It's used pounds of tin per base box (lb/bb). Are produced in Brazil electrolytic tin plates with 0.10, 0.25, 0.50, 0.75, 1.00 lb/bb and differential coatings.

Differential coatings:

Differential 0.75/0.25, 1.00/0.25 and heavier coatings 0.75 and 1.00 lb/bb are produced in no. 2 FERROSTAN Line bacause it is equiped with Pannier marker and more available plating current.

Current density:

Current density is the term used to describe the current per unit area. It's expressed in amperes per square foot (ASF). For operating purposes, current density calculated on the basis of the strip area immediately opposite the anode is satisfactory. Both FERROSTAN Lines in Brazil work around 250 ASF.

Strip width:

The width of the strip is proccessing in the lines, is expressed in inches.

Pass and pass length:

A pass is defined as the movement of any point on the strip down from the top roll to the sink roll or up from the sink roll to the top roll. Thus, the strip makes two passes in each tank. It is expressed in feet, from the solution level to the bottom of the electrode.

Plating time:

Plating time is the time (expressed in seconds) during which a given strip area is exposed to the plating current. It is a function of strip speed and pass length.

Strip speed:

Strip speed is the actual lineal speed of the strip through the line. It is usually expressed in feet per minute.

Total current:

Total current is the sum of the current used in all plating passes. It is expressed in amperes. For differents coatings see tables 1, 2, 3, 4 and 5 used in Brazilian FERROSTAN Lines.

Anode practice:

Two things would prevent such an arrangement from giving uniform current distribution over the sheet. First, the electrical resistance of the strip is sufficient to cause an appreciable IR drop in the strip, and, since the current is fed from the top, the current density would be higher at the top of the pass than at the bottom. This can be largely overcome by tilting the anode so that it is closer to the strip at the bottom than at the top. For best current distribution, the anode-strip spacing for the gages of strip commonly plated is 1 inch at the bottom of the pass and 1 5/8 inch at the top. The current density would be higher at the extreme edges of the strip. This edge effect is reduced somewhat by making the mode slightly narrower than the strip. If it is too narrow, however, the current density will be low on that part of the strip extending beyond the anode (except at the extreme edges). Ideally, strip should extend beyond the anodes about 1/2 inch. Table 6 shows the maximum and minimum width of strip that should be coated with the various numbers of anodes in each bank. See anode thickness table, page 32.

Cathodic-anodic Electrochemical treatment in sodium dicrhomate solution (Treatment 320):

We use this tretment in FERROSTAN Line no. 1

Treating solution:

The preferred concentration of sodium dicrhomate is 20 to 30 grams per liter. Excellent resistance to warehouse discoloration has been obtained

	WIDTH INCHES	SPEED FPM													
		450	500	550	600	650	700	750	800	850	900	950	1000	1100	1200
COATING .010	25	5500	6100	6800	7400	8000	8600	9200	9800	10500	11100	11700	12300	13600	14840
	26	5800	6400	7600	7700	8300	9000	9600	10200	10900	11500	12200	12800	14100	15400
	27	6000	6700	7300	8000	8600	9300	10000	10600	11300	12000	12600	13300	14600	16000
	28	6200	6800	7600	8200	9000	9800	10300	11000	11700	12400	13100	13800	15200	16600
	29	6400	7100	7900	8600	9300	10000	10700	11400	12100	12900	13600	14300	15700	17200
	30	6600	7400	8100	8900	9600	10300	11100	11800	12600	13300	14100	14800	16300	17800
	32	7100	7900	8700	9600	10200	11000	11800	12600	13400	14200	15000	15800	17400	19000
	36	8000	8800	9800	10600	11900	12400	13300	14200	15100	16000	16800	17800	19600	
	1/8	28	31	34	37	40	43	46	49	52	55	58	61	64	67
	1/4	56	62	68	74	80	86	92	98	104	110	116	122	128	134

TABLE 1

TOTAL PLATING CURRENT BASED ON 95 PER CENT CATHODIC EFFICIENCY

WIDTH	INCHES	SPEED FPM													
		400	500	550	600	650	700	750	800	850	900	950	1000	1100	1200
	25	[illegible]	16400	17000	18800	20000	21600	23100	24700	26200	27800	[illegible]	30900	34000	37100
COATING OZS.	26	14470	[illegible]	17800	[illegible]	20000	22500	24100	25700	27300	28900	30500	32100	35300	38500
	27	15000	16800	18300	20000	21700	23300	25000	26700	28300	30000	31700	33300	36700	40000
	28	15500	17300	19000	20700	22500	24400	25900	27700	29450	31100	32300	34500	38000	41500
	29	16100	17900	19700	21500	23000	25100	26800	28600	30400	32200	34000	35800	39400	43000
	30	16600	18500	20800	22200	24100	25900	27800	29800	31600	33000	35200	37100	40800	44500
	32	17800	19700	[illegible]	23700	25700	27700	29600	31800	33800	35600	37500	38500	[illegible]	47800
	36	[illegible]	[illegible]	24400	26700	28900	31100	33300	35600	37800	40000	42200	44500	48900	53400
	1/8	70	75	80	90	100	110	120	130	140	150	160	180	190	200
	1/4	140	150	160	180	200	220	240	260	280	300	320	360	380	400

TABLE 2

TOTAL PLATINGCURRENT BASED ON 95 PER CENT CATHODIC EFFICIENCY

WIDTH INCHES		SPEED FPM													
		450	500	550	600	650	700	750	800	850	900	950	1000	1100	1200
COATING	25	[illegible]	[illegible]	34800	37000	40000	43400	45700	48400	52400	55600	58600	61300	68000	74000
	26	[illegible]	32000	35200	38400	41800	45000	48200	51400	54600	57800	61000	64200	70600	77000
	27	30000	33200	36600	40000	43400	46800	50000	53400	56600	60000	63400	66600	73400	80000
	28	31000	34600	38000	41400	45000	48400	51800	55400	58800	62000	65600	69200	76000	83000
	29	[illegible]	35800	39400	43000	46800	50200	53600	57200	60800	[illegible]	68000	71000	75800	86000
	30	[illegible]	37000	40800	44400	48200	51800	55800	59200	63000	66600	70400	74200	81600	89000
	32	[illegible]	3940	42400	47400	51400	55400	[illegible]	63200	67800	71200	78000	79000	[illegible]	91800
	36	[illegible]	44400	48800	53400	57800	62200	[illegible]	71200	75800	80000	84400	89000		
OZS.	1/8	140	150	170	150	200	220	230	250	270	280	300	320	330	350
	1/4	280	310	340	370	400	430	[illegible]	490	520	550	580	610	640	670

TABLE 3

TOTAL PLATING CURRENT BASED ON 95 PER CENT CATHODIC EFFICIENCY

[illegible]	SPEED FPM													
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	700	[illegible]	800	[illegible]	900	[illegible]	1000	1100	1200
25	41730	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	74200	78800	84400	87900	92700		
26	43410	[illegible]	[illegible]	57700	62700	67500	72300	77100	81900	86700	91500			
27	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	70100	[illegible]	80100	[illegible]	90000	95100			
28	[illegible]	[illegible]	57000	[illegible]	[illegible]	72700	77900	[illegible]	[illegible]	93300				
29	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	91200	[illegible]				
30	[illegible]	[illegible]	[illegible]	[illegible]	72300	[illegible]	[illegible]	[illegible]						
32	53400	58100	[illegible]	[illegible]	77100	[illegible]	[illegible]	[illegible]						
35	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]								
1/8	210	230	250	280	300	320	[illegible]	370						
1/4	[illegible]	460	[illegible]	[illegible]	[illegible]	[illegible]	700	[illegible]						

COATING .075

TABLE 4

TOTAL PLATING CURRENT BASED ON 95 PER CENT CATHODIC EFFICIENCY.

WIDTH		SPEED FPM													
	INCHES	450	500	550	600	650	700	750	800	850	900	950	1000	1100	1200
COATING	25	[illegible]	61000	[illegible]	74000	80000	86000	92000							
	26	[illegible]	[illegible]	70000	77000	[illegible]	90000	96000							
	27	[illegible]	67000	73000	80000	86000	93000								
	28	[illegible]	[illegible]	76000	83000	90000	96000								
	29	64000	71000	78000	86000	93000									
	30	[illegible]	74000	[illegible]	89000	96000									
	32	71000	79000	[illegible]	[illegible]										
1 oz.	36	[illegible]	[illegible]												
	1/8	[illegible]	310	340	370	[illegible]	[illegible]	[illegible]							
	1/4	[illegible]	[illegible]	[illegible]	700	[illegible]	[illegible]	[illegible]							

TABLE 5

TOTAL PLATING CURRENT BASED ON 96 PER CENT CATHODIC EFFICIENCY.

ANODE - THICKNESS TABLE

ANODE POSITION	WIDTH OF ANODE BANK INCHES	WIDTH OF STRIP INCHES MAX.	WIDTH OF STRIP INCHES MIN.	ANODE THICKNESS INCHES
1	-	-	-	2.0 to 1.9
2	-	-	-	1.9 to 1.8
3	-	-	-	1.8 to 1.7
4	-	-	-	1.7 to 1.6
5	-	-	-	1.6 to 1.5
6	18	18	21	1.5 to 1.4
7	21	21	24	1.4 to 1.3
8	24	24	27	1.3 to 1.2
9	27	27	30	1.2 to 1.1
10	30	30	33	1.1 to 1.0
11	33	33	36	1.0 to 0.9

Based on the use of anodes having a 3 inches face.

TABLE NO. 6

within this range. The preferred temperature range is 46 °C to 51,5 °C. The recommended pH of the treating solution is 4 to 6. The pH is controlled by using chromic acid for part of the daily additions required to maintain the desired concentration. A minimum cathodic current of 25 coulombs per square foot of treated surface is suggested. A control circuit is used to vary the current automatically as the line speed varies. It is recommended that an anodic treatment of 2,5 coulombs per square foot of treated surface be used. Control circuits vary the total anodic current as the line speed varies. We use table no. 7 in FERROSTAN Line no. 1. (page 35)

Cathodic Electrochemical Treatment in sodium dichromate solution (Treatment 311):

All passes are connected to the cathodic current retifiers. We use this treatment in FERROSTAN Line no. 2.

Treating solution:

The preferred solution contains 20 to 30 gr/l of sodium dichromate. The preferred temperature range of the solution is 57 °C to 65 °C. The recommended pH of the treating solution is 4,5 to 5,5.

A minimum cathodic current of 30 coulombs per square foot of surface is recommended. Less than 30 coulombs may lead to difficulties in the wetting properties with certain lacquers, and may also decrease the stability of the protective film. Control circuits are used to automatically vary the total current with line speed, if desired. We use table no. 8 in FERROSTAN Line no. 2. (page 36)

Oiling:

We use in both FERROSTAN Lines cotton seed oil film, 0.15 to 0.25 gr of oil per base box.

<u>General consideration about production costs in 1966: December</u>

COSTS OPERATION COSTS	HOT DIP US$/t	ELECTROLYTIC US$/t
Electrolytic cleaning	4,80	4,80
Coil preparation	-	1,49
Flying shear	6,52	-
White Pickler	6,52	-
Tinning	27,84	15,30
MATERIAL COST		
Tin	74,05	17,80

TOTAL	120,23	39,47

OBSERVATIONS:

1 - Costs data of December, 1966.
2 - Dollar tax at this time: CR$2,22
3 - Tin price: US$ 4,52/kg

DEZ - CHEMICAL TREATMENT NO. 320 (CATHODIC-ANODIC) ETL NO. 1

CONCENTRATION AND OPERATION CONDITIONS

SODIUM BICROMATE	20,0 TO 30,0 G/L	
TEMPERATURE	46ºC TO 51,5ºC	
PH	4 TO 6	

D.C. { CATHODIC PASS - 25 COULOMBS/SF; ANODIC PASS - 2,5 COULOMBS/SF }

SPEED METERS MINUTE	SPEED FEET MINUTE	WIDTH OF STRIP MM 635 / IN 25	MM 686 / IN 27	MM 711 / IN 28	MM 737 / IN 29	MM 762 / IN 30	MM 813 / IN 32	MM 864 / IN 34	MM 914 / IN 36
		MINIMUM AMPERAGE							
91	300	520	555	585	605	625	670	710	750
107	350	610	655	680	705	730	780	825	875
122	400	695	750	780	805	835	890	945	1000
137	450	780	845	875	905	940	1000	1065	1125
152	500	870	940	975	1010	1045	1110	1180	1250
168	550	955	1030	1070	1110	1145	1225	1300	1375
183	600	[illegible]	1125	1165	1210	1250	1335	1415	1500
198	650	1130	1220	1265	1310	1355	1445	1535	1625
213	700	1215	1315	1360	1410	1460	1555	1655	1750
229	750	1305	1405	1460	1510	1565	1665	1770	1875
244	800	1390	1500	1555	1610	1665	1780	1890	2000
259	850	1475	1595	1655	1710	1770	1890	2005	2125
274	900	1565	[illegible]	1750	1815	1875	2000	2125	2250
290	950	1650	[illegible]	1850	1915	1980	2110	2245	2375
305	1000	1735	1875	1945	2015	2085	2220	2360	2500

TABLE NO. 7

Obs.: Control PH using small additions of chromic acid. For intermediate speeds adjust amperage to the immediately superior speed.

CSN

DEZ - CHEMICAL TREATMENT NO. 311 (C A T H O D I C) ETL NO. 2

CONCENTRATION AND OPERATION CONDITIONS

SODIUM DICROMATE 20,0 TO 30,0 G/L

TEMPERATURE 57ºC TO 65ºC CURRENT DENSITY = 30 COULOMBS/SF

PH 4.5 TO 5.5

SPEED		WIDTH OF STRIP							
METERS MINUTE	FEET MINUTE	MM 635 / IN 25	MM 686 / IN 27	MM 711 / IN 28	MM 737 / IN 29	MM 762 / IN 30	MM 813 / IN 32	MM 864 / IN 34	MM 914 / IN 36
		MINIMUM AMPERAGE							
91	300	625	675	700	725	750	800	850	900
107	350	730	790	820	845	875	935	995	1050
122	400	835	900	935	970	1000	1070	1135	1200
137	450	940	1015	1050	1090	1125	1200	1275	1350
152	500	1045	1125	1170	1210	1250	1335	1420	1500
168	550	1145	1240	[illegible]	[illegible]	1375	1465	1560	1650
183	600	1250	1350	[illegible]	1450	1500	1600	1700	1800
198	650	1355	1465	1525	1570	1625	1735	1840	1950
213	700	1460	1575	1635	1590	1750	1865	1985	2100
229	750	1565	1690	1750	1815	1875	2000	2125	2250
244	800	1670	1800	[illegible]	1935	2000	2135	2265	2400
259	850	1770	1915	[illegible]	2055	2125	2265	2410	2550
274	900	1875	2025	2100	2175	2250	2400	2550	2700
290	950	1980	2140	2215	2295	2375	2535	2690	2850
305	1000	2085	2250	2335	2415	2500	2665	2835	3000

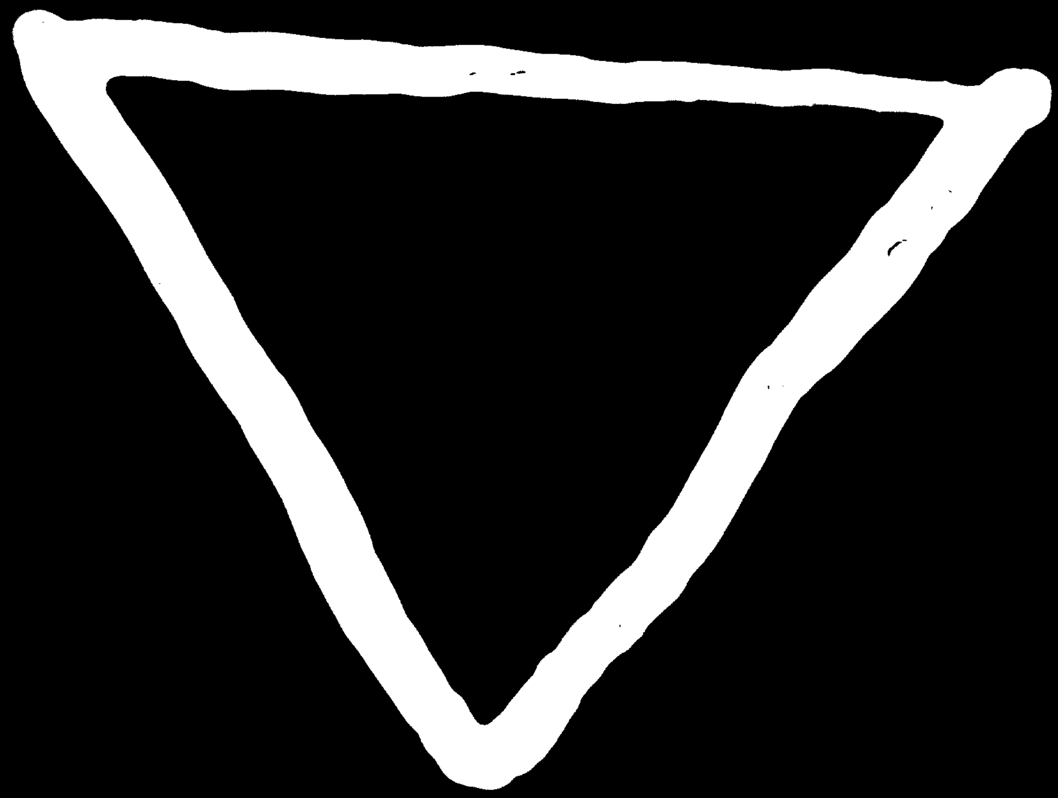
TABLE NO. 8

Obs.: Control PH using small additions of chromic acid.

For intermediate speeds adjust amperage to the imediately superior speed.

[redacted]

CSN



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