TALAT Training in Aluminium Application Technologies

TALAT Lecture 5301

The Surface Treatment and Coil Coating of Aluminium

26 pages, 19 figures

Basic Level

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Objectives:

– to describe the continuous coil coating processes for aluminium in sufficient detail in order to understand the industrial coating technology and its application potential

Prerequisites:

– aluminium surface treatment technology as outlined in lectures 5100 and 5200
– general background in materials engineering

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5301 Coil Coating of Aluminium

Contents

5301.01 Introduction

Aluminium strip in either sheet or coil form can be surface treated and coated to provide a variety of protective, decorative, or special-property finishes making it an ideal material for a wide range of applications.

The different surface treatments and coatings can be carried out on individual sheets or formed components where process stage times can be relatively long, i.e. measured in minutes. However, the handling of individual pieces and transference between process stages is frequently complex and time-consuming. Since many of the applications have now developed into high-volume markets, the modern tendency is to avoid these disadvantages by producing material, wherever feasible, on continuous strip process lines and so achieve the level of productivity required at a favourable unit cost.

Some process stages, such as those involved with the production of anodized finishes, must remain quite long in which case the strip treatment line will run relatively slowly (for example, anodic film sealing requires around 3 minutes in boiling water, so a line running at only 10m/min. would require a sealing tank 30m long, and associated energy to maintain the bath temperature). But in other instances, particularly with paint or lacquer coating, the process stages have been developed to be effective in a matter of seconds and here line speeds of 200 m/min. are attainable, and even 300m/min. for pretreatment-only lines.

In addition to high productivity, the continuous strip treatment line is amenable to strict process control, programmable for a variety of product properties tailored to specific customer requirements and, moreover, provides a consistently high standard of quality across the strip width, throughout the coil length, and throughout successive coils.

5301.02 Treatments and Coatings

- Cleaning and etching
- Pretreatment
- Coatings
- Anodic films
- Special properties

The different treatments and coatings may be summarised as follows

- Cleaning: to remove residual oil and detritus.
- Etching: to diminish or remove the oxide film generated in previous fabrication process steps (e.g. hot rolling, annealing).
- Pretreatment: to stabilize the surface against oxidation and hydration as well as to modify the surface for improved bonding of subsequent paints, lacquers or laminates.
- Coatings: protective or decorative paints, lacquers or laminates.
- Anodic films: protective or decorative films, also as a dielectric in electrical applications.
- Special properties: e.g. electro-grained and anodized lithographic substrate.

Cleaning and Etching

Today, aluminium strip is finish-rolled with a minimal amount of residual rolling oil left on the strip surface, and as-rolled material is adequate for many engineering applications. However, cleaned strip may be requested to provide a consistent, uniform surface, or to avoid contamination of subsequent chemical operations in a customer's plant. Cleaning is the essential preparatory stage in most pretreatment processes.

The removal of residual rolling oil and detritus from the strip surface is usually achieved by spraying with either an alkali or acid solution, heated to 60-80 °C, for 5 seconds. The sprays can also have a beneficial mechanical effect in loosening attached particles (especially on the underside of the strip). Today, many of the strip alloys contain magnesium, which migrates to the surface of the strip during the thermal part of the fabrication cycle, giving a magnesium-rich natural oxide film; this is a disadvantage to many subsequent finishing processes. An acid will uniformly attack the mixed oxide film whereas an alkali will preferentially attack aluminium oxide resulting in a non-uniform attack of the metal (producing a roughened surface), so today there is a tendency to prefer acid cleaning to the alkali process; typical is to use a mixture of sulphuric and hydrofluoric acids with surface activants (wetting agents).
The spray cleaning section is followed by spray rinsing cascades (see Figure 5301.03.06) and drying.

An alternative to spray degreasing is electrolytic cleaning, in which the strip passes through a bath containing an electrolyte (acid) and electrodes connected to a d.c. (i.e. reverse polarity to anodizing) or a.c. power supply. The cathodic action rapidly expels any loose particles from the strip and cleaning can be effected in as short a time as 0.5 seconds. At present electrolytic cleaning is rarely used, but it is worthy of future consideration.

Rolling oil removed from the strip in the degreasing section must be collected and sent for disposal off-site.

Spent acid or alkali from the degreaser plus the contaminated rinse water overflow must be neutralised before disposal.

In the case of acid cleaners, most of the spent acid can be regenerated and returned to the process, leaving a greatly reduced volume of dilute acid and salts for treatment prior to disposal. For example, one acid regeneration system is based on an ion exchange process, which employs resins which have an affinity for the acid but exclude the aluminium content. This purified acid can then be recovered by washing out of the resin by water.

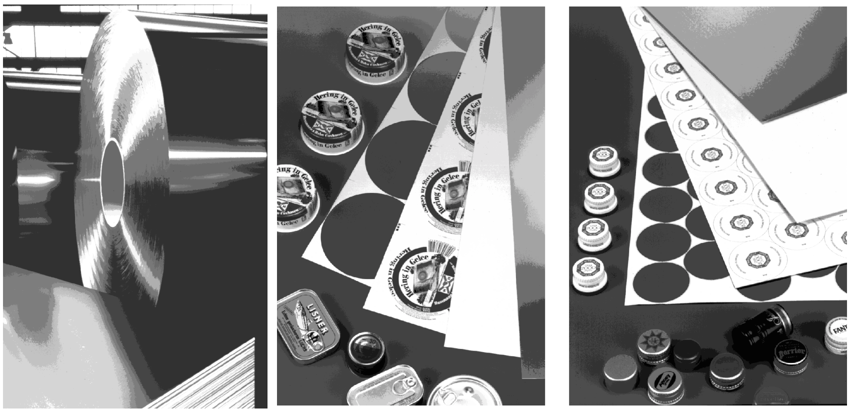
Typically, acid effluent is treated by mixing the spent solution with calcium hydroxide which neutralises the acid and precipitates calcium sulphate (for example) and aluminium hydroxide. This precipitate is then fed to a filter press where much of the liquid is removed, and the `filter cake' is disposed of on an official dumping site, or used as land-fill.

In the case of continuous anodizing, the cleaning and etching is used to produce a specific surface appearance. For bright reflective finishes a solution of phosphoric, sulphuric and nitric acids is used to chemically brighten the sheet. This is an immersion process, typically for 1-2 minutes at 95-105 °C. To produce a matt finish the cleaning and etching solution is typically 15% caustic soda (NaOH) at 60-70°C, which can be operated either as a dip or a spray process, followed by a spray rinse and then a spray desmut with 10-20% nitric acid at room temperature, followed by a final spray rinse before the strip enters the anodizing stage.

Pretreatment

Pretreatment, modifying the strip surface for the improved bonding of subsequent paints, lacquers, laminates, etc., is integrated with a preceding strip cleaning process, and usually a subsequent coating process.

An exception is the provision of pretreated-only coil cut into sheets for the packaging industry (e.g. food cans, metal closures) where the individual sheets are lacquered and decorated (printed) on sheet coating lines. This is because it is not practical to print or decorate coils due to the wide range of designs required, and the relatively small runs per design (**Figure 5301.02.01**). Pretreated-only strip is given a thin coating of dioctylsebaccate (DOS) at around 5-10 mg/m^2 to ensure the cut sheets destack and feed smoothly into the sheet coater/decorators. The level of DOS is carefully regulated to ensure it is compatible with the subsequent lacquer coatings.



PRETREATED-ONLY COIL AND LACQUERED SHEET

FOOD CANS

BOTTLE CLOSURES

PRINTED SHEET

Source: Alcan Germany.

TALAT	PRETREATED-ONLY COIL FOR SUBSEQUENT SHEET COATING AND PRINTING.	5301.02.01

The pretreatment can be either a chemical process, or an electrolytic process, to replace the natural oxide film. Today, the chemical process is the more usual, with different versions for food packaging applications (to satisfy regulations) and for architectural or transport applications.

Until a few years ago, the chemical solution was applied to the strip and after a finite reaction time, rinsed off. This of course gave rise to a considerable volume of contaminated rinse water requiring treatment before disposal. However, today the chemical is usually applied by roller coating whereby a precise amount of solution is applied uniformly across the strip, and then dried in place. These ‘no-rinse’ aqueous chemicals have been formulated to stay on the aluminium surface. Their reaction with the aluminium means that no products are formed which will subsequently require removal, so avoiding most of the potential environmental problems.

Typical chemical coatings are based on chromium compounds, but in view of possible future stringent regulations, chrome-free versions have been developed and are already commercially available.

The main function of the pretreatment is to improve the durability of the bonding of subsequent organic coatings.

Coatings

There is a wide variety of organic coatings to suit specific applications (**Figures 5301.02.02 to 5301.02.06**). Paints and lacquers have been formulated to be compatible with the requirements of high-speed coil coating lines, i.e suitable for roller coating application and stoving within 10-30 seconds, yet still retaining the necessary adhesion, flexibility, wear and weather resistance, as well as colour matching properties.

BEER CANS

EASY-OPEN FOOD CANS AND LIDS

Source: Alcan Germany.

TALAT	COIL-COATED ALUMINIUM FOR NON-DECORATED CANS AND LIDS.	5301.02.02

TRUCK BODIES

CARAVAN BODIES

Source: Alcan Germany.

TALAT	COIL-COATED ALUMINIUM FOR TRANSPORT APPLICATIONS.	5301.02.03

Source: Alcan Germany.

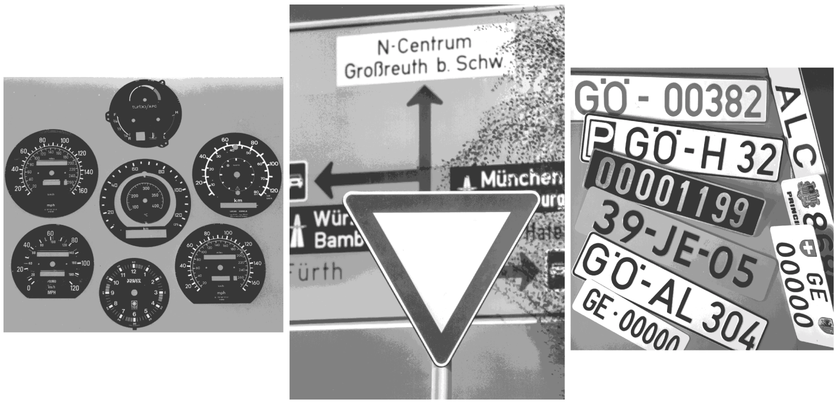
TALAT	COIL-COATED ALUMINIUM FOR ARCHITECTURAL APPLICATIONS (exterior).	5301.02.04

VENETIAN BLINDS

SUSPENDED PANEL CEILING

Source: Alcan Germany.

TALAT	COIL-COATED ALUMINIUM FOR ARCHITECTURAL APPLICATIONS (interior).	5301.02.05



INSTRUMENT DIALS TRAFFIC SIGNS CAR LICENCE PLATES

Source: Alcan Germany.

TALAT	COIL-COATED ALUMINIUM FOR NAMEPLATES, ETC..	5301.02.06

Typical coil coatings are:

- Organosol lacquers for the inside of food can bodies, and easy-open lids for food and beverage cans

  However, as the chloride content of organosols leads to additional cost for scrubbing exhaust gases when decoating or melting scrap to comply with new, stringent regulations, alternative epoxy-modified polyesters are under development.

- Epoxy-amine lacquers for the outside of the above products.

  The lacquers must have good adhesion and flexibility, withstand product processing conditions, be compatible with the can contents, and satisfy FDA and other regulations.

  Before the lacquered canning strip leaves the coil coating line it may be lightly lubricated on both sides to assist the subsequent coil-fed press forming operations; typical is to use food grade petroleum applied at 50-100 mg/m^2 which is compatible with most food products.

- Polyester paints in a variety of formulations for applications as diverse as caravan bodies, interior architectural applications, and instrument dials and nameplates.

- Polyurethane paints for truck bodies.

- PVdF (Polyvinyldifluoride) paints for special exterior architectural applications. Good wear and weather resistance.

- Polyamide-enriched polyurethane paints with excellent abrasion resistance, for roll shutters and some architectural applications in an aggressive environment.

- PVC film laminate, embossed with special effects such as wood grain, leather or stone patterns. Special reflective film for road signs, etc.

- A protective film can be applied to coated surfaces to prevent handling damage during fabrications; this film is then stripped off the completed product.

- On lines with tandem coating facilities, the coating can be applied as a primer and top coat, or a single coat can be finished with a clear lacquer top-coat, or the second coater can apply stripes of a different colour to the first, single coat.

Anodic Films

Coil anodizing can be classified into three categories:

- decorative thin-film anodizing for the manufacture of reflectors, name-plates, control panels, suspended ceilings, domestic appliance trim, etc.

- dielectric coating on capacitor foil.

- thick film anodizing for architectural applications such as curtain walling, awnings, sun screens, louvre blinds, and laminated thermal insulation panels.

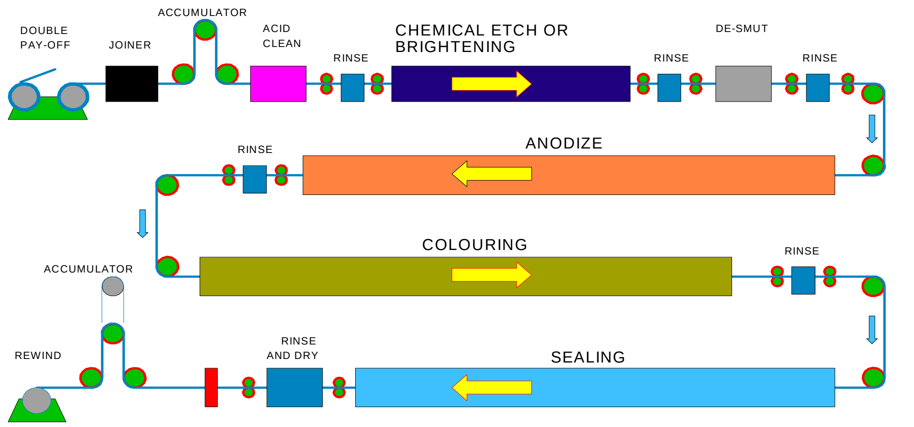
Coil anodizing lines vary in width and line speed depending upon the type of finish being produced.

Decorative anodizing lines and capacitor foil lines are generally narrower than architectural finishing lines, i.e. 150-900 mm compared with 1500-2200 mm.

Strip thicknesses between 100 microns and 3.5 mm are being coil anodized.

Given a specific anodizing tank length, the speed of the line is mainly determined by the thickness of the anodic film applied. Decorative finishes are usually typically 2-5 µm whereas architectural finishes are typically 15-20 µm. Typical anodizing current densities are 150-300 amp/m^2 for bright finishes and 1500-6000 amp/m^2 for architectural finishes, even so a 15 µm architectural finish would require an anodizing time of either 3 minutes or ¾ minute, respectively. Similarly, even with accelerated sealing, (e.g. Alexis Speedseal), a dwell time of 0.5-1 minutes per micron is required in the final sealing stage. Hence, at a line speed of 20m/min., the anodizing tank would need to be about 20m long and the sealing stage at least 150 m long. Consequently, most coil anodizing lines run at around 5-10 m/min. to reduce the size of the process stages.

As the anodic film is porous, it can be coloured prior to the final sealing stage. This is achieved either by a spray dye technique, or by the electrolytic deposition of a metal such as cobalt, tin or nickel, from the appropriate metal salt solution. These colouring processes are also relatively slow and can result in the line speed being reduced further to 2-5 m/min. A schematic layout of a typical strip anodizing line is shown in **Figure 5301.02.07.**



Source: Alcan Germany.

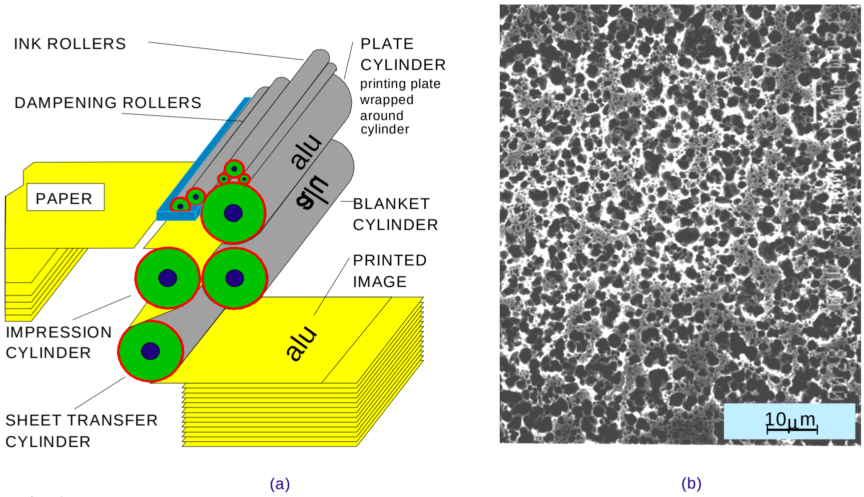
TALAT | SCHEMATIC ARRANGEMENT OF COIL ANODIZING LINE. | 5301.02.07

Most of these coil anodizing processes are d.c. and to handle the high current densities, the liquid contact principle (see later, **Figure 5301.03.09**) is usually employed.

In the case of electrolytic colouring, it is usual to use the same liquid contact employed for the anodizing stage in combination with a biased a.c. applied via suitable counter electrodes in the colouring electrolyte.

Special Properties

An example of surface treatment to provide special properties is the electrograining and anodizing of strip for lithographic substrate, subsequently cut to size for printing plates.
In the lithographic printing process a plate is developed in a similar method to a photographic film except that the resulting image area comprises a thin polymeric coating supported on the roughened anodized substrate. During printing the plate is wrapped around a cylinder and passes various coating rolls (**Figure 5301.02.08** (a)). First, water is applied to the plate by a dampening roll which wets the non-image area (exposed substrate) but not the polymeric image area. A second roll applies a grease-based ink which can wet the image area, but is unable to wet the already water-wet non image area. The plate then makes contact with a third rubber roll and the ink is transferred. The transfer roll then makes contact with the paper supported by another roll. This process is also called offset lithography as the printing plate does not make direct contact with the paper.



Source: Alcan Germany.

TALAT | LITHOGRAPHIC PLATE. | 5301.02.08

The demands on the substrate during printing are considerable. It must provide good adhesion for the light sensitive coating which later forms the image area. It must retain just the right amount of water in a non-image area to prevent ink pick-up. Thirdly, it must have good wear resistance since plates often make more than 200,000 impressions during extended runs, e.g. for magazines and catalogues.

The electrograining process which roughens the aluminium substrate has a similar configuration to the a.c. pretreatment geometry except that only one side of the coil is treated. Dilute hydrochloric or nitric acids are used to pit the surface and the action is driven by the application of power. Control of the alloy, electrolyte, current density and line speed allows the size and distribution of the pits on the surface to be engineered (e.g. **Figure 5301.02.08** (b)). The surface is d.c. anodized in sulphuric acid to give an approximately 1 mm film. The wetting, adhesion and wear resistant qualities of the plate are determined by the topography imparted by both the graining and anodizing processes.

In a continuous coil treatment line, the electrograining and anodizing processes each require approximately half a minute, so together with various inter-stage rinsings and dryings practical space requirements limit the speeds of such litho-lines to around 10-50 m/min. Although these speeds are relatively slow compared to other continuous processes, this is a highly demanding surface finish process.

5301.03 Coil Coating Lines

- Operational requirements
- Mechanical features
- Uncoiling and strip joining
- Tension levelling
- Entry accumulator
- Degreasing, rinsing, drying
- Pretreatment
- Coating
- Drying and stoving ovens
- Exit section and re-coiling
- Process control

Operational Requirements

The design of coil coating and treatment lines is dependent on the anticipated line speed (to satisfy the envisaged market requirements) and the minimum time required for each process stage which in turn fixes the space required for any particular stage. This, in turn, relates to the building space available. Savings can be made by running the line on two or even three levels, and some process stages (such as rinsing) can be compacted by running the strip in vertical loops. Obviously, at this stage there should be no doubts about the feasibility of the operational parameters for the various stages, for example, most coatings (paints, lacquers) have a time/temperature curing relationship such that a shorter curing time can be achieved at a higher temperature. However, care must be taken to ensure that the operational limits on temperature do not result in unacceptable coating colour variances, particularly when close colour-matching is essential between different batches of coils produced over long time intervals. It is not unknown for ‘improved’ formulations of coatings to be so colour sensitive to temperature that they can only be run at reduced line speed in a lower (less sensitive) temperature band. It is essential when modifying pretreatments, lacquers or paints for coil coating, to ensure that the parameters are compatible with realistic operational limits.

As mentioned previously, some process stages in coil anodizing, and coil treatment for special finishes such as lithographic substrate, must be quite long so because of space and other limitations, these lines run at relatively slow speeds (say up to 20 m/min.).

However, coil coating lines run at up to 300 m/min. for pretreatment-only and 200 m/min. for most paint, lacquer and laminate coatings. These lines usually run continuously (24-hour day, 6-day week) so a high standard of reliability has to be incorporated. Rarely are two lines identical, but the main features described below are applicable to most high-speed lines and to some extent also to the slow-speed lines.

In addition to the normal mechanical engineering details of the line, the stringent environmental regulations, applicable or envisaged, demand considerable attention to waste products, for example to emission of solvents from the paint curing ovens (fume incineration combined with a heat recovery system) and to chemical effluent (acid regeneration).

In operation, a spare coil is usually held in reserve for line start-up or any major process adjustment. The strip would be fed slowly through the line while solution tanks and ovens reached their operational temperatures. On line shut-down, such a coil is fed and left in the line to avoid the inconvenience of thread-up prior to the next production campaign.

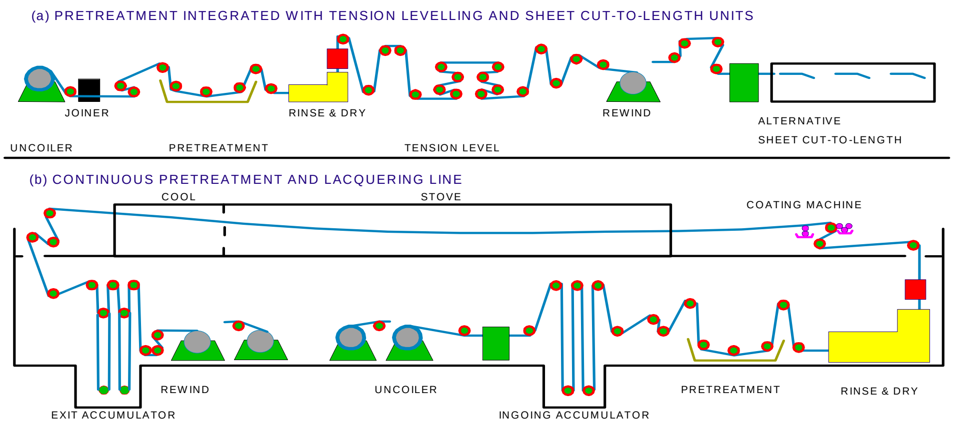
Coil-coating lines should be capable of handling the widest strip produced by the associated rolling mills. Should the customer require narrow coils it is more economical to coat a wide width and slit to multiple coils rather than coat single narrow coils.

Most coil coating lines today are built for 1650 mm wide strip, but the latest lines will handle 2100 mm to cater for the wider strip mills now coming into production, handling 15 tonne coils, and with an output of around 50,000 tonnes per year.

Many lines are multi-purpose, but a line dedicated to canning strip would cater for a strip thickness range 0.15 - 0.5 mm and a line for architectural strip 0.3-2.0 mm. Roll diameters and strip tensions throughout the line can then be sized accordingly.

Mechanical Features

There are two basic designs of coil treatment lines - those that stop for coil change-over and those that run continuously, i.e. feeding from or into an accumulator during coil changeover (**Figure 5301.03.01**).

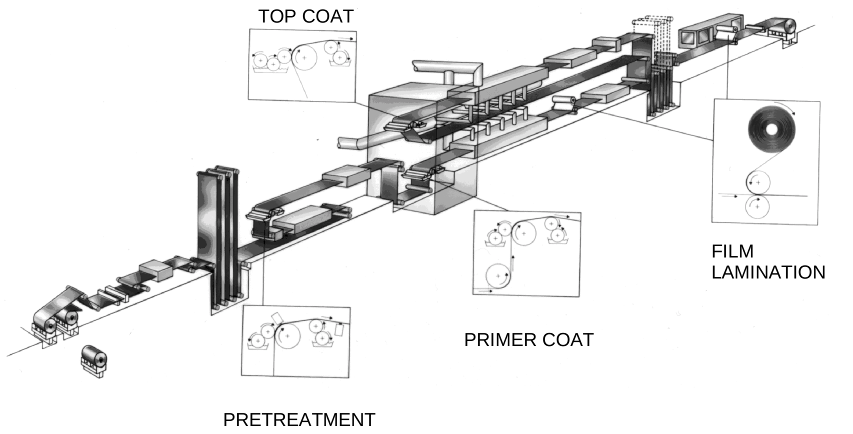


Source: Alcan Germany.

TALAT | BASIC DESIGNS OF COIL-TREATMENT LINES. | 5301.03.01

Strip accumulators are expensive items both in terms of cost and space requirement, so they are usually omitted where the process time and overall line length is relatively short, such as in pretreatment-only lines. The disadvantage is that the strip in the line during deceleration, stoppage for coil change-over, and acceleration to operational line speed, must be scrapped as it will be incorrectly treated. However, this is offset to some extent by the fact that the beginning and end of coils are frequently scrapped because of off-gauge.

Figure 5301.03.01 (a) shows a pretreatment-only (electrolytic) line with the option of running coil-to-coil, or into an alternative sheet cut-to-length unit (pretreated-only sheet is a high-volume market for the packaging industry). **Figure 5301.03.01** (b) shows a simple pretreatment and single-coat lacquering line, with an ingoing accumulator to feed the line at normal speed during the introduction of a new coil, and an exit accumulator to store the strip during changeover of completed coils.



Source: Alcan Germany.

TALAT	COIL-COATING LINE WITH 2-COAT FACILITY.	5301.03.02

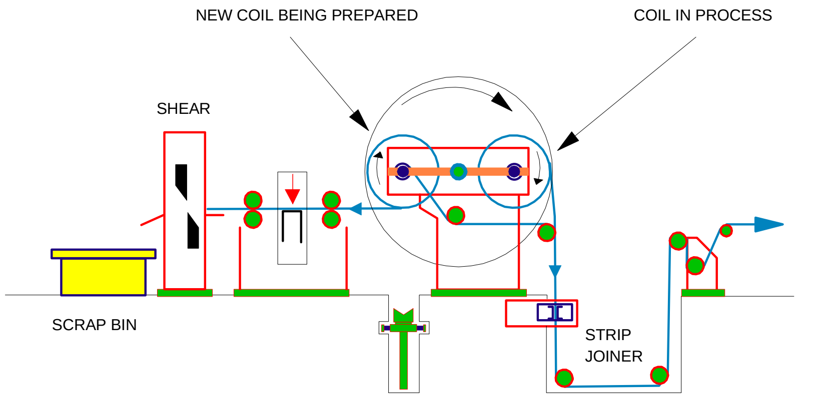
Figure 5301.03.02 shows a more complex coil coating line with 2-coat facility and provision for laminating decorative film and strippable protective film.

Some typical mechanical features for a 200 m/min. line are now described.

Uncoiling and Strip Joining

Ideally, the coil coating line should be located adjacent to a coil storage warehouse with mechanised handling so that the appropriate coils (alloy, temper, gauge, width) can be automatically selected from the store, transported to the line by means of a coil car, and positioned ready for loading onto the uncoiler mandrel.

A twin mandrel (**Figure 5301.03.03**) carries a coil feeding the line on one mandrel whilst the other mandrel is free for unloading the empty spool from the previous coil, and loading the next coil from the storage area.



Source: Alcan Germany.

TALAT | UNCOILING & STRIP JOINING. | 5301.03.03

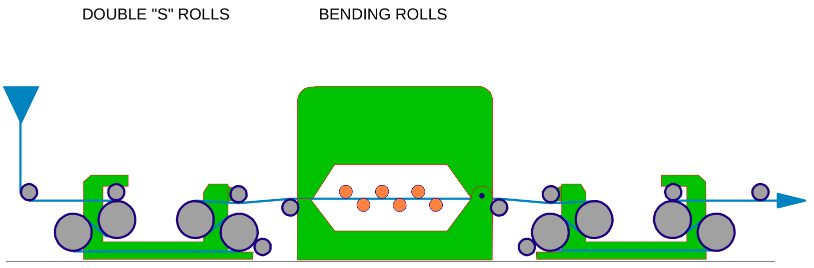
When the new coil has been loaded onto the free mandrel, the constraining straps are removed and the end of the strip fed into a coil preparation section where any damaged or off-gauge strip at the coil end is removed.

When the first coil is almost completed, the turret uncoiler rotates 180° to bring the new coil into the running position, and the coil end is fed into a strip joining machine, but clear of the strip from the first coil which is virtually completed, the strip is sheared and the end run into the joining machine. The entry section of the line is halted, and the joining machine operates to produce a 4-row mechanical interlock joint. The press tools retract and the entry section restarts to pull the new strip into the line. A typical time cycle for coil changeover is 30-40 seconds.

During the joining cycle a hole is punched in the strip to facilitate detection of the passage of the joint through the line to initiate retraction of the tension leveller, squeegee and coater rollers, etc., and at the start of a new order, to initiate changes to process parameters as programmed via dedicated computers.

Tension Levelling

A tension leveller (**Figure 5301.03.04**) applies both tension and bending to the strip. Double pairs of 'S' rollers at the entry and exit of the leveller are independently driven and their speed differential can be steplessly regulated to produce strip extensions of between 0% and 2%, depending on the alloy, gauge and temper of the material being processed.



Source: Alcan Germany.

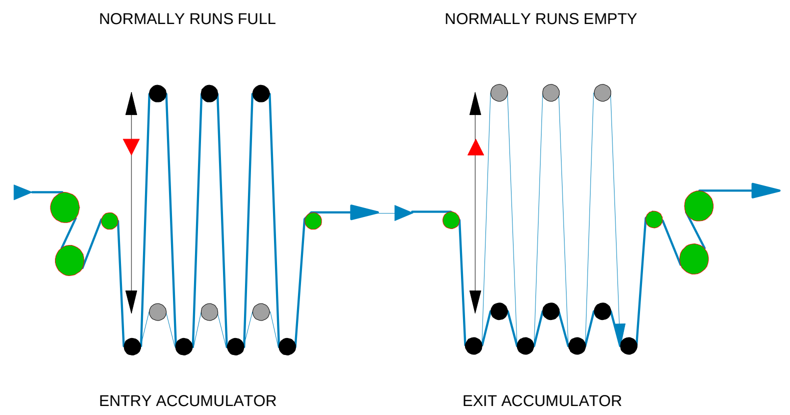
TALAT | TENSION LEVELLER. | 5301.03.04

The tension leveller ensures that the strip runs true throughout the line with the minimum of correction, and also that it lies flat on the various coating rollers. Also, as the strip passes over the multiple steel leveller rollers, any slitting burrs, which could otherwise scratch rubber rolls throughout the line, are flattened.

Strip tracking throughout the line is assured by positioning steering rolls prior to each process section and before the final rewind.

Entry Accumulator

The entry accumulator (**Figure 5301.03.05**) normally runs full and has a capacity for 200 m of strip which enables the entry section of the line to remain stationary for strip joining (coil change-over) for up to 1 minute at maximum line speed. On completion of the joint, the now partially-empty accumulator is refilled by the coil feed running at 275 m/min.



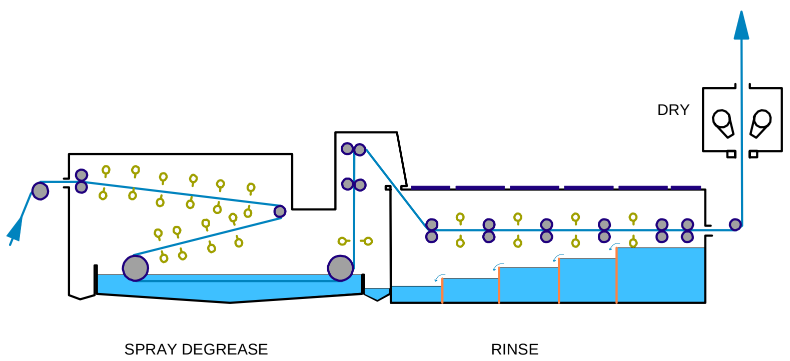
Source: Alcan Germany.

TALAT | STRIP ACCUMULATORS. | 5301.03.05

Degreasing, Rinsing, Drying

Figure 5301.03.06 shows a typical spray degrease, rinse and dry section.

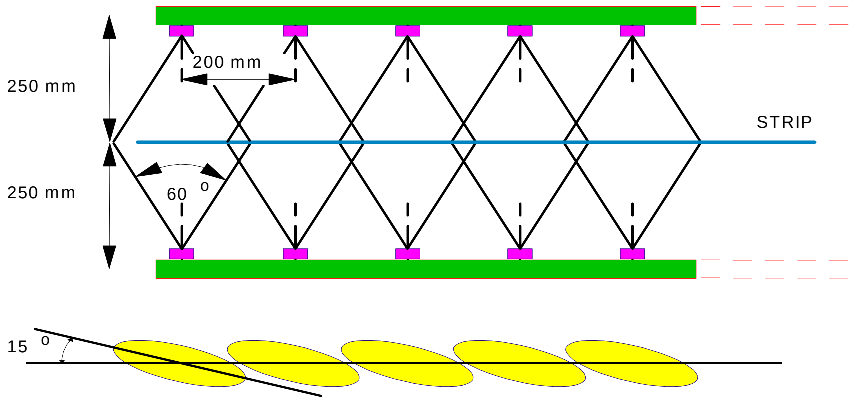
The strip passes through two banks of sprays which provide a path length of 8.5 m and then an immersion length of 5 m equivalent to a total cleaning time of 4 seconds at 200 m/min. The sprays should have a configuration as shown in **Figure 5301.03.07** to ensure overall coverage of the strip yet avoiding sprays clashing. They are fed via a heat exchanger from a recirculation tank. Spent solution returns to the tank with adequate dwell time for oil to separate and be removed by skimming.



Source: Alcan Germany.

TALAT | DEGREASING, RINSING & DRYING. | 5301.03.06

The strip exits vertically from the degreasing bath, through a final set of solution sprays which wash off any oil particles loosely adhering to the strip, and then passes through a double pair of squeegee rolls before entering the rinsing section.



Source: Alcan Germany.

TALAT | SPRAY CONFIGURATION. | 5301.03.07

The rinsing section should be preferably 5 zones, with each set of sprays followed by squeegee rolls. Demineralised water heated to 60°C is fed to the last rinse zone, and is counter-cascaded through to the first rinse zone, being recirculated within each zone. The conductivity of the rinse water in the first zone is monitored, and controls the amount of fresh water fed into the last zone and thence counter-cascaded to keep the rinse water contamination within pre-determined limits.

Rinsing should be based on the dilution principle. This assumes that the liquid film on the strip after a pair of squeegee rolls is 0.02 mm thick and before the next squeegees 0.1mm thick, i.e. a theoretical dilution of 5:1 per stage. Thus, commencing with 20% sulphuric acid (200,000 ppm H_2S0_4) the theoretical contamination levels on subsequent stages would be:

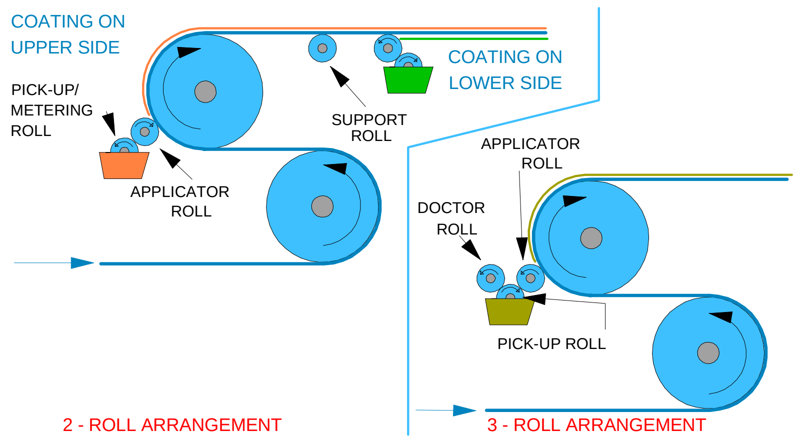
200,000 : 40,000 : 8,000 : 1,600 : 320 : 64ppm

A contamination level on the strip less than 100 ppm can usually be tolerated, indicating that a 5-stage rinse should be used.

The strip exits from the rinse section via a double pair of squeegee rollers, and then passes vertically through a short drying oven, with air at room temperature.
Fumes from both the degreasing and rinsing units are exhausted to a fume scrubber before discharge outside the building. Overflow from the degreasing and rinsing units is collected and pumped to the main effluent treatment plant.

Pretreatment

The pretreatment, typically a no-rinse chrome chemical type, is applied to each side of the strip by roller coating. **Figure 5301.03.08** shows a single-station chem-coater whereby the top side of the strip (designated to be the more important side) is coated whilst the strip is supported by a back-up roller). In each case a 2-roll coating arrangement is used, i.e. pick-up/metering and applicator rolls. Each roll is independently driven, and operates in the reverse coater mode, i.e. the periphery of the applicator roll rotates contrary to the direction of the strip. A typical pretreatment is 120 mg/m^2 dry coating weight.



Source: Alcan Germany.

TALAT	TYPICAL ROLLER COATING ARRANGEMENTS.	5301.03.08

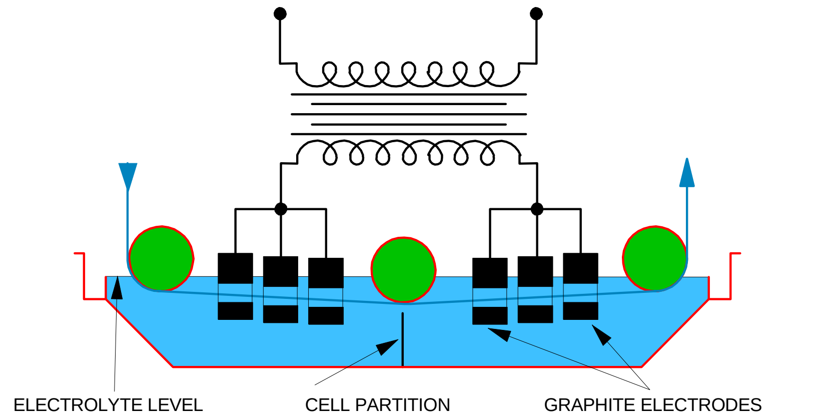
The pretreatment is dried, typically a hot air oven heating the strip to around 40°C. The strip is then air cooled and water cooled to around ambient temperature with squeegees and an air knife to dry the strip before it passes to the next, paint coating, stage.

On the wider coating lines (i.e. over 2000 mm) some unflatness and lack of stiffness of the strip may cause difficulties when coating the lower side using the arrangement shown in **Figure 5301.03.08.** A more precise pretreatment film weight is achieved by applying the top and bottom coatings in two separate stages, each with a back-up roller. In this case it is necessary to pre-dry the first coating before it contacts the back-up for the second coating.

An alternative electrolytic pretreatment process is effectively anodizing in a hot electrolyte using liquid contacts. The power supply can be either d.c or a.c. with the latter either single or 3-phase.

A cell containing an electrolyte (e.g. 20% sulphuric acid) is divided into 2 or more compartments, with electrodes in each compartment. Current passes between the electrodes and the strip via the electrolyte - there is no mechanical contact with the strip.

A pretreatment cell is shown schematically in **Figure 5301.03.09**. By using a.c., graphite electrodes can be used in each half of the cell. The electrodes are graphite blocks with slots through which the strip passes, pretreating each side of the strip simultaneously. In operation, the pretreatment film is produced whilst the strip is subjected to the anodic half-cycle, and the film is modified by chemical attack during the cathodic half-cycle. Full pretreatment can be effected in around 3 seconds. When using d.c., either lead, or lead-covered, electrodes must be used in the cathodic section.



Source: Alcan Germany.

TALAT | SCHEMATIC 2 - COMPARTMENT ELECTROLYTIC PRETREATMENT CELL. | 5301.03.09

If a preceding acid degrease is used, it can employ the same chemical composition as that in the pretreatment cell (e.g. 20% sulphuric acid) thus avoiding the necessity of rinsing the degreased strip prior to entering the pretreatment cell.

The liquid contact cell principle is also used in the other electrolytic strip treatment processes such as cathodic cleaning, electro-graining and anodizing.

Coating

A typical 2-coat line arrangement is shown in **Figure 5301.03.02**.

The pretreated strip is fed through the first coater where usually a primer coat is applied. The strip then goes through the first stoving oven and cooling section before returning to the second coating station where the top coat is applied followed by final stoving and cooling. A coating can be applied to the underside of the strip at either of the coating stations.

The coating roll assembly can be rapidly swung out of engagement for cleaning, or a colour change, and a new assembly swung into position.

Where a decorative film is to be laminated the first coater will apply an adhesive instead of the normal primer coat, which can then be dried or cured prior to lamination.

Drying and Stoving Ovens

The paint or lacquer drying and stoving (curing) ovens are probably the most critical elements in a coil coating line affecting line speed. The oven length dictates the line speed for a given stoving time, but whether this speed (metal throughput) is attainable depends not only on the ability of the oven heating to provide the necessary strip temperature, but also on the fume exhaust system to handle the paint's solvent emission volume and keep within an allowable solvent concentration of 15 g/Nm^3 (i.e. safely below the explosive limit).

The ovens are also expensive to operate both in terms of supplying heat energy and treating fume exhaust to meet stringent regulations. However, a well-engineered fume incineration and heat recovery system is a practical and economic solution.

The prime requirements for drying and stoving paints and lacquers on a coil coating line are:

- the initial rise in temperature must be sufficiently gradual to prevent solvent boil in the coating.
- a specific peak metal temperature must be reached for satisfactory curing of the coating.
- temperature difference across the strip width must be less that 3 °C to avoid coating colour variations or impairment of strip flatness.
- cooling must be sufficiently gradual to prevent distortion of the strip.

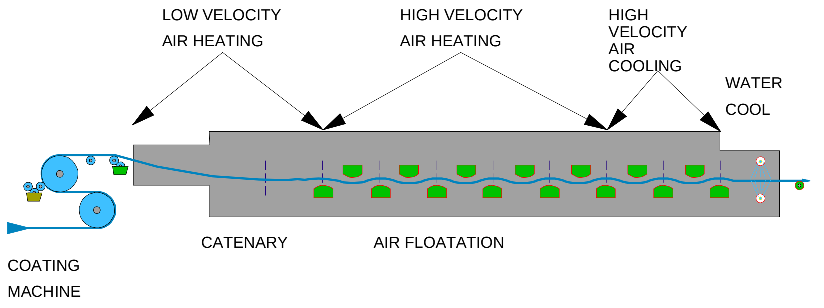
In addition to the above, as the strip may be coated on both sides, no contact (i.e. support rolls) can be made with the underside of the strip until the underside coating has been stoved and cooled to around ambient temperature.

On low-speed lines with relatively short stoving ovens, the strip can run through the oven as a catenary, but with the longer ovens, for higher speeds, the tension necessary to support the catenary is so high that strip breakage (particularly in the strip joint) may result. The solution is to support the strip by ‘air flotation’.

A typical oven is shown in **Figure 5301.03.10**. The main features are:

- a short trunking leading from the coater room to the start of the oven to catch solvents.
- a low velocity air heating section for solvent evaporation, i.e. drying the coating, (may be air flotation).
- a high-velocity air heating, air-flotation section to bring the strip up to the specific peak metal temperature (typically up to 250 °C) and hold it there to complete curing of the coating.

- a high-velocity air cooling section to bring the strip down to about 120 °C, followed by a water spray to cool the strip to around ambient temperature, followed by squeegee rolls and an air knife to dry the strip.



Source: Alcan Germany.

ARRANGEMENT OF TYPICAL COATING DRYING AND STOVING OVEN. 5301.03.10

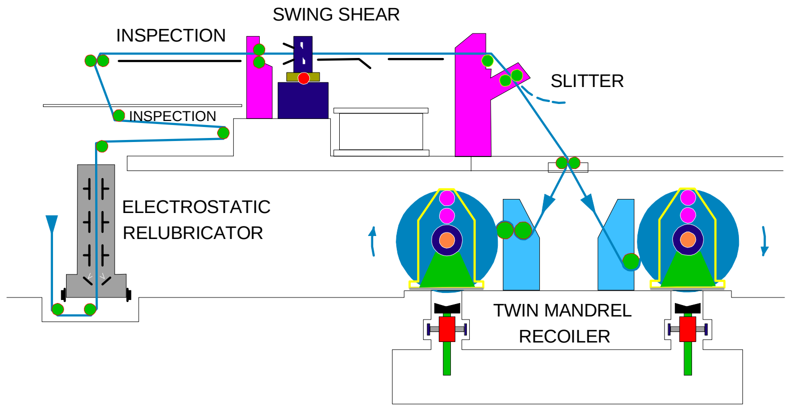
The oven is constructed with individual zones, each independent as regards its temperature and atmosphere composition. Air temperature distribution in each zone can be sensitively controlled by using high circulation volumes.

In operation, exhaust air from the drying section (at around 180 °C) is preheated to around 280 °C and fed to an incinerator where latent heat (solvent burning) raises the air to around 680 °C. Heating with natural gas then raises the exhaust air to the final, purified air temperature of 750 °C. This hot purified air is then available for feeding back into the circulating air of all the individual zones in the oven, preheating the exhaust air from the drying zones, and usually with sufficient excess to heat a boiler to generate steam to heat cleaning solutions and driers throughout the line.

With such a fume incinerator and heat recover system, residual carbon concentration in the oven exhaust stack can be limited to an acceptable 50 mg C Nm^3.

Exit Section and Re-Coiling

After the coating has been applied and cured, the strip will run into an exit accumulator (**Figure 5301.03.05**) which effectively isolates the process section from the units in the exit section (**Figure 5301.03.11**). The exit accumulator normally runs empty and will store strip to enable the process sections to run continuously while the exit section is halted to remove completed coils and to initiate new coils. The strip is edge-trimmed immediately prior to coil winding, so coil changeover may involve a cutter width adjustment at the commencement of a new order. Consequently, the exit accumulator has a larger capacity (1.5 minutes) than the entry accumulator (1 minute). Thus a 200 m/min. line would have a 300m exit accumulator capacity.



Source: Alcan Germany.

TALAT | EXIT SECTION & RE-COILING. | 5301.03.11

The exit section usually has twin coilers preceded by a transverse shear and a slitter. The shear is used for cutting out the strip joint and, on customer request, cutting the strip to provide smaller-diameter coils from a larger ingoing coil. The slitter is used to edge trim the strip to precise width prior to rewinding. However, on the wider coil coating lines, the strip can also be centre-slit to produce two narrower coils, with both strips being wound simultaneously on the twin mandrels.

On completion, the coils are strapped and automatically transported from the line to a computerised coil store to await dispatch.

The exit section shown in **Figure 5301.03.11** has an inspection area. The strip is looped so that both top side and reverse side coatings can be inspected at the same time. This can be done as the strip is running at line speed, or a crawl speed, or even stationary, with the exit accumulator storing material temporarily as the process section continues to run.

The line shown in **Figure 5301.03.11** also has an electrostatic lubricator for applying a thin, precisely controlled film of oil to each side of the strip. Typically this oil would be DOS for pretreated-only strip, applied at 5-10 mg/m^2, or petrolatum as a drawing lubricant for lacquered can stock, applied at 50-100 mg/m^2. Normally a process unit such as this lubricator would be expected to be sited prior to the exit accumulator, but the lubricated strip would be difficult to track through the multi-roll accumulator and furthermore, not all orders require lubrication; rolls subsequent to the relubricator have to be cleaned down after use to avoid contamination of the following strip, consequently with the lubricator located after the exit accumulator the minimum number of rolls have to be cleaned down.

The electrostatic lubricator can be constructed with an open side (‘C’ frame) so that it can be withdrawn from the line when not in use. This prevents droplets of lubricant falling from the machine (after it has been switched off) onto strips requiring no lubricant. It also facilitates maintenance of the lubricator.

Process Control

Continuous strip coating lines are a high initial cost investment demanding high utilisation to be economically justifiable. Also they have a high throughput, so unless all process conditions are held strictly within the operational limits, they can be expensive in scrap generation.

Today, it is usual for all process parameters to be computer-controlled, with visual display units (VDUs) at key positions throughout the line as well as in the main control room. As the next coil to be processed is loaded onto the entry mandrel, the line operator enters the process parameters for that particular coil and if necessary pre-selects any changes in the different processes via their dedicated computers. These parameters are then automatically adjusted as the strip joint (the leading end of the new coil) progresses through the line. The line operator can then monitor the detailed operation of any particular process by viewing the display from the appropriate dedicated computer.

For each coil, all significant process parameters are monitored and transmitted to a data bank for off-line statistical analysis. This information is correlated with the product properties thereby allowing process improvement and rapid response to any customer query.

All faults and malfunctions are also reported and stored for evaluation, rapidly identifying any component with an abnormally high failure frequency so that suitable remedial action can be taken. This will reduce line 'down-time' and lead to an overall high standard of mechanical integrity throughout the line.

5301.04 List of Figures