License Plate Technology Overview

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Introduction

License plates have come a long way since Massachusetts started making license plates in 1903. The earliest tags were made from leather, wood and porcelain (Delaware still permits porcelain plates). The earliest reflectorized plates were actually introduced in Mexico in 1936, but reflectorization didn’t come into use in the United States until 1948 in Connecticut. This early reflectorization was accomplished by a beads-on-paint process, a process Connecticut discontinued in 2000. Most states have already converted to reflective sheeted plates, a process first introduced by 3M in the 1960’s.

The earliest plates were simply numbered sequentially, but both California and New York reached tag number 1,000,000 in 1924 - coincidentally the same year the John R. Wald Company was founded.

In the United States, license plate manufacturing has typically been a correctional industry with an emphasis on inmate employment and a relatively low level of technological integration. However, as early as 1928, Idaho introduced tags with a potato motif and in 1931, Pennsylvania became the first to produce ‘vanity’ tags. These early forays into the use of license plates for advertising / personalization statements have grown to become a major driving force in the modern day license plate business. In light of all the changes license plate manufacturing has seen, it remains important to remember the core purpose of license plates: To provide a unique and clear personal identity of a vehicle and its owner, day or night.

What’s New? As plate designs and numbering requirements have become more complex, technology has become an important factor in the manufacturing process. With ever increasing computer literacy as well as the need for reduced waste, improved reporting on manufacturing status and more efficient methods for getting the finished plate to the end user, there has been a flurry of evolution in license plate manufacturing. The purpose of this document is to assemble a comprehensive reference source for all entities involved in the license plate process. Specifically, this resource will serve to describe typical license plate manufacturing processes and the potential for enhancement of operations by computer integration into one streamlined, cohesive system. We welcome any comments to suggest alternatives or corrections to this document.
Order Entry / Processing

Orders to the license plate manufacturing facility typically come from the state Department of Motor Vehicles (DMV) in the form of a paper document that specifies the plate characteristics (type, design, size, etc.) and the number that is to be placed on the plate. In some cases, the physical appearance of the finished plate evolved at the manufacturing facility as a function of what was possible with the equipment on hand. Sometimes this was formalized in an official policy/procedure document for license plate manufacturing.

As computer technology increases in the license plate manufacturing business arena, such a document becomes very important. Simply having a supervisor or inmate operator ‘know’ that a handicap plate has a certain sequence and placement of characters and handicap symbol is not sufficient when computer controls are integrated into the manufacturing process. Clearly defined rules are an absolute necessity for computer integration and also serve an important law enforcement function as well.

Production Scheduling is usually handled by shop supervisors who are aware of equipment and operator capabilities and shipment deadlines. This can be a very complicated process. In addition to regular orders, there are usually remakes, special orders, lost plates, production machines down for repairs, etc. that need to be considered when creating a production schedule.

What's new? Digital Order Fulfillment is a new term used in the license plate industry to define the integration of computer based control with license plate manufacturing technology to increase accuracy and efficiency at every step from the ordering of raw materials to the delivery of a finished license plate to the end user. The ultimate goal is to interconnect existing computer operations and equipment with additional systems that enhance the operations and complete the information feedback loop to provide a clear digital trail for a specific plate at each step of the manufacturing and distribution process.

With this new computerized system, Orders are typically generated on DMV (Department of Motor Vehicles) computer systems where a database of vehicle owners is maintained. Orders with or without owner addresses (depending on security issues) are then transmitted to the manufacturing facility in digital format. The actual method of order placement might be via removable storage media such as a USB drive, or it might be a direct digital link via network, modem, or a secure FTP web site. (FTP is File Transfer Protocol a procedure for file transfer between computers using the internet.)
What’s New? (cont’d) Production Scheduling software package should address a number of issues. First is to sort the DMV order data into logical production batches that might be broken down by day, machine, delivery requirement, etc. as required. Once production batches have been created, the next step could be a paper document or a digital transfer of data via removable media or network to the production area. This information would inform operators (for manual production) or computer controlled embossing / printing equipment for automatic production as to which plates are to be produced and organize the list in the most efficient sequence.
Materials

SUBSTRATE is the primary structural component of a license plate. At one time, steel was the main substrate material. Rusting concerns then brought galvanized steel and prepainted steel into much wider acceptance. Those materials continue to be used at a few sites, but aluminum is now the predominant substrate of choice.

Aluminum:

For embossed license plate production, it is very important to use aluminum with the proper working properties. This can be accomplished using several different alloys if they have the proper temper.

The most widely used aluminum alloys seem to be 3003 and 3105. Like steel, aluminum has evolved over the years. As an example, the 3105 alloy with H-21 temper and a typical thickness of 0.027 inches (~0.7 mm) is 98% pure aluminum with a few additives to improve strength and formability.

With the increase in awareness of recycling across the country, alloys such as the 3105 referenced above are using up to 92% recycled aluminum. These recycled alloys are not only less expensive to produce but have good working properties, if made properly. The mill does have to carefully control the chemical composition of the aluminum being recycled. Improper quality control at the mill may result in inconsistent characteristics of the aluminum. This can lead to license plate manufacturing problems (excess warping, machine jams, and cutting through during embossing) and thus rejected plates.

For license plate purposes to improve adhesion of reflective sheeting, aluminum should have a conversion coating. Typically this might be 6-9 mgs/square foot of a tightly adherent, chrome-free conversion coating with a polyester coating for backside protection as well as protection of the front side conversion coat.

Any reputable aluminum supplier will replace or give credit for defective material upon proper documentation that manufacturing problems and rejects are the result of inconsistent quality or aluminum that does not meet specifications. However, the cost of the aluminum due to rejects is often substantially less than the cost of wasted reflective sheeting and labor. Purchasing aluminum just on the basis of price is not always the best policy.
Materials (cont’d)

Aluminum (cont’d):

While flat license plates are missing a key security feature (embossing) there are a number of jurisdictions that are employing this process. Because of the lack of embossing on a flat plate, a harder and thinner aluminum can be used. This will not substantially affect the price of aluminum per pound, but should allow more plates to be produced per pound, and also improve mailing costs. Aluminum pricing is often volatile subject to market trends but typically (in mid 2017) is running $1.40-$1.50 per pound not including transportation costs.

REFLECTIVE SHEETING with a pre-clear protective coating is the most common face treatment material used in license plate manufacture, although there are still a few painted plates in use. (The precursor to pre-clear sheeting was the clear dip coat process. This “post-clear” sheeting is virtually extinct now.) The 3M Company and Avery Dennison are the leading suppliers of reflective sheeting in the United States' license plate industry, although Nippon, Orafol (Oracal) and Kiwa Chemical Company are also suppliers in this field.

Prices for reflective sheeting may range from $0.70 to $1.00 per sq.ft. for plain white sheeting to $1.00 to $1.50 (or more) per sq.ft. for pre-printed graphics (depending on quantities and colors). See Graphics Section for further details relevant to short-run graphics.
Graphics and Printing

GRAPhICS, in addition to the tag number is what makes a given license plate unique. The days of plain, single-color, unadorned plates are pretty much a thing of the past in the United States as well as in a growing number of other nations around the world. Just about anything is fair game for consideration as a license plate background.

Graphics Preparation may start as the idea of a special interest group or political entity. From preliminary ideas, artwork must be developed, usually with the aid of computer graphics software. Original images may be created on screen, scanned from photographs, etc. Configuration of the graphics image should consider many factors - physical size of license plate, mounting holes, quantity and size of identification characters that will be added to finished plates, color contrast, etc. Once the completed graphic image is arrived at, the next step is to decide how the image will be transferred to the reflective sheeting. Printing plates may be etched or engraved, printing screens may be developed, or in the case of digital printing, the image may be simply printed directly by a special computer controlled printer. In most cases, the computer graphics software must create color separation templates that sort a multicolored image into its constituent primary colors. Each of these color separated images must also include a method of accurately registering (or locating) so that as colors are placed on the sheeting the end result doesn’t show any color shadowing.

Long Run Graphics are what you find on standard issue graphic plates. These are the plate background styles that are found on large quantities of license plates. They are usually mass produced at the sheeting manufacturer’s facilities by a couple of different methods, but typically the printed image is ‘buried’ inside the reflective sheeting component layers to protect it. Roto-Gravure method is one in which millions of minute cells are etched or engraved below the surface of a printing cylinder in a web press. Very fluid inks are transferred from these cells to the sheeting at high press speeds. Because of the expense and complexity of rotogravure cylinder engraving, this process is suitable only for long run printing jobs. Each of four colors that make up a finished image requires a separate cylinder and each color must be dried before the next color is applied.

Rotary Flexographic printing is also typically web fed and is similar to Roto-Gravure in that each color must be dried after printing. The difference is that these cylinders use a raised image (like a typewriter key or rubber stamp) on the cylinder surface to transfer the image to the sheeting.

Rotary Screen printing is more often seen in the textile business but could also be considered for long run graphic sheeting. In this system, cylindrical screens are created of meshed material in which the desired image areas are porous and the colors are forced from the inside of the cylinder onto the surface of the reflective sheeting.
Graphics and Printing (cont’d)

Short Run Graphics are the specials. These include the low quantity custom graphics such as Purple Heart, wildlife plates, institutional (university, fire department, etc.), and more. If the quantity is not extremely small, these have been done with some of the long run graphics methods, but cost is high. (May be $2.00 to $5.00 per plate or more for sheeting alone, depending on quantity and complexity.) One caution here is that as graphics become easier to change the diversity and content of image can lead to the production of plates that don’t serve the primary purpose of quick identification. The ability to create high quality short-run graphics with a digital printer system opens the door to designs that prevent the accuracy of automated license plate reader ALPR systems that have become a key traffic control technology used in many jurisdictions. Some states, including PA, VA and AZ have already had designs recalled.

Screen Printing (Manual and Automatic) has been the usual method of creating short run graphics in the past, and is still used in some cases today. This is similar to rotary screen except the screens are flat and may print as few as 1 to 4 license plates at a time directly on a plain sheeted individual license plates. This is an economical, relatively easy to use, but low production system.

What’s New?
Digital Printing
Digital methods can be used to quickly produce about any conceivable graphic background. Digitally printed flat plates may be simply monochromatic printing of the identification number on a preprinted or plain background, or it may be the entire background image and identification number printed with a multicolor graphics printing system. The main difference is the computer software that controls the printers. Instead of repetitively printing the same background (or maybe a number of backgrounds) on the reflective sheeting, now the identification number and possibly some other data may also be printed.

This high tech addition to license plate manufacturing systems probably requires a few basic definitions for clarification.

Definitions:
Media for purposes of this discussion is the reflective sheeting or clear laminate that will receive the printed image.
Thermal Transfer Printing places a thermal transfer ribbon between the printhead and the media. Heat from the printhead melts components of the ribbon and transfers them to the media. Lubricants are frequently incorporated into the thermal transfer ribbons to significantly extend life of printhead. This explains why many manufacturers are adamant about use of proprietary ribbons and void the warranty when generic ribbons are used. This process is currently the most common type of digital license plate printing in use today for average production rates required in many jurisdictions.

Thermal Transfer Ribbons are typically available in three varieties: wax, resin and combination wax/resin. Wax is less expensive, less durable and easily smeared. Resin ribbons require higher printhead temperatures but produce very durable images. Combination ribbons are an attempt to achieve lower cost, but the tradeoff is durability.

Process Color is where 3 primary colors (cyan, magenta and yellow) are combined with black (or a 4th color) to produce a full spectrum of colors.

Spot Color is used where a very specific shade of color or perhaps a metallic or fluorescent tint is required. In those cases a custom ribbon color is developed for these specific applications.

Fixed data is the background image, state name, other logos etc. that is unchanged from plate to plate.

Variable data is the number, and possibly some other items such as expiration date, special symbols, special legends, etc. that may change from plate to plate. Typically, the printer manufacturer supplies variable data software that eases the manipulation of this variable data and links it to a database. This type of software usually separates the fixed and variable elements of the finished license plate image to speed up the Raster Image Processing (RIP) operation, then merges the data streams on the fly to ensure consistent quality and registration (within 40 microns, or so) in the finished printed image.
Graphics and Printing (cont’d)

Thermal Transfer Printers:

While there are a number of digital printing methods available on the market capable of printing on reflective sheeting, thermal transfer technology has become the most commonly accepted method for license plate production over the last decade. Due to the unique requirements of license plates, nearly all digitally printed sheeting is being processed on one of the following print engines.

**Matan Spring G³** Thermal transfer printer is a 6 color, high-resolution production printer that can print up to four process and 2 spot colors at speeds approaching 900 ft. per hour on 12” wide area at 400 x 200 dpi. Higher resolutions for even more detail are also possible but at slower production speeds. A custom laminator / rewinder system added to the exit of this printer and integrated with printer controls provides for application of a clear overlaminate and rewinding up to 300 yard rolls, This printer can process any roll width up to 12”, so it can be used for standard 6x12 US license plates as well as 4x7 motorcycle plates and any other width up to 12”.

An optional feature of this printer is to print to a registration mark allowing addition of other custom graphics and/or plate serial number to pre-printed long run reflective sheeting.
Graphics and Printing (cont’d)

Inkjet Printers:

Solo Inkjet Printer – is a low volume direct-to-plate inkjet printer ideal for specialty plate production and remakes. While capable of only 30-40 plates per hour this 6 head printer uses piezo heads to print 4 colors (plus two clear liquid heads for a durable protective coating). Photographic image quality is typical with 1200 x 1200 dpi print resolutions. This is a scanning head type printer with integrated LED UV curing for CMYK inks and a post-print arc type, shuttered UV curing system for protective clearcoat. A vacuum table is used to hold license plate blanks (typically with white reflective sheeting) for printing.

High Speed Roll-To-Roll Inkjet Printing – is a promising new technology that offers lower consumable cost than thermal transfer printers and much higher production rates. However, they are typically very expensive and somewhat finicky to operate. The biggest problem is that the high cost and production rate can possibly make these less than ideal for many low to moderate volume license plate producers.
Thermal Transfer Printers (continued):

**Custom Software** While the standard Spring G³ comes with printing software, an entire suite of custom license plate production software has been developed for use in conjunction with this printer –

**Digitag Order Fulfillment and Inventory Control Software** can manage all aspects of order fulfillment for License Plates, Validation Stickers, Registration Cards and more. This barcode-driven solution reduces human errors and provides real-time inventory reporting for all desired distribution points.

**Digitag Order Administration Software** handles all aspects of license plate order processing, including order entry and editing, production control, digital print reporting, etc.

**Varidata Software** is a graphical template management software package that can manage assignment and placement of 8 (or more in some cases) variable data fields linked to databased information. This package also performs color management for some types of product workflow and produces the required output files to drive the printer. A Lite version of this software also interfaces with the Solo inkjet printer.
**Production-Blanking**

BLANKING is the process by which license plate stock is converted from roll form to individual license plate sized blanks. Unless the plates are prepainted, non-reflective sheeted, this process includes lamination of reflective sheeting to the substrate metal.

Major components of a blanking line are as follows:

**Horizontal Coil Handler** – Most older blanking lines use a stock reel, but newer lines and some older lines with retrofits are using these. This system provides a safer, easier-to-load system for holding and supplying license plate metal substrate as it is unwound and fed through the blanking line. An added benefit is that the easier handling of substrate coils, results in less likelihood of damage to coils.

**Optional Wash/Rinse Tank** -(not shown above) Is used to clean any residual contaminants from the surface of the substrate. Typically this is an insulated tank containing hot water or cleaning solution and incorporating squeegee rolls at the discharge end to remove excess liquid from the substrate. An added benefit of the heat is that adhesion of reflective sheeting to the substrate is improved. It may also have a power rotary brush submerged in the solution for improved cleaning. There also could be an optional second tank so that one tank might be used for cleaning and one for rinsing. In production, steel substrate usually requires cleaning and rinsing while aluminum substrate requires only a hot rinse. In some cases, operations that do not use a rinse tank incorporate some sort of substrate heating system to aid in adhesion and stretch control.
**Production-Blanking, cont’d**

**Coil Stock Straightener** - Pulls the substrate from the uncoiler through the wash tank (if used). In addition, it flattens the inherent curl from coiled substrate and introduces a controlled amount of upcurl. This final upcurl property of the substrate carries through the applicator where it improves performance at the blanking die. Although available in wider dimensions, the units used in most US license plate production have a limiting stock width capability of 12.125”.

**Applicator** - Applies reflective sheeting to the substrate and recoils the protective liner for disposal. In the normal case of preprinted reflective sheeting, changes in humidity and temperature can cause minor variations in the actual size of the preprinted images. While these variations are quite small, the finished blank size is identical every time. Without a control system, blanks would often be cut with the image off center from top to bottom, rendering the blank useless. The applicator shown below has a control system that measures every image and stretches the sheeting to just the right size. In those cases where a digitally printed graphic requires a clear overlaminate for durability, the applicator may include a second application system for that overlaminate material. While typically used as a 12”+ wide stock processing unit, the applicator can process stock widths up to 16” if other parts of the blanking line are compatible.
Production - Blanking (cont’d)

Feeder/Graphic Registry System – The laminated stock is fed into the Blanking Press and Blanking Die by a precision Servo Roll Feed. The Servo Roll Feed receives timing signals from the Blanking Press as well as the Graphic Registry System. A photoelectric sensor detects a registration mark on the graphic sheeting and controls the length of material fed into the Blanking Die. This ensures a consistent location of the graphic printing on the blank as well as blank size. Older feed systems use mechanically driven roll feeds or air feeds which are less accurate.
Production-Blanking (cont’d)

Blanking Press - is typically a 30-60 ton mechanical press operating at a set speed of 90-120 strokes per minute. This provides the muscle to blank 4,000-7,000 license plates per hour from the laminated substrate/sheeting roll stock.

Vacuum Slug Collector - uses a combination of aimed and timed compressed air with a heavy duty industrial vacuum system to capture the trims from radiused corners. (Punched hole slugs drop through to a collection pan.)
Production-Blanking (cont’d)

Blanking Dies – are the precision die cutting systems that actually create a license plate with each stroke of the blanking press. For license plate purposes, these dies are most commonly available as Drop-Thru type, Parting Die Type and Compound Blanking Die, and each type serves a different purpose.

Drop Thru Blanking Die - is designed such that practically no waste or scrap is generated as an inherent function of the manufacturing process. The only scrap is the slugs punched from the mounting holes, and the corners trimmed to provide the corner radius. Everything is mounted in a 4 post leader pin die set to maximize accuracy. Blanks from this process are flat and have all required holes / corner radius work complete as they are ejected from the blanking press, typically being removed from the die area via a low profile conveyor.

[Image of Drop Thru Blanking Die with labels indicating Die Guarding and Conveyor]

Flat Blank w/Preprinted Sheeting
Blank and Rim Blanking Die (sometimes called Compound Blanking Die)
In addition to punching holes and radiusing the corners, this type of blanking die also forms a rim on the plate by incorporating the border forming in the same unit. Usually the rim in this case is of the depressed flange design.

This type of die is typically used in ‘flat plate’ operations in which the plate number has been digitally printed on the sheeting but not embossed. This is also usually a drop thru design in which the finished plate drops out the bottom of the die and is removed from the die area by a low profile conveyor.
Production-Blanking (cont’d)

Parting Die Unusual sizes or other non-standard requirements are often best met with a parting die. This type of die can allow for easy transition from one plate size to another where the width is consistent but the length is different.

This is also a good solution when the width of the desired blank is non-standard. Rather than make a complete custom drop thru die for the special size, (expensive and long delivery) a relatively simple replacement of the cutoff steel die to suit desired width can be done.

The variable nature of plates produced with this type of die is not consistent with drop thru die design, so plates are typically ejected from the end of the blanking die and may be handled with either a basic gravity chute, a conveyor, or, as in the case with the die shown below, a custom air assist low profile chute.
Low-Scrap Die One other type of blanking die is referred to as a low scrap die and is used for low production quantities of smaller size blanks. These may be custom blank sizes for special purposes, off-road vehicles, or standard 4 x 7 motorcycle plates if quantities are low. This die is designed to take a standard large blank (typically 6x12) from a high speed blanking line and cut the special size out of the middle of that larger blank. This type of die can be used in most of the typical embossing presses and has also been adapted for use in any small press with sufficient die space.

Example of cutout in 6x12 blank to create 4x7 blank. This example shows an unsheeted blank, but a digitally printed image of the smaller plate is typically used with this die so that after blanking, a ready to use motorcycle plate blank is created.
**Production - Embossing**

**EMBOSSING** is the process by which raised or depressed letters, numbers, symbols, and/or border is created for a license plate. A significant benefit of an embossed plate is the difficulty of counterfeiting. At one time, the most common type of license plate was manufactured as a fully embossed or sometimes, debossed product, but flat plates are becoming more prevalent due to lower production and distribution costs. However, embossed plates continue to exhibit the best security feature available.

Embossing Presses are typically hydraulic presses with tonnage capacities as low as 30 tons and up to 200 tons. Historically, most license plate embossing presses were 200 ton HPM machines. These were sturdy, trouble free machines that were very good at making license plates, especially when one considers that most license plates were steel in the past and required higher embossing pressures.

New embossing presses are usually Hydraulic Press Brakes in the 60 to 135 ton range, depending on service needs. The 60 ton press shown here has a four foot bed which is well suited to installation of a safety feeder.

Larger press brakes such as the CB-135 have the capability of being fitted with either two safety feeders or a safety feeder and a sliding die if necessary.
Production – Embossing, cont’d.

Traditional embossed plates are usually created with the custom feeding and embossing systems installed in embossing presses. The Safety Feeder shown in the picture below is a two-station system that permits loading of blanks by one operator and changing of embossing dies by a second operator. Inherently safe design features keep operators hands safely out of pinch points. This unit uses male/female rim dies to create the border of the plate, and hinge dies (which are easily interchangeable) to create the license plate alphanumerics. Different parts of the country refer to hinge dies as flipper dies, paddle dies, etc. These dies are available in numerous sizes and designs for specific applications and incorporate male and female inserts for each embossed character. Safety feeder embossing provides the best character definition, and is available in standard 6x12 license plate format or 4x7 motorcycle format. This type of embossing can produce embossed license plates, complete with embossed or debossed border at 900-1,200 plates or pairs per hour. (When license plate pairs are required, two blanks are fed into the system at the same time, and both are embossed in the same operation.)
A **Sliding Die** is a single station system that uses a male and female rim die for the border of the plate and interchangeable male block dies for each character to be embossed. Female block dies are used only for legend inserts (typically for top or bottom line legends). The female portion of the rim die encases a special elastomeric pad to control embossing. A single operator loads blanks and changes the embossing dies, and as with the safety feeder, inherently safe design features keep operators hands out of the pinch points. Production capability of the Sliding Die is up to 400-500 plates per hour.

Single aluminum plates require approximately 60 tons embossing pressure. Pairs of aluminum plates are sometimes embossed in a sliding die, but require at least a 135 ton press and excellent quality aluminum. This method of embossing is often referred to as **rubber counter embossing** and is not always suitable, especially in cases of pairs of steel plates.

**Low Volume Embossing System** is ideal for specialty plates, remakes and production facilities with lower production requirements. The main component of this system is a low volume embossing press capable of 120-150 cycles per hour with the capacity to emboss pairs or singles. To complement this press a ‘suitcase embossing die’ and a full complement of character dies are used to emboss blank plates.
Production - Embossing (cont’d)

Print to Emboss (P2E) is an embossing operation closely allied with digital printing. This process entails digital printing of a plate using a custom font for the serial number that has been designed to exactly match the embossing tooling. This is a process that requires very good accuracy, both in printing and in embossing to ensure the resulting finished product exhibits good alignment between printed and embossed features. While initially implemented using low volume systems (Solo Inkjet Printer and Low Volume Embossing System), if good control is exercised in the digital printing, blanking, and high production embossing systems it also works well there and has, in fact, been used successfully in a high production Central American facility, completely eliminating the need for a finishing system.
Production - Embossing (cont’d)

What’s new? Manual Embossing continues to be the primary mode of plate identification for most license plate production facilities. To introduce computerization to manual embossing, an Embossing Production Enhancement System (PES) has been designed to assist and verify manual embossing requirements. This is particularly valuable in the case on non-sequential plates. This unit can take a variety of physical configurations, but the primary function is to provide a graphic display of each required license plate number to an embossing press operator.

The sequence of this data might be optimized for the most efficient production sequencing or, if required, would display each number in a predetermined production sequence. In addition to displaying the tag number, the display also presents the required sequence of manually placed tooling, including spacers and special characters. Once the operator places tooling as specified and presses the dual palm buttons, the system verifies that tooling placement is correct before engaging a press permissive interlock. In addition to reducing waste due to mis-made plates, an added benefit of this step is to link production status of a specific plate back into the computer data environment. The other advantage of verifying the embossing is that now date and time is trackable since the process is computer based. This data can be communicated back to the Production Scheduling computer system to provide real time tracking of production status.

In addition to manual systems, License Plate Identification may also be done by a computer driven equipment such as an Automatic Embossing System, although the equipment cost is quite high. With this type of system, the required identification number is digitally delivered to the automatic stamping system by the computer scheduling software and the required plate is created without the need for an operator to change tooling manually. Production capacity of a machine such as this is up to 500 plates per hour.
Production - Finishing

FINISHING operations typically complete the manufacturing process. This step is typically not used with digitally printed plates that are protected by a clear overlaminate and not embossed, or for Print To Emboss plates.

Liquid Numeral Coating is the traditional method used for embossed plates. Not only is it the most economical method of finishing plates, but it is excellent for high production rates. In this process, a custom design roll coating machine is typically used to apply a liquid coating to the raised (embossed) portions of a license plate at a rate of 2,000 or more per hour. This system usually incorporates a timed feeding mechanism with the special designed roll application action to efficiently coat all raised areas. In some cases, the identification numbers are debossed into the plate and the roll coating material is applied to the surrounding flat areas of the license plate.

M31 Coating Machine

Typically, the M31 Coating Machine applies solvent based coating inks to raised portions of an embossed license plate, and, with a few modifications, is also used with UV curable formulations of coating inks.
Environmental concerns have forced most solvent-based liquid coating manufacturers to use a high solids formulation. To maintain the best viscosity for application, an optional circulation system designed to operate in conjunction with the coating machine may be used. In addition to viscosity control, this unit also assures a constant ink flow to the coating rolls to maintain quality of coating. This same feature also eliminates the problem of coating rolls drying out. Rolls that dry out may stick together and cause major damage to the coating machine.

Since this is usually a solvent based coating, an optional Fume Exhaust System may also be used for fume control at the coating machines.
Curing System for license plates in past years had to deal not only with numeral curing but also with an additional curing requirement - clearcoat. The earliest systems were typically crossbar ovens. In these, license plates were hung from hooks on crossbars that were conveyed through the dip coating and oven areas. In later systems, numerals were coated and cured typically on a combination carrier suspended from a monorail conveyor. The carrier had shelves for numeral coated plates for curing and a hook arrangement on the bottom. Plates that were numeral coated and cured were then hung from the bottom of the carrier and dipped in a clearcoat dip tank prior to going through the oven a second time to cure the clearcoat.

The advent of Pre-cleared Reflective Sheeting eliminated the need for clear coating systems in the license plate manufacturing facilities. The new curing system is now, typically, a single or dual flat belt oven. Nominally, the flat belt conveyor operates at about 5 fpm and curing takes place in 10 minutes or less at 240-300° F. The oven system normally uses either a direct gas fired heating system with an internal ductwork distribution system to spread the heat evenly across the oven belts, or an electric infrared curing system. A refrigerated cooling tunnel at the discharge end of the oven ensures plates are easy to handle and coating has cured to proper hardness. An added benefit is that the oven also relaxes sheeting wrinkles that may occur during embossing.
Flatbelt Curing Ovens are typically available in single or dual belt configurations rated at 2,000, 4,000 or 6000 plates per hour depending on space and production requirements. Normal method of feeding the flatbelts that run through the oven is via plate distributors that convert a serial plate stream to a parallel arrangement.

A Plate Distributor at the discharge of the coating machine automatically transfers a single file production line of wet, coated plates to a 2 to 4 (or more) wide flat belt running perpendicular to the coating line. This eliminates operator handling (common in the past) and subsequent risk of touching (and therefore ruining) wet numeral ink on the license plate.

UV Curable Inks are a relatively new development in license plate manufacturing. These have been proven to be an excellent alternative to solvent based coatings for license plate numeral coating. They have been through the full complement of weatherization testing and fully meet warranty requirements. They have the advantage that traditional solvent fumes are reduced or eliminated and the system is quite compact. However, the UV ink does have some odor, so a ventilation system is incorporated into a standard system.

For curing, an ultraviolet light curing system is required, and that carries some operator hazards of its own, in particular, heat from the lamps and ozone generation.

The main disadvantage of the UV inks is a limited palette of colors to choose from. The most typical black and blue coatings are available along with a few other colors, but if a very specific color is required, it would most likely require some additional custom development and weatherization testing.
Production - Finishing (cont’d)

M31-UV combines a conveyorized UV curing system with exhaust with an M-31 roller coating machine to create a very compact finishing system for license plates. The 500 watt model can easily cure 2000 plates per hour to match output from the coating machine. While a typical flat belt, gas fired curing system would occupy 1500-2000 sq.ft. of floor space and consume over 400,000 BTU of gas every hour, the M31-UV has a footprint of less than 50 square feet.

M31-UV Numeral Coating Machine With Integral Ultraviolet Curing System

Hot Foil Stamping is another numeral coating process using a heated transfer roller to press a section of roll fed hot stamping ribbon against the raised portions of a plate to apply the coating. It is ideal for low volume production, quick turnaround remakes, special colors, etc. The US concept of large scale, centralized license plate production within a correctional environment typically utilizes higher production coating methods for primary production. Hot foil coating is relatively low production (approx. 400 plates per hour) and the ribbon is quite expensive.
Packaging and Distribution

Packaging of finished license plates is handled in a variety of ways. Plates may be plastic wrapped, bagged or plain. Singles, pairs (or more) may be placed in shipping or mailing envelopes or possibly boxed/bagged for bulk mailing. Boxes may be palletized for ease of loading. Plates may be sent directly to the motorist, to DMV distribution facilities, local distribution authorities, or to private sector bulk mailing facilities. In short, a wide variety of methods have been employed to get finished plates to the end consumer and to update DMV database as to the status of delivery - most of them pretty inefficient and labor intensive until recent years.

License Plate Digitizer (LPD) is a computerized optical verification system that is far superior to visual verification by operators. Experience has shown that an error rate of 5-8% from visual inspection can be improved to significantly less than 1% with the LPD System. An LPD can allow a production or distribution facility to digitize/computerize flat or embossed finished plates so that computer software can be utilized to do myriad improvements in tracking, distribution, reporting, preparation of supporting documents, etc.

<table>
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<th>Last</th>
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</tr>
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<td>Samuel</td>
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How does the LPD work? A production database of license plates currently on order is created by a digital transfer of data from the production scheduling system (or direct from DMV data if production scheduling software is not in use). This data is used as a checklist for the computerized optical verification capabilities provided by the LPD.

A camera and custom OCR (optical character recognition) software operate in conjunction with a custom Graphical User Interface (GUI) and mechanical hardware to optically scan and interpret finished plates. An optical sensor detects when a plate is in the camera’s field of view and tells the computer to capture an image for computer recognition and database processing. The computer recognized plate numbers are evaluated in conjunction with the production database to determine status (plate found and marked as read, plate not in database, etc.).

In addition, when a plate is marked as “Read”, the database also gets a time and date entry to serve as further production scheduling feedback, and at this point print commands can be issued to prepare a wide variety of documents as required (as long as information is in the database). These documents could be validation stickers, year date stickers, barcode labels, registration cards, mailing labels, envelopes, etc.

**Barcoding** is an important part of any packaging / distribution / identification system. Available in many symbologies in both 1 and 2 dimensional formats, these can be linked to a specific plate numbers to provide a wide range of functionality. The plate-barcode link can be via database assignment, or LPD OCR system. Once assigned to a plate number, the barcode can be applied to paper order documents, individual plates or pairs, boxes of plates, pallets of boxes, etc. to provide any level of data tracking and control desired. As an added advantage, address data can be coded in the barcode to provide further data security and print mailing envelopes or self adhesive labels for manual or automatic attachment to any of the various formats from envelopes to plates to boxes.
Packaging and Distribution

Direct, real time printing of mailing envelopes is another major benefit of the LPD System. A high speed printer in conjunction with the OCR system prints vehicle owner addresses on **Mailing Envelopes** or labels at a rate of approximately 1,000 per hour. As an added feature, additional software can be incorporated to enhance zip coding and verify address accuracy.

In addition to printing on labels, it is also possible to print barcodes directly on license plates or on labels as part of the LPD process.

**Shipping/Mailing:** Another step in complete Digital Order Fulfillment is the capability to sort bulk shipments by postal zones/zip codes to reduce mailing costs. This step could be taken during initial production scheduling if a specific shipping sequence is not pre-defined. Alternatively, products processed through the LPD System and identified with barcodes that include address information can be sorted for bulk mailing advantages.
Packaging and Distribution

Customized Reports that can list plates missing from order (to develop a remake list) and indicate completion status at the plate, box or order level, shipment status, etc. are a usual feature of the LPD System. In addition, this data can be exported to the production management or DMV mainframe database as required.

Other Benefits: Companion documents for license plates, such as Owner’s Registration Cards, Validation Stickers, Yeardate Stickers, etc. can also be printed for insertion into mailing envelopes. This eliminates the need for later matching of items from different sources prior to mailing. In addition, the capability to sort bulk shipments by postal zones/zip codes can significantly reduce mailing cost by taking advantage of bulk mail distribution rates.
Security Features

In this modern high tech era the potential for identity theft, counterfeiting, etc. is a very real concern. There are a wide variety of security features available for inclusion on a license plate to try to maintain or enhance the security of the original purpose of a license plate - To provide a unique and clear personal identity of a vehicle and its owner, day or night. Some of these features can be very costly to implement and, frankly, of questionable cost / benefit value.

Embossing is the oldest and probably still the most secure method of preventing counterfeiting since it requires large, custom equipment to create an embossed plate. This process has been in use almost since the inception of license plates and is still the most prevalent for of license plate.

Watermarked Reflective Sheeting is another prevalent and difficult to counterfeit security technology that has come into use with the advent of reflective sheeting for license plates. This is most typically ‘built-in’ to the reflective sheeting as provided by sheeting manufacturers. It is highly customizable per customer requirements and can also include date coding. As this is typically embossed into the sheeting during the manufacturing process, it does take some time for design approval, rotary die building and ultimate implementation in sheeting manufacturing equipment, although some other processes such as laser marking can create watermark features as well.

License Plate Fonts & Background Designs contribute heavily to the readability and hence security aspects of a plate. A background design that is either not ‘busy’ or features a clear white space where the serial numbers are to be located is strongly recommended to improve ALPR readability.

Another problem is that as jurisdictions have increased the number of registered vehicles, it has often led to the requirement to increase the number of characters on a plate, which means smaller (and more difficult to read at a distance) characters. Also, special interest groups have lobbied for more and more graphic backgrounds which also contribute to readability issues.
Security Features, cont’d.

License Plate Fonts & Background Designs, cont’d. Numerous measures can be applied to improve these issues. It is advisable to try and keep font characters to a height of at least 2.5” with a proportional width and a stroke width of 0.2” to 0.4” wide. In addition, main serial number characters should be kept a minimum of 1.25” from top and bottom edges of the license plate. Clear font designs that are ALPR friendly are always preferred.

Custom ALPR (Automatic License Plate Reader) Fonts are not exactly a security feature, but they do enhance security by allowing ALPR units to more quickly and accurately identify a plate. This is done by redesigning a standard license plate font so that easily confused characters have more distinctive features.

Plate Barcoding can be as simple as encoding plate number in a barcode format or, especially if 2D codes such as QR code are used, it can encode much more, including vehicle data, owner data, etc.. Although relatively easy to implement, there are some challenges such as the requirement for enforcement officers to carry barcode readers and also the fact that barcodes are a bit more difficult to read on reflective sheeting.

Laser Marking is a new feature found on a few plates around the world but is not widely used. It can mark anything from an identification number to a plate number or even a barcode, but it is an expensive technology to implement and can slow down production speed. The added concern is that it is not readily visible unless closely inspected, but that is also mostly true for watermarking.
Security Features, cont’d.

**Inscripted Hot Stamp Foil** is the term used for hot stamp foil which has another feature in a different color running through the background color. Usually the background feature is text and may spell out the jurisdiction name. It requires the use of hot stamp roll coaters for application which is a slow production process. In addition, it is expensive and essentially not recognizable from a distance of just a few feet.

**Holographic Label** is a feature used in a few places as a security mark, but it is quite expensive and very difficult to see as anything other than a dark square unless you are quite close to it. These can be of a variety of constructions, but most durable are chromium (which are, unfortunately, the most expensive, also).
Credits and References

Historical notes:
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Printing and LP Technology References:
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http://www.labelandnarrowweb.com/july002.htm
http://www.epa.gov/ttn/chief/eiip/techreport/volume03/iii07.pdf
AAMVA License Plate Standards of 2016

General JRW License Plate Manufacturing Information:
John R.Wald Company Employees, particularly Mike Rodli, Lynn Conaway, Sam Lynn, Doug Tietjens and Ed Rogers