ID Laser Marking of LOD Pipe

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INTRODUCTION

Large Outside Diameter (LOD) pipe manufacturers are required to accurately identify their pipe both for internal record-keeping purposes, and for their customers. They are also required to mark these pipes with certain identification markings, typically required by API Spec. 5L[1]. This pipe mark provides identity and traceability for each pipe, thus enabling the manufacturer and the end-user to determine the manufacturing origin of the pipe.

Technology is now available that enables bar code identification to be created "on-site and on-demand" and to be automatically and permanently marked on LOD pipe by laser marking a paint patch applied inside the pipe diameter. The white paint patch can be marked with text, graphic images and bar codes. The inherently high contrast nature of black laser marking on the white background eliminates variations in surface appearance that would otherwise preclude bar code marking. This leads to reliable bar code reading that can be performed using low cost commercially available bar code scanners. The addition of this laser marked identification further enables the use of downstream bar code reading systems to scan the bar code for identification of the pipe at key manufacturing nodes, and also enables the ability to automatically update the database with manufacturing process results at these nodes on a pipe-by-pipe basis.

This paper discusses the evolution of laser-marked identification for LOD pipe, and also discusses the equipment to automatically apply laser-marked identification to these pipes.

HISTORY

Manual LOD pipe marking can be less-than-optimum operation. A worker typically prepares an punched oilboard stencil and sprays white paint through the stencil to apply a multiline identification to the bottom dead center at the end (or both ends) of a pipe. In some cases, certain data such as pipe weight is filled-in later by hand using a metal paint pen or additional punched stencils, after the application of the main stencil. The punched stencil board may be punched manually by hand using a die punch machine, or in some cases, an automated punching device can prepare the stencil board using a computer download.

[1] API Spec. 5L – American Petroleum Institute Specification 5L, "Specification for Line Pipe"

This manual marking job has accuracy, ergonomic and hazard issues. Due to the boring and repetitive nature of the work, human errors can occur in the punched stencil. Constant bending to apply and spray the stencil can result in repetitive workplace injuries. Constant close quarters exposure to sprayed paint fumes are not desired by workers or by the employer.

In some cases, adhesive labels are used. These labels can peel off and contaminate pipeline valves if not properly removed at pipe installation in the field.

In the year 2000, LOD pipe mills started using a new type of identification – laser marked identification, starting with the Berg Steel Pipe facility located in Panama City, Florida, USA. The equipment used to apply this mark is called the "Inside Diameter Laser Marking System" or simply "IDLMS". The IDLMS accepts downloaded information from a Mill computer, automatically compiles the mark image without requiring worker input or action, and automatically applies the mark inside the open end of the pipe. The IDLMS uses a spray nozzle to spray apply a laser-markable white paint patch onto the bottom dead center of the pipe. A special white paint is used, designed to turn black when exposed to laser energy. After laser marking, a clear overcoat is applied by a second spray nozzle to seal the mark and help to protect the mark from weather.

The laser mark is printed using a scanned CO_2 laser beam to quickly create the mark "on-site and on-demand". Much like an office laser printer, laser marking systems can print any combination of text, graphics and barcodes in high resolution.

The advent of automated "on-site and on-demand" laser printing for pipe mill products eliminates the requirement to manually prepare punched stencils and add fill-in data later. The Mill Computer can now download the entire mark data to the IDLMS to dynamically create the required pipe mark on-demand, dynamically create a suitable product identification number on-demand, and dynamically fill-in critical manufacturing data in the mark for each pipe in real time as it arrives at the IDLMS marking station. The laser marker can also use the downloaded data to automatically parse out certain data to compose a pipe identification bar code suitable for downstream bar code scanning. Operator actions are still required for periodic maintenance and to replenish paint and solvent containers, but accuracy, ergonomic and hazardous issues are greatly improved when compared to past cut stencil board operation.

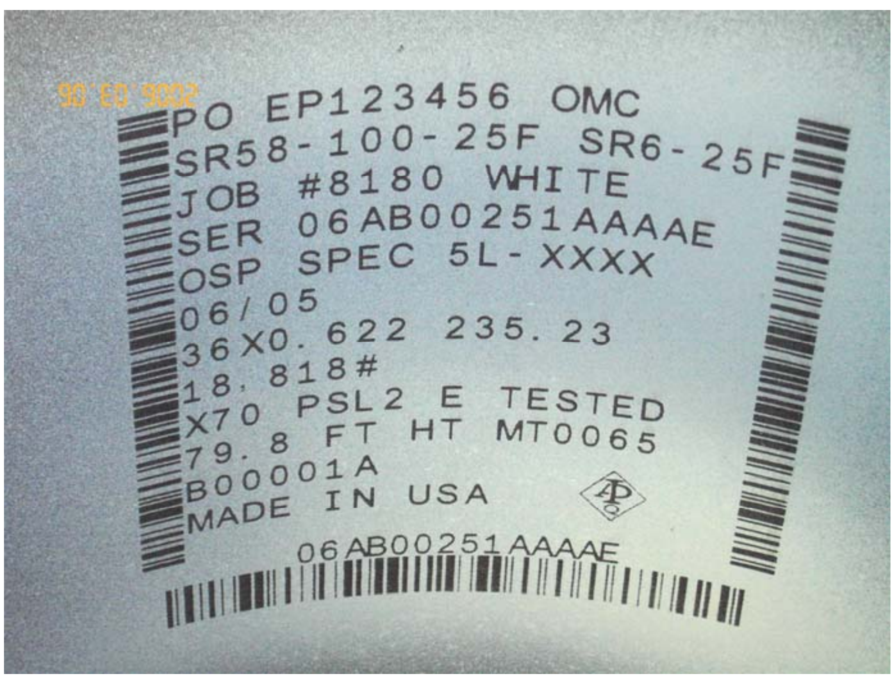

Figure 1 Typical IDLMS Mark (this picture is distorted due to the angle of view looking into the pipe)

MARK LOCATION AND CONTENT

API Spec 5L requires a specific location of mark defined as follows:

- "Welded Pipe size 16" or larger – Paint stencil on the inside surface starting at a point no less then 6 in. (152.4 mm) from the end of the pipe in a sequence convenient to the manufacturer, unless otherwise specified by the purchaser."

API Spec 5L also requires a considerable amount of data to be marked on the ID of the pipe. Specified marks are as follows:

- Manufacturer
- Specification
- Compatible Standards
- Specified Dimensions
- Grade and Class
- Product Specification Level
- Process of Manufacture
- Heat Treatment
- Test Pressure
- Supplemental Requirements

The pipe purchaser may specify even more data to be marked in addition to the above API-specified data, for example, purchaser name, purchase order number, weight, delivery location, etc. This total amount of data requires a considerable number of marked lines and also considerable area. In the mark shown in Fig. 1, the text can be up to 12 lines. This mark illustrates that abundant text; multiple bar codes and multiple logos can be marked – limited only by what will "fit" in the laser marking window area within the white paint patch.

IDLMS MACHINE COMPONENTS

The IDLMS is positioned to perform marking at the open end of a reasonably end-indexed LOD pipe, centered in a vee roll or vee saddle centerline at the marking station.

The machine consists of the following major components or assemblies:

1. Marking Machine Assembly
    a. 100 watt CO_2 laser with power supply and control
    b. Low wattage red laser pointer with power supply (used for diagnostics for laser aiming)
    c. Laser optics chamber
        i. Chamber is air-purged to keep paint and clearcoat "mist" contamination out
        ii. The optics chamber contains:
            1. Laser lenses as required
            2. Galvanometer control and mirrors as required for laser beam aiming
    d. White spray nozzle
    e. Clear spray nozzle
    f. Air cylinder for extension to "find" the end of the pipe
    g. Air cylinder to lower and "find" the bottom dead center of the pipe
    h. Stepper motor/ballscrew drive for extend / retract control
        i. Fast step for spray operations
        ii. Slow step for laser marking
    i. Purge fan blower used to positively purge the marking enclosure
    j. Heated Air fan blower for heated air used to "tack" the paint patch prior to marking
    k. Cabinet heater
    l. Motor Control Enclosure (for fans)

    m. Power transformers as required
    n. Electrical takeover point boxes as required
    o. Air takeover point connection as required
2. Floor Control Panel, with pushbuttons/switches/lights for local machine control
3. Paint System, with valves, regulators and plumbing necessary for operation
    a. Pressure pot white paint supply
    b. Pressure pot clearcoat supply
    c. Pressure pot solvent supply
4. Laser Chiller – circulating system that routes ethylene glycol coolant through the laser, with a fan cooled heat exchanger for laser cooling
5. Air Dryer – used to supply dry instrument quality purge air to positively purge the laser optics chamber
6. Electronics Enclosure – located remotely from the marking machine, provides microprocessor marking control and PLC machine control
7. Data Terminal – used for setup and diagnostics only

The maximum size of laser marking window containing all marking is typically approximately 200mm x 200mm (8” x 8”) square. The paint patch is applied somewhat larger than the marking window – approximately 300mm x 300mm (12” x 12”) square, with fuzzy (sprayed) edges.

It is possible to design the IDLMS to be combined with other technologies. For example, the IDLMS can be combined with other equipment to receive length data and weight data from separate subsystems to create an integrated weigh-measure-stencil (WMS) system.

IDLMS MACHINE OPERATION

The IDLMS machine generally will extend and lower to “find” the end and bottom dead center of the pipe, spray a white fuzzy-edged paint patch in the bottom of the pipe, laser-mark the patch, spray a clearcoat on the just-marked patch, and then retract to a “Marker Clear” position.

Figure 2 IDLMS Marker shown in testing – marking a cutaway pipe section

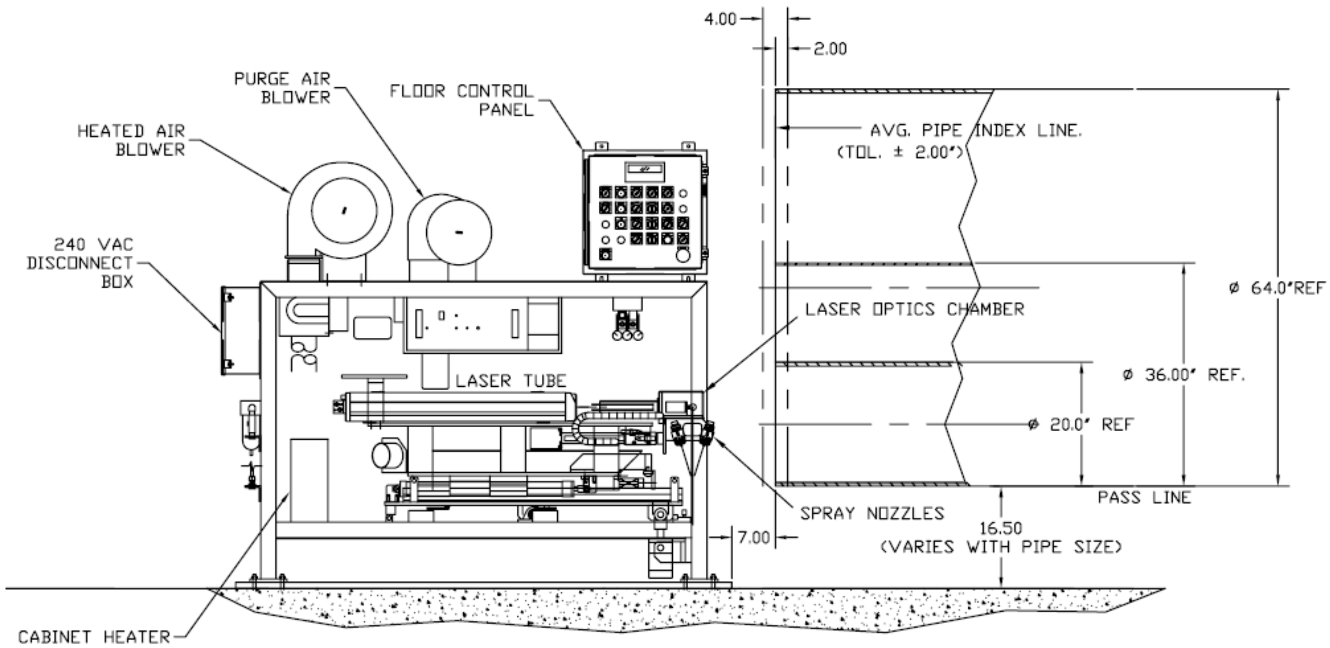

Figure 3 Typical IDLMS Marker Arrangement – side view

A more detailed sequence of operation is given.

1. The Mill Computer downloads the marking data in advance of the next pipe to arrive at the marking station.
2. The IDLMS compiles the marking image for laser marking
3. The pipe arrives at the marking station, centered in a vee centerline, with the pipe end indexed within a defined end-of-pipe index tolerance.
4. Conveyor controls issue the START MARKING CYCLE signal to the IDLMS.
5. The IDLMS extends by air cylinder to contact and "find" the end of the pipe
6. The IDLMS lowers by air cylinder to contact and "find" the bottom of the pipe with a contact "foot"
7. The stepper motor ballscrew drive rapid advances the end-of-arm spray nozzles to spray the white paint patch onto the pipe bottom surface.
8. The stepper motor ballscrew drive rapid retracts the end-of-arm spray nozzles to spray a second coat of the white paint patch onto the pipe bottom surface.
9. The heated air blower turns on to blow heated air onto the just-applied white paint patch to air tack the white paint coating, and later to keep marking vapor from blocking the laser beam during marking, and also to air tack the (later) clearcoat. The direction of the air flow blows the paint odor into the pipe ID during application and marking.
10. The stepper motor ballscrew drive slow advances, while the galvanometer drive scans laterally, to project the laser beam to mark the white paint patch. IDLMS controls precisely turn the laser beam on and off during the scan as required to create the mark.
11. When the laser marking is completed, the end-of-arm spray nozzles rapid retract to spray a final single coat fine mist clearcoat to seal the mark.
12. The air cylinders raise and retract the marking assembly to the home position.
13. The MARKER CLEAR signal is issued to the conveyor controls by the IDLMS. The pipe is then removed.
14. Marking times range from about 40 seconds to about 80 seconds, depending on laser-marked content and density, and the total size of the marked image.

Machine maintenance is typically required once per shift to replenish consumables and perform a brief cleanup on the spray nozzles.

Figure 4 View of Laser marking in progress

Note that the same technology can be adapted to apply a laser mark on the outside diameter of pipes, as shown below. This mark is approximately 150mm wide x 50mm high (6" wide x 2" tall), and is typically applied at the 9:00 o'clock position on the side of a stationary pipe.

Figure 5 View of Laser marked pipe OD

PITFALLS

The marking technology discussed herein is an excellent way to apply bar codes to LOD Pipe Mill products, but it is necessary to evaluate the downstream manufacturing processes that the mark and the bar code must survive. Following is a list of potential pipe mill pitfalls:

1. The mark will not survive shot blast
2. Outdoor storage may create rust "stripes" in the bottom of the pipe, caused by water ponding in the bottom of the pipe, thus obscuring bar codes.

For Item 1 above, consider reading the bar code at the entrance to the shot blast process, then inference- or queue-track the pipe through the process, and then reapplying an echo mark at process exit.

For Item 2 above, multiple redundant bar codes can be formatted into the mark so that at least one code will not be at bottom dead center and therefore can be read in the event of a rusty stripe causing by standing water settling in the bottom of the pipe.

The IDLMS mark will generally survive downstream pipe temperatures up to 650ºC (1200ºF) as long as the temperature ramp profile and duration is not too severe.

BAR CODES

Successful bar code reading technologies and solutions are discussed.

The challenges related to successful bar code implementation in pipe mills are:

1. How to select and use a suitable code symbology and content
2. How to apply a mark and bar code that will survive and remain readable throughout the process
3. How to "find" the bar code at the downstream reading stations

The user must be knowledgeable about bar code suitability and limitations. Many users initially assume that they can insert "unlimited" text and numerical data into a bar code. This is true only if you have enough room in the marking area for a very large code. Code 39 and Code 128 symbologies both provide the ability to encode both text and numerical data, but if text is encoded within a Code 128 bar code, then the bar code length grows very quickly. If we then scale down the resulting bar code so that it will fit into the available width, the code resolution (both space width and bar width) becomes so fine that the code is unreadable in a practical sense in a pipe mill environment.

We generally recommend that the user implement the Code 128 symbology encoding up to 12 digits (numbers only) max. This will allow the laser printer to print a robust bar code in a large scale with relatively wide bars and spaces, thus guaranteeing readability downstream. We generally do not recommend Code 39 for pipe mill use. Reading technology is now readily available whereby two dimensional (2D) bar codes such as Data Matrix™[2] codes can be used to advantage by encoding a larger quantity of data in a smaller area, but the readers for this code may be more expensive and require shorter focal distances than for a one dimensional (1D) bar code.

Providing that (a) the pitfalls discussed above are avoided, and (b) the bar code symbology and content are correctly selected and implemented, then the potential for mark and bar code survival for downstream reading is very good.

Due to the 360º radial variability of the bar code position, as well as pipe diameter variability at downstream reading stations, handheld bar code scanners are generally recommended for downstream bar code data acquisition. Automated bar code reading may be possible to implement in some cases, for example at spin roll stations, and can be evaluated on a case-by-case basis.

[2] The Data Matrix™ code was invented by RVSI/Acuity CiMatrix

SUMMARY

The technology to automatically apply automatic identification to LOD pipe is routinely used today. An Inside Diameter Laser Marking System, or IDLMS, receives downloaded data from the Mill Computer, spray-applies a white patch to the inside bottom dead center of a pipe, laser-marks the paint patch, and then spray-applies a clear protective coating on top of the mark. The laser mark can contain text, graphic images such as industry-standard or company logos, and bar codes. The mark is designed to withstand long term outdoor storage. Downstream bar code readers can capture the identification of the pipe from the mark at various manufacturing nodes. The IDLMS can be integrated with other subsystems to create, for example, an integrated weigh-measure-stencil (WMS) system. The IDLMS marking technology enables real-time identification and tracking of LOD pipe using bar codes, where none was available before when using stencil board identification.