Inline Wire and Cable Identification

By Pete Doyon, VP of Product Management, Schleuniger, Inc.

Introduction

Many OEM's require that individual wires and cables used in their products be clearly identified with a mark or label. For some, such as in the military and aerospace markets, wire and cable identification (or "wire ID") is mandatory and the process is governed by stringent specifications, such as SAE AS50881 (formerly MIL5088L). For others, the decision to use wire ID is a voluntary one.

Wires and cables can be identified as part of an "inline" process while they are being cut to length and stripped on automatic equipment. Alternatively, wire ID can be applied using a secondary manual or semi-automatic process. The scope of this article is limited to inline wire ID. This article will describe what type of information is typically identified on wire and cables, concepts for improved productivity, what types of systems are available and the pros and cons of each.

Why Wire ID is Used

Wire ID is used to identify individual wires during the life of a product, from initial product assembly and testing to servicing the product years down the road. Key identification requirements are legibility, permanence and abrasion resistance. In order to meet those requirements, the identification method used must be well suited for the environment where the product will be utilized.

Typical Wire ID Uses

Termination ID's

The most common type of wire ID is the Termination ID. The Termination ID clearly identifies where a wire or cable is terminated on a terminal strip, mating connector, etc. The Termination ID prevents any miswiring during wiring harness assembly, product assembly and testing as well as when the product is serviced.

Traceability

Many industries require traceability of product components and sub-assemblies. Company logos, serial numbers and date codes can be directly marked or labeled on each wire or cable to aid in traceability. This is especially common for more expensive assemblies which have undergone electrical performance or other testing. If there are any field failures or warranty claims, the unique code makes it possible to trace a particular assembly back to the original test report.

Bar Coding

Several of the wire ID methods allow barcodes to be printed directly on wire or cable or on labels that are applied to them. There is a practical limitation when using barcodes on wires or cables under 0.100", since the barcode scanner may not be able to read the barcode. Samples should always be run to verify each application.

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Logos

Some companies like to differentiate their cable assemblies by marking or labeling their logo, brand name or other unique identifying mark on them. Most of the wire ID methods (except hotstamp) offer this capability.

Wire ID Concepts for Improved Productivity

Lean Manufacturing of Wiring Harnesses

Wire ID can be very cost effective, especially in high mix, low volume applications, such as when building one wiring harness at a time. Fully integrated, PC controlled wire processing machines can produce all of the wires necessary to build one complete wiring harness. All of the wires are typically collected in a tray or wire stacker. Without wire ID, it would be difficult to identify the individual wires and where they go. By marking or labeling the termination ID's on each wire, an operator can quickly identify the "from" and "to" points when routing the wires on the harness board. If there are no identifying marks or labels, the operator must first determine which wire is which (by overall length, color, strip length, terminals, etc.) and then look at a schematic or other cross reference list to determine where each end goes. Having the termination ID's on each wire or cable end is like having routing instructions right at your fingertips.

Single Wire Color vs. Many Different Colors

In high mix, low volume applications, the key to success is to reduce tooling changeover time to the absolute minimum. In wire processing applications, each wire color change can take from one to several minutes. By reducing the number of wire colors from 10 to 1, changeover frequency and therefore labor can be reduced by 90%. If permitted, using labeled white wire instead of many different colors can yield exceptional savings. Some applications are governed by specifications and codes which specify that specific different wire colors must be used. One example is ground wiring in electrical equipment must be green or green with a yellow stripe. Many other applications and circuits allow any wire color to be used. If permitted by the product manufacturer and any applicable specs, there are many benefits that can be had by using one wire color wire to replace many.

Some of the benefits include:

- Reduced changeover frequency saves labor costs
- Purchasing wire in bulk (larger reels or wire barrels) at a lower unit cost
- Reduced wire inventory cost
- All wires can be marked using one inkjet ink or hotstamp foil color
- Larger reels or barrels impart less "memory" on the wire, resulting in more consistent wire processing

If the wiring harness for a given product was originally designed with many different colors, an alternative is to use white wire exclusively and print the name of the color it replaces on the wire. For example, the word "RED" could be printed every 3" along a white wire instead of using a red wire. In addition, the circuit number could be printed on the wire as well to distinguish it from other white wires that have the "RED" designation.

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Using a single wire color (or just a few) with an integrated inline wire ID system saves time and money, especially in high mix, low volume applications.

End Marking vs. Continuous Marking

End marking is typically used for termination ID's, as mentioned earlier in this article. Continuous marking can be used in addition to end marking to provide more information at preset intervals along each wire or cable assembly. Typical nomenclature includes the wire part number or circuit number and it is repeated every 3 to 6 inches or more along the wire. This makes it possible to identify individual wires anywhere along their length when servicing them. If a particular mark is difficult to read, another mark is located just a few inches away.

Marking on-the-fly

Like laser marking, inkjet marking is done on-the-fly, i.e.; while the wire is moving. The benefit is that the wire doesn't have to stop during the marking process, therefore the production rate of the wire processing machine is not greatly reduced. Continuous marking is best suited for inkjet or other marking methods that can be done "on-the-fly". For labeling, hotstamp and direct thermal transfer marking, the wire must be stopped, therefore these methods are best limited to end marking applications only.

Wire List Management Software

To realize the maximum benefits that inline wire ID has to offer, some type of Wire List Management Software (WLMS) is required to control the wire processing system and the inline Wire ID system. The WLMS is used to keep track of the processing parameters for every wire that will be produced. Typical parameters include wire type and size, overall wire length, strip lengths, marker text and marking positions. The WLMS synchronizes the functions of the wire processing machine and the wire marker, including automatic text changes (depending on the wire ID method used). All of the wires for a particular wiring harness may be produced in sequence without any operator intervention. Since all functions are synchronized, there is no waste wire when the system changes over from one wire to the next in the wire list. The wire list can be sorted by wire size/type/color. In this way, the only time the system has to stop processing is for the operator to change the wire size, type or color.

Wire Identification Methods

Hotstamp

Hotstamp marking is one of the oldest wire identification methods. On the positive side, it's one of the lowest cost marking methods and the marks are quite legible and permanent. Other than laser marking, it's one of the few marking methods that can produce a permanent mark on Teflon insulations. It's also easy to change the color of the marking foil, making it possible to print on every insulation color. On the negative side, the wire must be stationary while the hotstamp process takes place (approximately 1 sec cycle time), thus lowering the production throughput. Changing the marker text is a manual process on most systems, which means that hotstamp marking is not a good

candidate for low volume, high mix production. Improper settings (temperature, pressure and dwell time) can cause damage to the wire insulation. Some specifications require that a spark tester be used after the hotstamp marker to verify the insulation integrity.

Labeling

New labeling machines offer print and apply technology, making it possible to use them with inline wire processing systems. They offer high resolution (300+ dpi) print resolution and multi-line text capability. Like hotstamp, the wire must be stationary during the labeling process (4 – 5 sec cycle time), which also lowers the production rate. In general, the cost for the labels is higher than for other wire identification methods. On the other hand, the ability to print logos, multiple lines of text, barcodes, etc. in a self laminating package may justify the higher applied cost. Applying labels as part of an inline wire processing operation is much less labor intensive than printing labels and then applying them manually in a secondary operation.

Direct Thermal Transfer

Direct Thermal Transfer is a relative newcomer to wire ID. Instead of using thermal transfer technology to mark labels (see Labeling above), the thermal transfer system marks directly onto the wire or cable. Like hotstamp marking or labeling, the wire or cable must stop during the marking process. The cycle time is slightly longer than hotstamp at approximately 1 – 2 seconds. An advantage of thermal transfer marking over labeling is that the cost per mark is much less since there are no labels to purchase. A unique function is used to roll the wire or cable to enable marking over a greater circumference than would otherwise be possible. Like hotstamp, foil colors can be easily changed, making it possible to print on all insulation colors.

Inkjet

Inkjet marking systems used for marking wire and cable are of the continuous inkjet (CIJ) type. Newer inkjet printers on the market are simpler, faster and more reliable than their predecessors. They feature automatic startup / shutdown cycles and much better process control. They use far less makeup solvent per unit time, resulting in less odor and improved air quality.

Inkjet marking can be used on most wire insulation types except PTFE/Teflon. Permanence and abrasion resistance is excellent on most PVC type insulations. It's always best for customers to get their wire samples marked so they can determine if the results will meet their application requirements. Depending on the system hardware and software, additional features may be available to the user. The user can select the font size to match the wire size. The standard text format is horizontal orientation but it's possible to change it to vertical, also known as "tower" orientation. Special codes can be programmed to automatically print the time, date or a different serial number on each wire. This is very useful for production traceability. Bold, underline and italics font attributes are also possible. Mirror is a useful feature which rotates the text string 180 degrees on one end. This is sometimes necessary to ensure that all marker text is oriented the same way on a terminal strip, such as on a jumper wire in a control panel, for example.

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New ink formulations have been developed specifically for wiring harness applications. These inks allow faster line speeds, better permanence as well as improved solvent and abrasion resistance. The basic colors are black and white, although other colors are available. Black inks are dye-based while white inks are pigmented. Dye based printers tend to be simpler and more reliable, therefore it's best to try to standardize with black ink on white or light colored wire.

The range of insulations types which can be successfully marked using inkjet can be expanded with additional processes such as plasma pre-treating and UV curing of UV curable inks. These additional process steps add significantly to system cost and complexity.

Laser

There are a number of different laser sources that are used in wire marking. By far, the most common are those that produce wavelengths in the UV part of the spectrum. UV laser marking is used primarily for military and aerospace applications. This marking method produces superior, permanent marks, even on Teflon insulated wires. For UV laser marking to work satisfactorily, the wire insulation must have a sufficient amount of Titanium Dioxide (TiO_2) in its composition for the color change to take place.

Fortunately, most wire insulations used in military and aerospace applications have an adequate amount of TiO_2 in them. Like inkjet wire marking, the laser marking process takes place while the wire is moving, allowing better production rates than hotstamp marking or labeling. Laser marking of wire for commercial applications is less common since it does not work as well on most commercial insulations such as PVC. Laser marking systems range in price from $100k to $500k or more. The more expensive systems can run at higher production rates while the entry level systems are typically used for low volume production and service work.

Conclusion

As wiring harnesses and cable assemblies become more and more complex, proper identification of individual wires and cables is crucial during wiring harness assembly, product assembly and testing as well as servicing. There are many different wire ID methods and each has its own pros and cons. Selecting the best system for a given company and application requires a thorough review, including

- Applicable specifications
- Insulation types being marked
- Information which needs to be marked (number of characters required, logos, etc.)
- Typical batch sizes
- Processing speed
- Cost per mark

According to Lean Principles, the ideal batch size is a quantity of one. A completely integrated wire marking / processing system can produce an individual wire on demand or all of the individual wires necessary to build one complete wiring harness. This results in less Work-In-Process and all of the other benefits of One-Piece-Flow manufacturing.

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Inline Wire and Cable Identification System Comparison			
Marking process	Cycle time (sec)	Pros	Cons
Hotstamp	1	Lowest cost wire ID system	Wire must stop during process
		Marks Teflon and Tefzel insulated wire	Marking disc typeface must match wire size - discs not easily changed
		Marking foil available in many colors - easy foil changeover	Can damage insulation if settings not correct
		Full alphanumeric capability	Radius of marking disc typeface must match radius of wire on smaller wires
Labeling	4 - 5	300 dpi print resolution	Wire must stop during process
		Multi-line marking possible	Cycle time longer compared to other methods
		Print and apply in one cycle	Higher cost per mark
		Multiple label sizes and types available	
		Self laminating labels protect mark	
		Barcodes and logos possible	
Direct Thermal Transfer	1 – 2	300 dpi print resolution	Wire must stop during process
		Multi-line marking possible	Requires several adjustments when changing jobs
		Marks directly on wire or cable	
		Barcodes and logos possible	
Inkjet	0	Marks on-the-fly	Can not easily change ink colors
		Marks most insulation types except Teflon and Tefzel	Ink and solvent are MEK based
		Can be fully synchronized with wire processing system	
		Ink available in multiple colors	
		Can mark wide range of wire and cable sizes	
		Barcodes and logos possible	
Laser	0	Marks on-the-fly* (only on higher end systems)	Most expensive wire ID system
		Marks Teflon and Tefzel insulated wires	Marks very limited range of insulation types
			Production rates are slow on all but the most expensive systems