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Information technology — Automatic identification and data capture techniques — Guidelines for direct part marking (DPM)

Technologies de l'information — Techniques automatiques d'identification et de capture des données — Lignes directrices pour DPM («direct part marking»)

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Foreword

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The main task of the joint technical committee is to prepare International Standards. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

In exceptional circumstances, the joint technical committee may propose the publication of a Technical Report of one of the following types:

— type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;

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Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

ISO/IEC TR 24720, which is a Technical Report of type 3, was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 31, *Automatic identification and data capture techniques*.

Introduction

Identification technologies have become an essential part of managing the life cycle of manufactured goods, from their "birth" to the scrap recovery process. The need to identify parts easily and correctly is critical for controlling and error proofing the assembly process, tracking work in process and building traceability. Fast and accurate identification methods are also important after the product leaves the plant.

Industries worldwide rely heavily on the use of various marking methods. Because many of these methods were originally designed to apply human-readable marks, they frequently are not appropriate for applying high-density machine-readable symbols.

With the widespread implementation of machine-readable marking, the parts identification industry began to refine existing marking methods. Dot peen machines replaced manual metal stamping and embossing techniques. Desktop publishing systems were developed for the production of stencils. Ink jet machines were built to replace rubber stamps. Laser marking systems were designed to replace electric-arc etching and hot stamping processes.

One of the most popular methods of identifying a part is with a two-dimensional (2D) symbol applied directly onto the surface of parts. Compared with printing and applying labels, marking directly on parts is more secure, more cost-effective and easier to automate. When direct marked, two-dimensional symbols are able to withstand harsh manufacturing processes and abuse in the field.

Several direct part marking (DPM) technologies are addressed in this Technical Report, such as ink jet printing, laser etch, chemical etch and dot peen marking. Ink jet printing is one of the least expensive of the marking methods. Laser etch is popular because of its ability to produce small, precise marks, and the ability of lasers to mark symbols on many materials, from hardened steel to soft plastic. Lasers can also access small, tight locations. Dot peen marking is usually reserved for marking metal. This marking method uses a stylus to indent the surface of the part to create the desired mark. Chemical etch marking is often used to mark printed circuit boards (PCBs), since it is already part of the normal manufacturing process.

For the purposes of this Technical Report, direct part marking (DPM) is considered a generic term referring to methods of applying a permanent mark directly onto a surface of an item. There are two generic direct marking techniques described in this Technical Report: intrusive and non-intrusive.

Intrusive (or subtractive) marking methods alter the surface of a part and are considered controlled defects. Of the intrusive marking methods, this Technical Report addresses dot peen and direct laser marking, and briefly describes other technologies.

Non-intrusive marking methods, also known as additive markings, are produced as part of the manufacturing process or by adding a layer of media to the surface of a part. Of the non-intrusive methods, this Technical Report addresses ink jet marking and other technologies.

Information technology — Automatic identification and data capture techniques — Guidelines for direct part marking (DPM)

1 Scope

This Technical Report describes several methods for applying permanent machine-readable symbols to items – including components, parts and products – using the direct part marking (DPM) methods outlined herein. This Technical Report describes marking methods, marking surface preparation, marking location, protective coatings and other parameters that contribute to the production of quality symbols, but does not specify the information to be encoded.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 19762-1, *Information technology — Automatic identification and data capture (AIDC) techniques — Harmonized vocabulary — Part 1: General terms relating to AIDC*

ISO/IEC 19762-2, *Information technology — Automatic identification and data capture (AIDC) techniques — Harmonized vocabulary — Part 2: Optically readable media (ORM)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 19762-1, ISO/IEC 19762-2 and the following apply.

3.1
intrusive marking
marking method designed to alter a surface to form a human- or machine-readable symbol

NOTE This marking category includes, but is not limited to, methods that abrade, burn, corrode, cut, deform, dissolve, etch, melt, oxidize or vaporize a surface. Intrusive marking methods include stamping, laser etching, chemical etching, dot peen and micro-sandblast.

3.2
non-intrusive marking
marking method designed to add material to a surface to form a human- or machine-readable symbol

NOTE Non-intrusive marking methods include ink jet, some forms of laser bonding, liquid metal jet, screen process, stencil and thin film deposition.

3.3
permanent marking
intrusive or non-intrusive markings designed to remain legible for at least the normal service life of an item, subject to operating or usage conditions

4 Abbreviated terms

EDM Electrical Discharge Machine or Machining

LISI Laser Induced Surface Improvement

5 Overview of DPM

5.1 DPM methods

For the purposes of this Technical Report, direct part marking (DPM) is considered a generic term referring to methods of applying a mark directly onto the surface of an item. There are two techniques for applying a mark, intrusive and non-intrusive.

5.1.1 Intrusive

Intrusive (also known as "subtractive") marking methods physically alter the surface or structure of a part (abrade, cut, burn, vaporize, bond etc.) and the marks are considered controlled defects. It is highly recommended that all item identification manufacturing methods should be controlled by appropriate manufacturing instructions, approved by Engineering Design and that testing of materials should be conducted before an intrusive mark is applied to an item. Typical intrusive marking methods include:

- Abrasive blast
- Direct laser marking
- Dot peen
- Electro-chemical marking
- Engraving/milling
- Fabric embroidery/weaving
- Stamping

Of these intrusive methods, this report addresses some forms of direct laser and dot peen marking, and briefly refers to other marking technologies.

5.1.2 Non-intrusive

Non-intrusive (also known as "additive") markings are produced as part of the manufacturing process or by adding a layer of marking media to the surface using methods that have no adverse effect on material properties. These methods include:

- Automated adhesive dispensing
- Cast, forge, and mold
- Ink jet
- Laser bonding (limited forms)
- Laser engineered net shaping (LENS)
- Liquid metal jet
- Screen printing
- Stencil (not when used by Electro Chemical Etch marking methods)

Of the non-intrusive marking methods, this report addresses ink jet marking in depth and other technologies only briefly.

5.2 Reasons for utilizing DPM

- If traceability is required after the product is separated from its temporary identification.
- When the part cannot be marked with labels or tags.
- If the part will be subjected to environmental conditions that preclude the use of add-on identification methods.
- When the use of DPM methods is more cost efficient than applying individual item labels.
- When identification is required for the anticipated life cycle of the part, as defined by the manufacturer.

6 Marking method selection

The overall quality of any form of part identification depends on several characteristics. These characteristics can include the material being marked, the shape or geometry of the marking surface and any surface coatings or discoloration that affects decode or readability of the mark.

It is, therefore, important to review all of these factors before selecting a marking method. If a component definition instructs a specific marking method for that component, that method should always be selected.

Table 1 below provides a cross-reference of marking methods and commonly marked materials and provides guidance for selecting marking methods appropriate for the listed materials.

Table 1 — Marking Method Selection

MATERIAL TO BE MARKED / MARKING PROCESS	METALLICS								NON-METALLICS								
	Aluminum	Anodized	Beryllium	Carbon Steel	Copper	Brass	Magnesium	Titanium	Ceramics	Glass	Cloth	Painted	Plastics	Rubber	Teflon	Wood	Epoxy-glass
Abrasive Blast	•	•		•	•	•	•	•	•			•	•		•		
Adhesive Dispensing	•	•	•	•	•	•	•	•	•	•	1	•	•	•		•	
Cast, Forge Or Mold	•	•	•	•	•	•	•	•	•				•	•			
Dot Peen	•			1	•	•		•				1	1				
Electro-Chemical Coloring	•	•	•	•	•	•	•	•									
Electro-Chemical Etching	•	•	•	•	•	•	•	•									
Embroidery											•						
Engraving/Milling	•	•		•	•	•						1	•			•	
Ink Jet	•	•	•	•	•	•	•	•	•	•	1	•	•	•			•
Laser Bonding	•		•	•		•	•	•	•	•			•				
Laser - Short Wave Lengths	•	1	•	•	•		•	•	•	•		1	•	•	•	•	•
Laser Visible Wave Lengths	1	1		•	1	•						1	•				•
Laser – Long Wave Lengths		1							•	•		1				•	•
LENS	•	1	•	•	•	•	•	•									
LISI	•	2		•	•		2	2									
Silk Screen	•	•	•	•	•	•	•	•	•	•		•	•	•		•	•
Stencil	•	•	•	•	•	•	•	•	•	•		•	•	•		•	
Thin Film Deposition	•	•	•	•	•	•	•	•	•	•			•	•			

• = Acceptable marking process for this material if marking location and marking parameters are agreed
1 = Additional technical input required from design authority and equipment / material suppliers
2 = Marking method under development for this material
Blank space = Marking method not recommended for this material0

The physical size of the item to be marked is also a factor in DPM. When available marking space falls below an accepted size, it may be necessary to review the data string and/or select a different marking method that is acceptable to the component definition and/or operating condition. Table 2 below provides additional guidance in the selection of an appropriate marking process.

Table 2 — Symbol sizes by marking process

Symbol Size Categories	Marking Process	Typical Data Cell Size (Assenting Order)	Data Format		
			P/N, EI and S/N - Typically 29 Characters (24x24 matrix)	EI and S/N - Typically 13 Characters (18x18 Matrix)	S/N Only - Typically 7 Characters (12x12 Matrix)
Micro - <0.008-inch (0,203 mm) data cells	Laser Marking – Short Wave Length (Excimer)	0.0002 inch (0,005 mm)	0.004 inch (0,102 mm)	0.003 inch (0,076 mm)	0.002 inch (0,051 mm)
Typical - 0.08 inch (2,032 mm) to 0.034 (0,864 mm) data cells	LaserShot Peening	0.009 inch (0,238 mm)	0.216 inch (5,486 mm)	0.162 inch (4,115 mm)	0.108 inch (2,743 mm)
	Stencil(Photo-Process)	0.010 inch (0,254 mm)	0.240 inch (6,096 mm)	0.180 inch (4,572 mm)	0.120 inch (3,048 mm)
	Laser Bonding	0.010 inch (0,254 mm)	0.240 inch (6,096 mm)	0.180 inch (4,572 mm)	0.120 inch (3,048 mm)
	Laser Marking	0.010 inch (0,254 mm)	0.240 inch (6,096 mm)	0.180 inch (4,572 mm)	0.120 inch (3,048 mm)
	Stencil(Mechanical Cut)	*0.020 inch (0,508 mm)	0.480 inch (12,192 mm)	0.360 inch (9,144 mm)	0.240 inch (6,096 mm)
	Adhesive Dispensing	0.020 inch (0,508 mm)	0.480 inch (12,192 mm)	0.360 inch (9,144 mm)	0.240 inch (6,096 mm)
	Dot Peen*	*0.022 inch (0,558 mm)	0.528 Inch (13,411 mm)	0.396 inch (10,058 mm)	0.264 inch (6,706 mm)
	LISI	0.024 inch (0,610 mm)	0.576 inch (14,630 mm)	0.432 inch (10,973 mm)	0.288 inch (7,315 mm)
	Stencil (Laser Cut)	*0.024 inch (0,610 mm)	0.580 inch (14,732 mm)	0.440 inch (11,176 mm)	0.288 inch (7,315 mm)
	Abrasive Blast	0.025 inch (0,635 mm)	0.600 inch (15,240 mm)	0.450 inch (11,430 mm)	0.300 inch (7,620 mm)
	Ink Jet	0.030 inch (0,762 mm)	0.720 inch (18,288 mm)	0.540 inch (13,716 mm)	0.360 inch (9,144 mm)
Macro – ≥0.035 inch (0,889 mm)	Engraving/Milling	*0.040 inch (1,016 mm)	0.960 inch (24,384 mm)	0.720 inch (18,288 mm)	0.480 inch (12,192 mm)
	Fabric Weaving	0.040 inch (1,016 mm)	0.960 inch (24,384 mm)	0.720 inch (18,288 mm)	0.480 inch (12,192 mm)
	LENS	0.040 inch (1,016 mm)	0.960 inch (24,384 mm)	0.720 inch (18,288 mm)	0.480 inch (12,192 mm)
	Fabric Embroidery	0.045 inch (1,143 mm)	1.080 inch (27,432 mm)	0.810 inch (20,574 mm)	0.540 inch (13,716 mm)
	Cast, Mold & Forge	0.060 inch (1,524 mm)	1.440 inch (36,576 mm)	1.080 inch (27,432 mm)	0.720 inch (18,288 mm)

Note: Table courtesy NASA-STD-6002B and is reproduced here verbatim.
* Includes spacing between data cells

Note: See Annex A and Annex B for descriptions of marking methods.

Note: Technology developments in the marking processes are continuously improving the resolution that is achievable using that process. It should be noted, however, that some equipment might achieve better or worse results than those indicated in Table 2.

7 Marking methods

For most two-dimensional symbols to be read successfully, the decoding software requires a quiet zone (a clear space of a specified minimum width) around the entire periphery of the symbol. In addition to this requirement, manufacturers often impose additional marking location restrictions within their drawings and/or specifications. This report recommends that care be exercised when marking in the following locations:

- Highly polished curved surfaces
- In direct air streams (e.g., leading edge of wings, helicopter rotors, exposed portions of turbine blades, etc.)
- Near high heat sources
- Sealing surfaces
- Wearing surfaces

In addition, the effects of adjacent structures on the imager's illumination source must be considered. Fixed station imagers with movable light sources can usually be configured to illuminate symbols placed in recesses or adjacent to protruding structures. These structures, however, can pose a challenge for hand-held imagers with fixed positioned light sources. It is therefore advisable to read marked parts in places that provide maximum access to lighting.

8 Cleaning

Cleaning processes used for removing soil and contamination from parts to be marked are varied, and their effectiveness depends on the requirements of the specific application. The appropriate cleaning method should be selected according to the needs of the specific application. In selecting a cleaning process, many factors must be considered, including:

- The nature of the soil to be removed
- Substrate to be cleaned (e.g. ferrous, non-ferrous, etc.)
- Importance of the condition of the surface to the end use of the part
- Degree of cleanliness required
- Capabilities of the available facilities
- Environmental impact of the cleaning process
- Cost
- Total surface area to be cleaned
- Effects of previous processes
- Rust inhibition requirements
- Material handling factors
- Surface requirements of subsequent operations, such as phosphate conversion coating, painting, or plating

9 Marking surface preparation

9.1 Assessment

Prior to marking, operators are required to determine if additional surface preparation is required. This assessment should address:

- Surface finishes that cause excessive amounts of shadow and/or specular reflection
- Surfaces that do not provide the necessary contrast for decoding
- Safety critical parts that cannot be marked using intrusive marking methods
- Materials that are not suitable for marking with the user's preferred marking method

The most common methods utilized to prepare surfaces for marking are additives and coatings.

9.1.1 Additives

To assist readability of the mark, specialized additives can be mixed with metal alloys and thermoplastic formulations to enhance and optimize marking contrast. These additives increase the ability of the material to absorb or reflect specific wavelengths of light, but do not generally affect overall material performance.

9.1.2 Coatings

In a limited number of applications, it is possible for coatings to be used to modify the surface of a part to improve readability and/or to provide corrosion protection. Coatings can be utilized to aid part marking by:

- Smoothing rough surfaces to reduce the effects of shadowing
- Providing increased contrast for surfaces of parts that inherently provide insufficient contrast
- Dulling highly polished surfaces to reduce specular reflection
- Providing a surface that can be removed with intrusive markings to expose a substrate of contrasting color
- Serving as a medium for marking using a stencil as a mask

Following are the processes most commonly used to coat surfaces prior to marking:

9.1.3 Dip, Barrier and Conversion Coating

"Dip, barrier, and chemical conversion coating" is a term that encompasses an entire family of processes used to prevent corrosion. The appropriate method should be selected according to the needs of the application.

9.1.4 Laser induced surface improvement (LISI)

LISI is a laser process utilized to impart stainless properties to carbon steel. The process can also be used to improve the wear characteristics of aluminum surfaces. LISI treated surfaces can be discolored or removed to create a symbol.

9.1.5 Plating and electroplating

Plating and electroplating processes are divided into two categories: Electro-deposition and Non-electrolytic deposition processes. These techniques should be selected according to the needs of the application.

9.1.6 Vacuum controlled-atmosphere coating and surface modification processes

"Vacuum and controlled-atmosphere coatings" is a general term that encompasses thermal spray, chemical vapor deposition, physical deposition, diffusion, and pulsed-laser deposition processes. This family of processes is used to modify surfaces by depositing material onto a surface that is subsequently marked. Vacuum controlled-atmosphere coatings and surface modification processes are frequently used in conjunction with stencil marking.

9.1.7 Machining

Because extremely rough surfaces can produce shadows that adversely affect reader performance, machining is often performed to smooth the surface roughness of parts to be marked. A number of machining methods are commonly used for surface smoothing, and the appropriate method should be selected according to the needs of the application.

9.2 Protective coatings

Metals are often unstable and susceptible to degradation by corrosion from hostile environments. Protective coatings are often applied to marked surfaces to protect the marking and prevent corrosion. It should be noted, however, that surface coatings might adversely affect the performance of some types of mark.