Technology White Paper

Machine Vision Verification of 1D and 2D Codes

Basics of Ensuring Code Readability for Reliable Process Operation

Machine Vision Verification of 1D/2D Codes

Legible, accurate codes have never been more important than they are today, when automated supply chains depend on data accuracy to ensure the reliable performance of global operations. Machine vision verification is one tool that can be used to ensure that codes meet a consistent level of quality for readability in an automated process, and that bad codes are identified before they result in costly failures.

This white paper introduces 1D and 2D code verification and identifies parameters for verifying codes against published standards.

- Why Verification?
- When Should You Verify?
- Validation vs. Verification
- What Kind of Hardware Is Required?
- Verification Evaluation Parameters
- Verification Grades
- Verification with di-soric AutoVision
- di-soric Meets Verification Needs

Why Verification?

Code quality is integral to the success of an automated system. In a process where quality codes accurately store and communicate data – from code to reader to central system – little manual intervention is required. Thanks to quality codes, the unique benefits of an automated system are realized:
Lower costs, higher productivity and fewer errors.

Poor quality codes, however, render the system almost as inefficient as using no automation at all. Unreadable codes may require re-labeling, re-scanning, or even manual entry of critical information by a human operator – disrupting the productivity of the process and causing a significant loss of time. Bad codes may prevent error-tracking, causing a domino effect of failures down the line and resulting in costly scrap and rework. All told, these effects completely counteract the benefits of implementing an automated system, the results being inflated cost, loss of productivity and increased errors.

The purpose of code verification is to prevent this outcome and preserve the intended benefits of the automated system. Verification systems evaluate a code's quality against published quality standards for 1D and 2D codes using precision instruments such as code verifiers or machine vision systems. A verified code ensures consistent readability, supporting 100% accurate automated data capture.

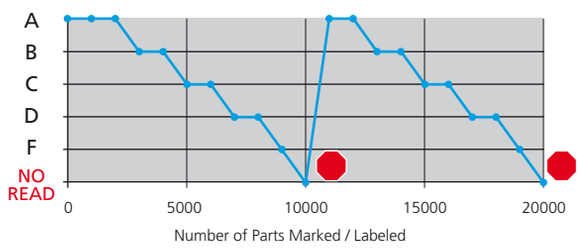
When Should You Verify?

To ensure that errors are prevented as early in the automated system as possible, verification must be executed before a part enters the system.

A verification step should be executed after a part is marked or labeled with a code and before the part reaches the station where the code is read for the first time.

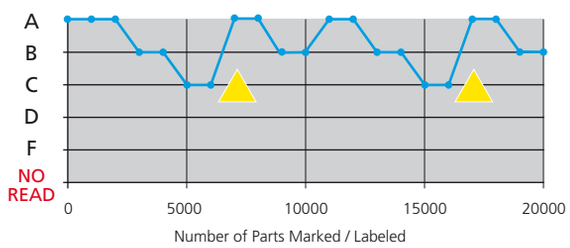
Proper verification ensures that every part is processed and shipped with a high-quality code, despite the fact that marking and labeling systems will degrade over time. A verification system is much more accurate than a standard code reader at identifying low-quality codes early in the process, before parts with bad codes make it through the line and are shipped to end customers. When code quality degradation is identified early, the marking or labeling system may be adjusted or replaced before unreadable codes are ever produced.

Code Quality Over Time Using
a Reader to Check Quality



Without verification, bad codes are not identified until they are unreadable. By the time a bad code is identified, thousands of poor-quality codes may have already escaped down the line.

Code Quality Over Time Using a
Verification System to Check Quality



With verification, bad codes are prevented from being applied to the product, eliminating the chance for future failures.

Validation vs. Verification

Depending on the requirements of a particular process, industry, company, or customer, there are two levels of quality grading for ensuring code readability: validation (sometimes called process control) and true verification.

Validation / Process Control: Process control is a kind of ensuring that codes are readable throughout a particular internal or internal/external process. Process control does not check codes for compliance to a published code quality standard. Despite, it provides objective measurements for code quality when verification to a standard is not possible or not desired. If you are not concerned with meeting published code quality standards in your application, you may opt to use a subset of the default verification parameters in the verification system as the criteria for passing codes.

Verification: Verification ensures that a code complies with published code quality standards, such as ISO 15415, ISO 15416, and AIM/DPM – ISO 29158. To ensure compliance, all evaluation parameters in the machine vision system must be enabled during the verification process. Fully-conforming verification systems provide reports as evidence of code compliance, which can be sent to customers or other involved parties to provide the highest assurance of code quality and consistency.

What Kind of Hardware Is Required?

Selecting the right light and camera combination is the key to success of the application once an appropriate software platform has been chosen. More precise quality grading requires a higher-performance hardware solution. A smart camera with integrated optics and lighting will often be suitable for validation; however, codes that must comply with published code quality standards must be verified by a system with superior optics and with complete and uniform lighting by an ISO/AIM-compliant light to produce an undistorted image.

Smart Camera Vision System with Integrated Lighting and Adaptable Software

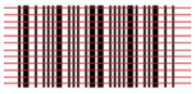
C-Mount Smart Camera Vision System with External Lighting and Adaptable Software

Verification Evaluation Parameters

There are a number of verification evaluation parameters that determine code quality and they may be used for either true verification or validation/process control. Published code quality standards, such as ISO 15415, ISO 15416, and AIM/DPM – ISO 29158, require that a designated set of these parameters are met to ensure that a code is verified to the standard, while process control grading may require that a code meets only a subset of these parameters. Parameters for 1D and 2D code evaluation are shown below.

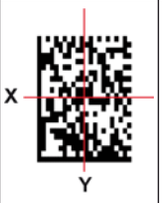
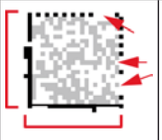
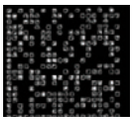
1D Verification Evaluation Parameters

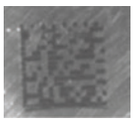
High Quality Symbol:

Parameter	Description	Example	ISO 15416
Decodability	Legibility per a reference decode algorithm		✓
Defects	Voids in bars or spots in spaces		✓
Edge Determination	Detection of all bars and spaces using a global threshold		✓
Minimum Edge Contrast	Minimum reflectance difference for any bar/space combination		✓
Minimum Reflectance	Reflectance of the darkest bar and the lightest space		✓
Modulation	Relation between wide and narrow elements in the symbol		✓
Symbol Contrast	Difference in reflectance between the darkest bar and the lightest space		✓
Quiet Zone	Size of the quiet zone		✓

2D Verification Evaluation Parameters

High Quality Symbol:

Parameter	Description	Example	ISO 15415	AIM/DPM ISO 29158
Axial Non-Uniformity	Amount of deviation along a symbol's major axes		✓	✓
Symbol Contrast	Difference in reflectance between light and dark symbol elements		✓	
Cell Contrast	Difference in grayscale value between light and dark symbol elements			✓
Modulation	Difference in reflectance of light and dark symbol elements		✓	
Cell Modulation	Deviation in grayscale values of symbol elements			✓
Decodability	Legibility per a reference decode algorithm		✓	✓
Fixed Pattern Damage	Damage to the quiet zone, finder pattern, or clock pattern		✓	✓
Grid Non-Uniformity	Amount of deviation of grid intersection		✓	✓
Minimum Reflectance	Minimum reflectance of light elements			✓

Parameter	Description	Example	ISO 15415	AIM/DPM ISO 29158
Reflectance Margin	Degree to which each module is correctly distinguishable in comparison to the global threshold		✓	
Unused Error Correction	Remaining error correction available		✓	✓
Print Growth	Variation of element size that could impede readability	 Overprint  Underprint	For Reference Only	

Verification Grades

Codes are graded by verification equipment like code verifiers and machine vision systems, which assign values 0-4/A-F to the code for each of the above listed evaluation parameters.

A code's overall grade is determined by the worst result for each parameter, so the code is always as good as its poorest parameter. Typically, a code with a grade A, B, or C is considered of acceptable quality, while a grade D or F signifies a poorly-marked or poorly-printed code.

It is possible that a code with grade D or F may still be readable within your system using certain equipment, but without verification there is no guarantee that this same code will be readable at other points in your supply chain, by different equipment, or by your customers.

By verifying codes to an agreed-upon code quality standard, such as those put forth by ISO or AIM DPM, it is no longer a question of a code's readability, but rather of a particular reader's ability to read a certain grade.

Verification with di-soric AutoVision

di-soric's AutoVision Machine Vision Software provides powerful tools for both text quality verification (Optical Character Verification or OCV) and code quality verification (Optical Character Verification and OCV only in conjunction with the Software-Upgrades *VS-UP-AV/OCV* or *VS-UP-AV/VS-OCV).*

Through its intuitive user interface, di-soric AutoVision enables easy setup of both offline verification and inline verification of products in production. Using di-soric AutoVision and high-performance smart cameras and lighting from di-soric, you can set up a complete verification system to determine code quality for both process control and true code verification, including conformance to three published code quality standards:

ISO 15415 **AIM/DPM – ISO 29158** **ISO 15416**

Clear and concise values are provided via the di-soric AutoVision user interface to grade 1D and 2D codes for each parameter required by a code quality standard. di-soric AutoVision assigns values 0-4/A-F to the code for each parameter and then the code receives an overall grade for meeting the quality standard.

Default parameters in di-soric AutoVision are pre-set to grade codes against published code quality standards (ISO 15415, ISO 15416, and AIM/DPM – ISO 29158), but can be adjusted in the di-soric AutoVision Symbol Quality Verification Tool to enable process control grading for codes that must meet application-specific criteria only.

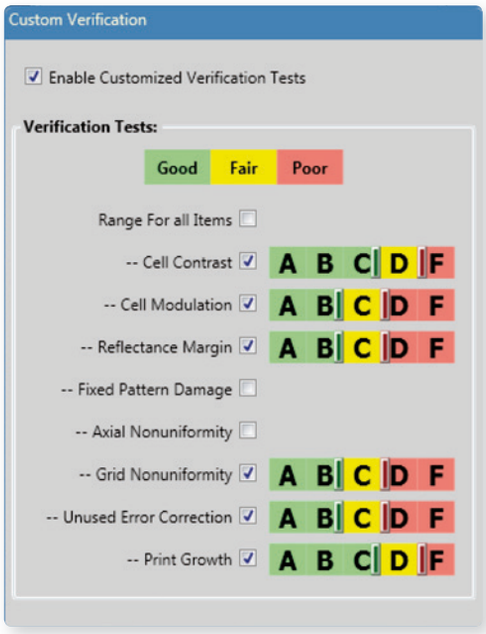
di-soric Meets Verification Needs

From 2D code verifiers to complete, scalable machine vision systems like the di-soric VS - Vision Systems, di-soric offers a range of products to ensure that automation systems operate at peak performance thanks to quality and compliant codes.

For engineers tasked with meeting quality control or global standards in marking and labeling, di-soric provides project evaluations to find the right code verification solution for any project.

More di-soric product information and training resources are available at **www.di-soric.com**.

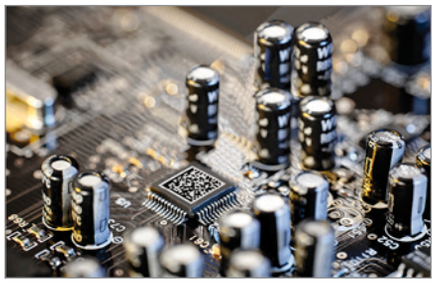
A Data Matrix 2D code is verified against the AIM/DPM – ISO 29158 quality standard using di-soric´s AutoVision machine vision software.



Verification evaluation parameters are adjusted in the di-soric AutoVision Symbol Quality Verification Tool to grade a code for internal process control.

di-soric Vision Systems

di-soric offers a wide range of vision systems for the industrial use. From All-In-One-Systems in the size of a matchbox up to high resolution C-Mount Systems; we have the perfect solution for your application. Thanks to a scaleable system even very demanding image processing applications can be easily solved.



VS-05

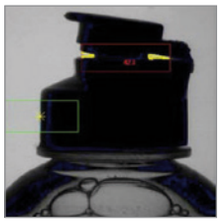
- Integrated with di-soric VS AutoVision software
- Upgradeable system – scaleable software with the same hardware
- Autofocus with wide angle optics
- Integrated lighting
- Compact design
- Ethernet, USB- and serial interfaces

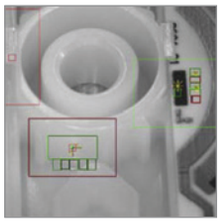
VS-06 C-Mount

- Integrated with di-soric VS AutoVision software
- Upgradeable system – scaleable software with the same hardware
- Industry proven machine vision tools
- C-Mount model
- Ethernet and serial interface
- Access via web browser possible

VS-06 with liquid lens

- Integrated with di-soric VS AutoVision software
- Upgradeable system – scaleable software with the same hardware
- Industry proven machine vision tools
- Fully integrated with processor, lens and illumination
- Liquid lens autofocus
- Ethernet and serial interface
- Integrated lighting
- Access via web browser possible





CE

Smart camera	CMOS, 752 x 480 pixel	CMOS, 1280 x 1024 pixel	CCD, 1280 x 960 pixel	CMOS, 2048 x 1088 pixel	Standard density	High density	Autofocus	Liquid lens autofocus	Optics	Sensor size	Images/s (max.)	Rolling shutter	Global shutter	Service voltage (V DC)	Outputs 1, 2 and 3 (V DC)	Protection class	RS 232 and RS 422 / 485	USB	Ethernet	Product-ID*
	■				■		■		fixed	1/2"	60		■	5,0	5 … 28	IP 54	■	■		VS-05-BM2-2-US
	■				■		■		fixed	1/2"	60		■	10 … 30	1 … 28	IP 54	■		■	VS-05-BM2-2-ES
	■					■	■		fixed	1/2"	60		■	5,0	5 … 28	IP 54	■	■		VS-05-BM2-3-US
	■					■	■		fixed	1/2"	60		■	10 … 30	1 … 28	IP 54	■		■	VS-05-BM2-3-ES
		■			■		■		fixed	1/2"	15	■		5,0	5 … 28	IP 54	■	■		VS-05-BM3-2-US
		■			■		■		fixed	1/2"	15	■		10 … 30	1 … 28	IP 54	■		■	VS-05-BM3-2-ES
		■				■	■		fixed	1/2"	15	■		5,0	5 … 28	IP 54	■	■		VS-05-BM3-3-US
		■				■	■		fixed	1/2"	15	■		10 … 30	1 … 28	IP 54	■		■	VS-05-BM3-3-ES
	■							■	15° 30° 45°	1/3"	60		■	5,0 … 28	1,0 … 28	IP 65 + IP 67	■		■	VS-06-BM2-15-ES VS-06-BM2-30-ES VS-06-BM2-45-ES
			■					■	15° 30° 45°	1/3"	20		■	5,0 … 28	1,0 … 28	IP 65 + IP 67	■		■	VS-06-BC3-15-ES VS-06-BC3-30-ES VS-06-BC3-45-ES
	■								C-Mount	1/3"	60		■	5,0 … 28	1,0 … 28	IP 65 [1]	■		■	VS-06-BM2-00-ES
			■						C-Mount	1/3"	20		■	5,0 … 28	1,0 … 28	IP 65 [1]	■		■	VS-06-BC3-00-ES
				■					C-Mount	2/3"	48		■	5,0 … 28	1,0 … 28	IP 65 [1]	■		■	VS-06-BM4-00-ES

* Excerpt from our delivery programme

[1] IP 65 +IP 67 when operating with VSID-LP-C-xx

Software-Extensions		Product-ID
I	Software-Upgrade (extended toolset)	VS-UP-AV/VS
II	Software-Upgrade (Symbol-Verification + OCV)	VS-UP-AV/OCV
I + II	Software-Upgrade-Complete-Package (extended toolset, Symbol-Verification + OCV)	VS-UP-AV/VS-OCV

Lenses and filters

A large range of suitable quality-lenses in focal lenghts from 3,5 up to 100 mm and a comprehensive program of high-end accessories like

- Converters

- Extension rings

- Objective protection glasses

- Bandpass filters
- Cutoff filters

- Daylight cutoff filters
- Neutral density filters

- Polarizing filters

can be found on our homepage at **www.di-soric.com/en/lenses**.

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