IPC-A-610 Standard Compliance by using Advanced AI Technology

White paper

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Introduction

In the ever-evolving landscape of electronics manufacturing, standards serve as guiding principles, adapting to the pulse of emerging technologies. This white paper embarks on an exploration of IPC-A-610, focused on the quality of assembled PCB, not merely as a compliance framework but as a dynamic entity poised for evolution.

Our focus zeroes in on electronic components. This is because existing practices predominantly utilize technology to inspect the assembly process, often sidelining the examination of individual electronic components. As a result, these crucial components often find themselves excluded from the majority of automated tests conducted along the manufacturing line.

We advocate for a user-centric approach, where immediate detection technology becomes the catalyst for redefining how IPC-A-610 integrates with the shop floor. This isn't a revolution; it's a transformation, a shift in the orchestration of compliance. As we engage in this dialogue, we pose a simple yet profound question: How does the user experience change with the infusion of real-time insights into IPC-A-610?

Amidst our contemplation, we introduce a novel technology — a visual inspection system based on advanced AI that scrutinizes every component during assembly, ensuring a discreet yet comprehensive 100% compliance check. Join us on this understated journey, not just to follow standards but to gently mold them into a harmonious resonance with contemporary possibilities, ushering IPC-A-610 into the realm of Smart Manufacturing.

Contents

“The Defect Class Definitions are Copyright 2024 by IPC International, Inc. and are used with permission of IPC International, Inc.”

Ensuring IPC-A-610 Standard Compliance by using Advanced AI technology

This guide provides an overview of IPC-A-610 Rev. G, a widely recognized standard for electronic assembly acceptance criteria. Specifically tailored for Advanced AI inspections, we will go into key sections of IPC, focusing on defects, corrosion, contamination, markings, and foreign object debris (FOD). By aligning our understanding with these criteria, we aim to enhance the clarity and precision of electronic component inspections. Let's embark on a journey to ensure electronic assemblies' highest quality and reliability.

In-depth Component Analysis

In the realm of electronic manufacturing, we present a thorough approach to inspecting components. This involves two key processes: checking the underside of components during Pick and Place (PNP) and Automated Optical Inspection (AOI) operations and examining the top side for detailed analysis.

- Bottom Side Analysis

The pick-and-place (PnP) machine takes an image of all components right after the pick-up and before the placement to measure the alignment parameters needed for accurate placement. The software uses this bottom-side Image to analyze the visual quality features of all mounted components. This helps identify issues like damage, corrosion, and irregularities in the structure and leads of the component. It ensures that each component meets the required standards for robustness and reliability.

- Top Side Analysis

The AOI machine takes an Image of the assembled board from Its top side to verify that the mounting process was completed correctly. A software analyzes the top side images, Inspecting the markings and identifiers. This ensures the markings are clear and accurate, match the traceability data provided, and comply with industry standards.

In the following pages, we address key requirements from the IPC standard and clarify how an advanced AI platform allows compliance to be checked automatically for all assembled components.

1. Defects on Component leads/terminations - Section 8.2.2

The standard criteria for a defect on leads in Section 8.2.2 for Class 1, 2, and 3 is damage or deformation exceeding 10% of the lead's diameter, width, or thickness.

Defect Assessment: The software meticulously examines each lead for damage or deformation exceeding 10% of the lead's diameter, width, or thickness.

An excerpt from the standard is presented here:

> **Defect – Class 1,2,3**
> - Lead is damaged or deformed more than 10% of the diameter, width or thickness of the lead.
> - Lead is deformed from repeated or careless bending.
> - Heavy indentations such as serrated pliers mark.

Examples of images taken by the PnP machines that were disqualified by the algorithm are presented in Figure 1.

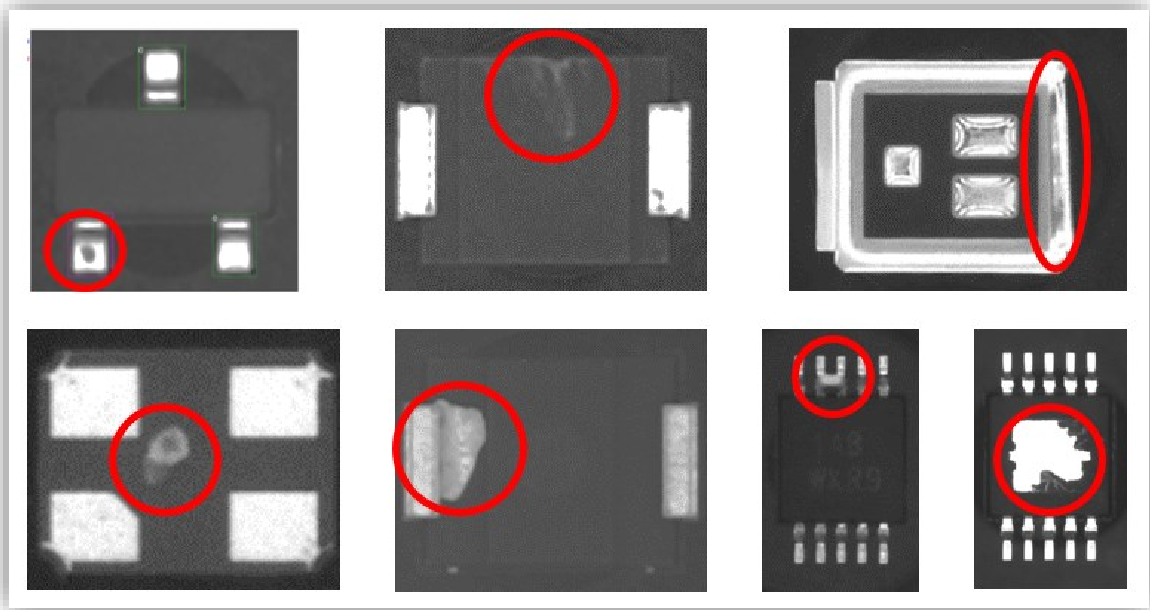


Figure 1: Examples from images taken by the pick and place machines and disqualified by the algorithm.

2. Bent or warped leads – section 8.3.5.8

The standard criteria for a defect on leads In Section 8.3.5.8 for Class 1, 2, and 3 is Component lead(s) out of alignment (coplanarity) preventing the formation of an acceptable solder connection.

- *Bending Evaluation:* The system analyzes leads for deformation resulting from bending, ensuring compliance with IPC-A-610 guidelines.
- *Indentation Recognition:* The technology is adept at detecting heavy indentations, including those caused by serrated pliers, and appropriately categorizes them.
- *Coplanarity Detection:* The system identifies component leads that are out of alignment (coplanarity), preventing the formation of an acceptable solder connection.

Any lead exhibiting damage beyond the specified threshold is flagged for further evaluation, contributing to fulfilling IPC-A-610 standards in electronic component inspections.

An excerpt from the standard is presented here:

> **Defect – Class 1,2,3**
>
> - Component lead(s) out of alignment (coplanarity) preventing the formation of an acceptable solder connection.

Examples of bent leads and coplanarity issues appear in Figure 2.

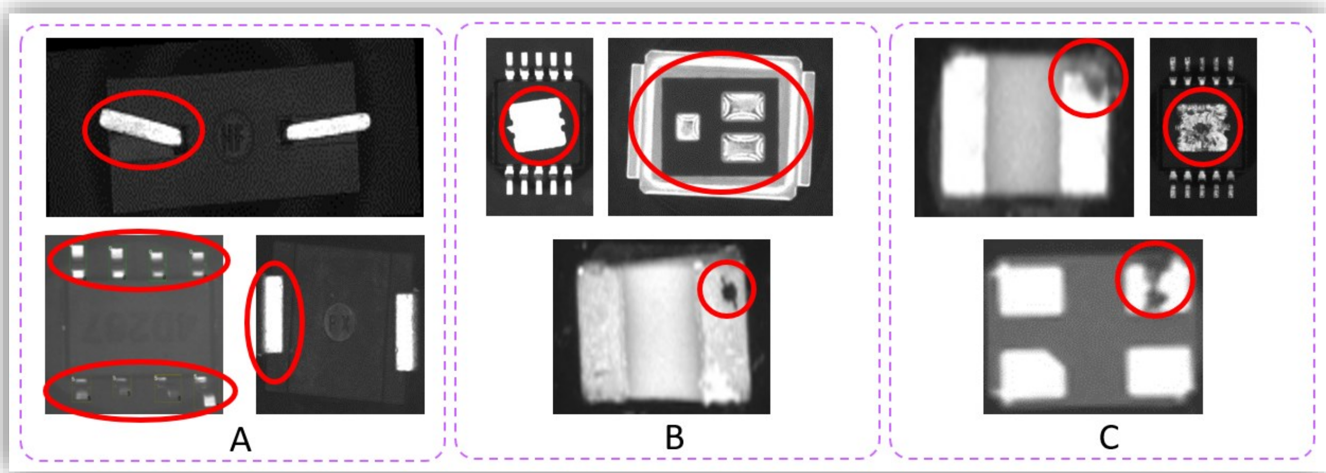


Figure 2: Examples of bent leads and coplanarity issues automatically detected by the algorithm that exceeds 10% of the lead's width. (A) bent leads, (B) deformed leads, (C) damaged leads.

3. Corrosion and Cleanliness - Section 10.6.4

In alignment with IPC-A-610 standards, the AI system is equipped to identify and evaluate corrosion on metallic surfaces or hardware, conforming to the criteria specified in Section 10.6.4 for Classes 1, 2, and 3. The standard criteria for a defect – Class 1,2,3 are colored residues, rusty appearance on metallic surfaces, hardware, or evidence of corrosion. Any volume of corrosion is a defect.

- *Residues Detection:* The inspection algorithm is designed to identify residues on metallic surfaces of the components, promptly recognizing any indications of discoloration.
- *Corrosion Evidence Recognition:* The AI system capabilities extend to recognizing evidence of corrosion, aligning with the defined parameters in Section 10.6.4 for cleanliness and surface appearance.

Any component or lead exhibiting residues or corrosion beyond the specified threshold is flagged for further evaluation, contributing to the fulfillment of IPC-A-610 Section 10.6.4 standard in electronic component inspections. An excerpt from the standard is presented here:

Defect – Class 1,2,3
- Colored residues or rusty appearance on metallic surfaces or hardware.
- Evidence of corrosion.

Examples of components with corrosion and contamination are presented in Figure 3.

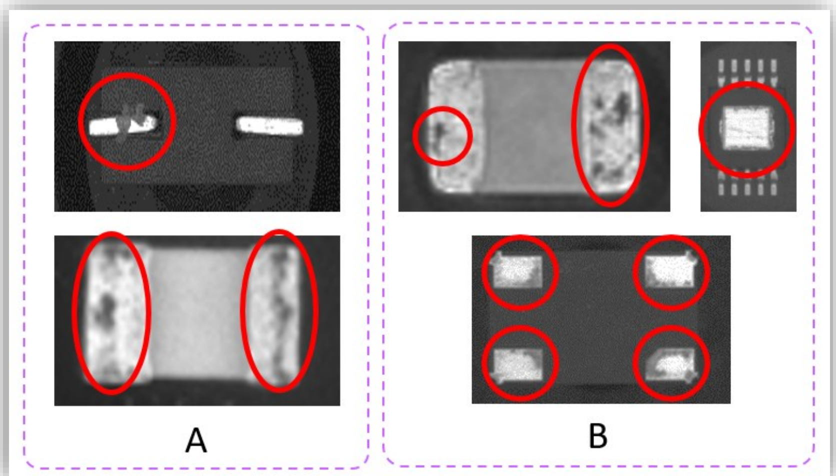


Figure 3: Examples of components with corrosion and contamination automatically detected by the AI algorithm that exceed 10% of the lead's width. (A) Contamination of leads, (B) Corrosion of leads.

4. Cleanliness – Foreign Object Debris (FOD) – sections 10.6.2 & 10.6.3

IPC-A-610 outlines the acceptability requirements for the cleanliness of assemblies, encompassing components with any electrical interfacing surfaces, such as connector mating surfaces and compliant pins. The standards apply to both the primary and the secondary sides of assemblies.

Contamination Evaluation: Contamination is assessed not merely on cosmetic or functional attributes but serves as a warning sign that the components containers (reels, trays) may be contaminated, mishandled, or exposed to contaminants.

The standard criteria for a defect – Class 1,2,3 in 10.6.3 is FOD not attached, entrapped, or encapsulated. Contamination, which is free to shift, and 10.6.3 refers to Cleanliness – Chlorides, Carbonates and White Residues

- Residue on component surface.
- Residues on or around terminations.
- Metallic areas exhibiting crystalline deposits.

Any component or lead exhibiting debris beyond the specified threshold is flagged for further evaluation, contributing to fulfilling IPC-A-610 Section 10.6.2 and 10.6.3 standards in electronic component inspections.

An excerpt from the standard is presented here:

Defect – Class 1,2,3

- FOD that is not attached, entrapped, encapsulated, see 5.2.7.1 Soldering – Soldering Anomalies – Excess Solder – Solder Balls and 10.8.2 Printed Boards and Assemblies – Conformal Coating – Coverage.
- Violate minimum electrical clearance.

Defect – Class 1,2,3

- White residue on printed board surface.
- White residues on or around the soldered termination.
- Metallic areas exhibit crystalline white deposit.

Note: The debris is typically an indicator of a root cause in the component's handling or processing. Debris may accumulate in the mounting machine or originate from an unclean packing process at the component's vendor, disintegrating component leads plating, etc.

Examples of components with corrosion and contamination are presented in

Figure 4.

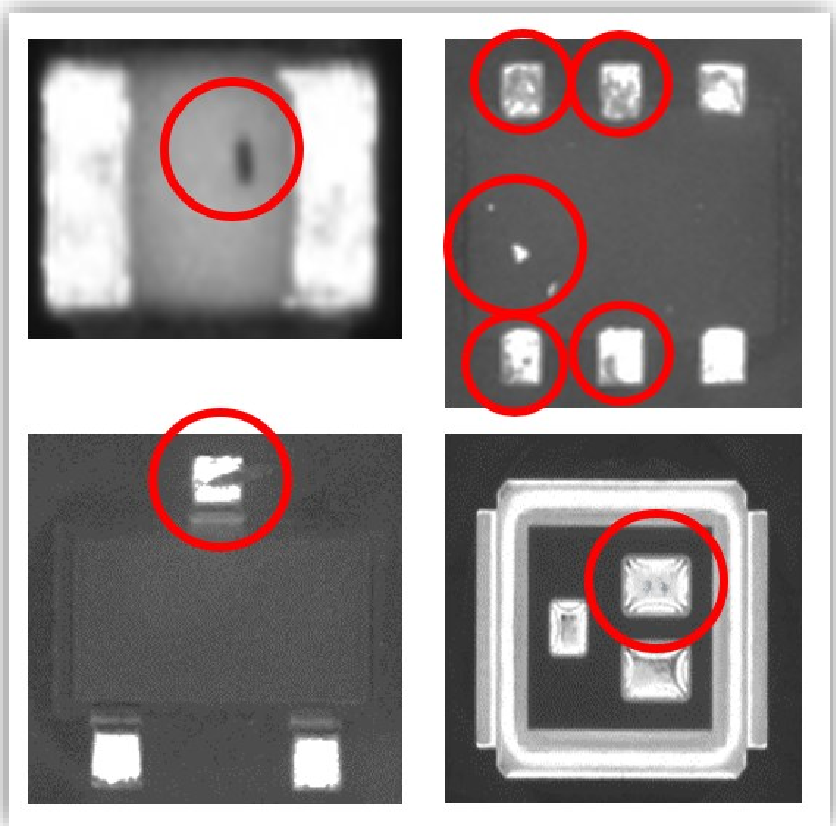


Figure 4: Examples of components with foreign object debris (FOD) automatically detected by The AI algorithm. Note that debris may be due to a component defect or point out a root cause in the supply chain, such as contaminated components in a container or poorly handled material.

5. Loss of Metallization – Section 9.1, 9.3

- *Metallization Loss on Terminal End Face -* This defect occurs when there is a discernible loss of metallization on the terminal end face, revealing the underlying ceramic material. The significance is that the ceramic's exposure compromises the metallization's protective layer, potentially affecting the component's electrical functionality and structural integrity.
- Metallization Loss on Any Termination Side

In this scenario, there is a metallization loss on any side of a five-sided termination component, excluding the end face, exceeding 25% of the termination's width or height. This defect signifies a substantial reduction in metallization coverage on a critical component surface, impacting conductivity and possibly leading to performance issues.

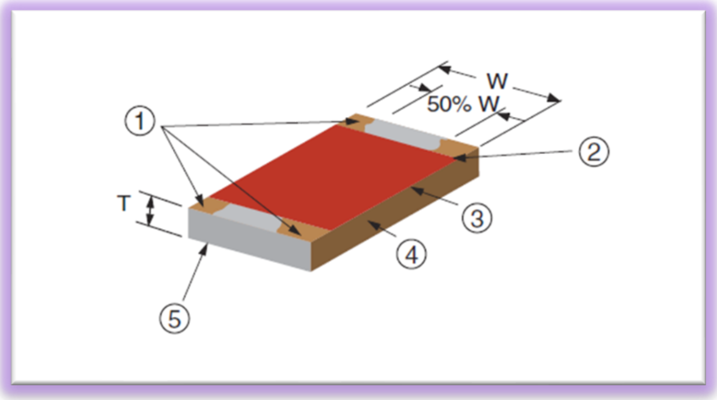


Figure 5 : Metallization loss on soldering leads.

- *Irregular Shapes Beyond Specified Dimensions -* Irregular shapes that deviate from the defined maximum or minimum dimensions for a specific component type.

In summary, as per IPC-A-610 standards, these metallization loss defects highlight critical vulnerabilities in electronic components, emphasizing the importance of maintaining the integrity of metalized surfaces for optimal functionality and reliability.

An excerpt from the section 9.1 of the standard for passives is presented here:

Defect – Class 1,2,3

- Metallization loss on the terminal end face exposing the ceramic, see Figure 9-3-A.
- Metallization loss on any termination side (not the end face) on a five-sided termination component greater than 25% of termination width or height, see Figures 9-4 and 9-5.
- Metallization loss greater than 50% of the top area on a three-sided termination component, see Figures 9-5 and 9-6.
- Irregular shapes exceeding maximum or minimum dimensions for that component type.

An excerpt from the section 9.3 for leaded components:

Defect – Class 1,2,3

- Chip-out or crack that enters into the seal, see Figure 9-16.
- There are cracks leading from the chip-out on a ceramic body component, see Figure 9-16.
- Chip or crack that exposes the component substrate or active element, or affects hermeticity, integrity, form, fit or function, see Figure 9-17.
- Chips or cracks in glass body beyond the part specification, see Figure 9-18.
- Cracked or damaged glass bead beyond part specification (not shown).
- Required identification is missing due to component damage (not shown).
- The insulating coating is damaged to the extent that the internal functional element is exposed or the component shape is deformed (not shown).
- Damaged area shows evidence of increasing, for instance from cracks, sharp corners, brittle material from heat, etc., see Figure 9-19.
- Damage permits potential shorting to adjacent components or circuitry.
- Flaking, peeling, or blistering of plating.
- Burned, charred components (the charred surface on a component has black, dark brown appearance due to excessive heat), see Figure 9-20.
- Dents, scratches in the component body that affect form, fit and function or exceed component manufacturer's specifications, see Figure 9-21.
- Cracks in shield material, see Figure 9-22.
- Component body delaminates from substrate, see Figure 9-23.

Any component or lead exhibiting metallization irregularities beyond the specified threshold is flagged for further evaluation, contributing to the fulfillment of IPC-A-610 Section 9.3 standard in electronic component inspections. Examples of components with metallization delamination are presented in

Figure 6.

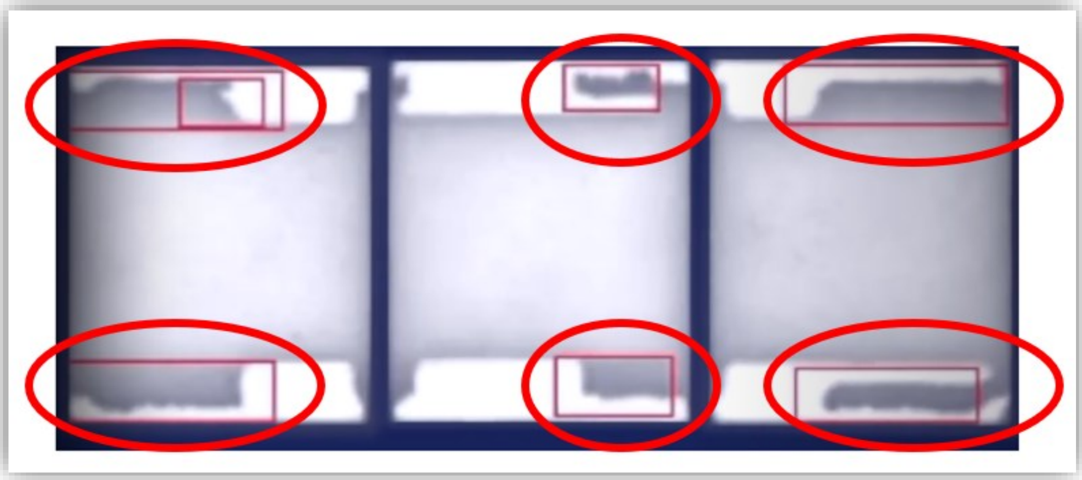


Figure 6: Examples of components with metallization delamination automatically detected by the AI algorithm.

6. Mounting Upside Down – section 8.3.2.9.2

- Defect definition – Class 1,2,3: Two-Sided Termination with Component Mounted Upside Down. When rectangular or square end chip components have one, two, three, or five side terminations, a defect is identified if the component is mounted upside down. This means that the component's orientation is opposite to the intended configuration, which is considered non-compliant. Any upside-down component is flagged for further evaluation, contributing to fulfilling IPC-A-610 Section 8.3.2.9.2.

An excerpt from the standard is presented here:

> **Defect – 1,2,3**
> - Two-sided termination with component mounted upside down.

A top-side example from the IPC standard is presented in Figure 7, and the AI software platform's detection of a component mounted upside down is presented in Figure 8.

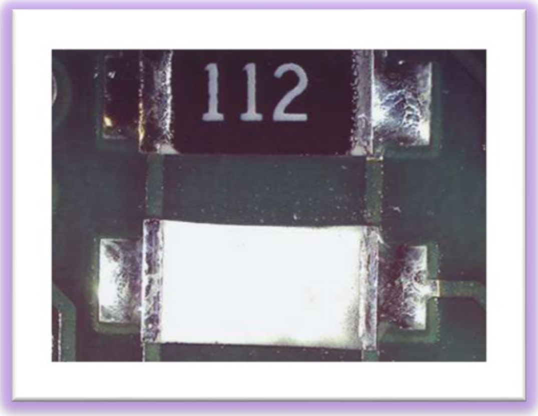


Figure 7: A resistor mounted upside-down from the top view.

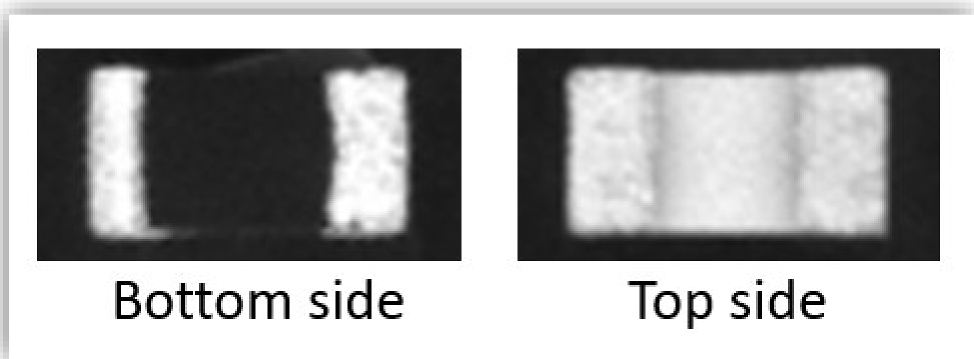


Figure 8: An example of a component mounted upside-down as automatically detected by the AI algorithm. The left image is of an up-side-down component, and the right image is a well-mounted component.

7. Incorrect or Missing Marking – Section 10.5

- *Incorrect Marking Content:* A defect is identified if the marking content is incorrect.
- *Missing Marking:* A defect is recorded when the marking is:
    - Missing or Illegible Characters: Characters in the markings are considered defective if they are absent or not legible, jeopardizing the identification of components.
    - Missing or Broken Lines Forming a Character: When lines forming a character are missing or broken to the extent that the character is not legible or is likely to be confused with another character, it is deemed a defect.
    - Assembly markings, including part numbers and serial numbers, must remain legible after undergoing all tests, cleaning processes, and other procedures defined by this standard.
    - Component markings and polarity indicators should be legible. Components should be mounted in a way that ensures the visibility of these markings.
- *Legibility Requirements:* Legibility is a critical aspect of marking standards outlined in IPC-A-610. To prevent misinterpretation or confusion during visual inspections, all characters must be clearly discernible.

Adherence to these marking standards is essential to ensure accurate component identification, compliance with electrical clearance limits, and overall legibility for successful visual inspections. Components failing to meet these marking criteria are considered defective as per IPC-A-610 standards.

All components' top marking is analyzed for marking legibility, and the system flags any component that fails as a marking defect.

An excerpt from the standard is presented here:

Defect – Class 1,2,3
- Marking content incorrect.
- Marking missing.

The marking on all components is compared to the traceability information inputted to the production systems, and any mismatch is flagged. The mismatch represents either wrong traceability information or wrong marking information.

Examples of components with illegible markings are presented in Figure 9.

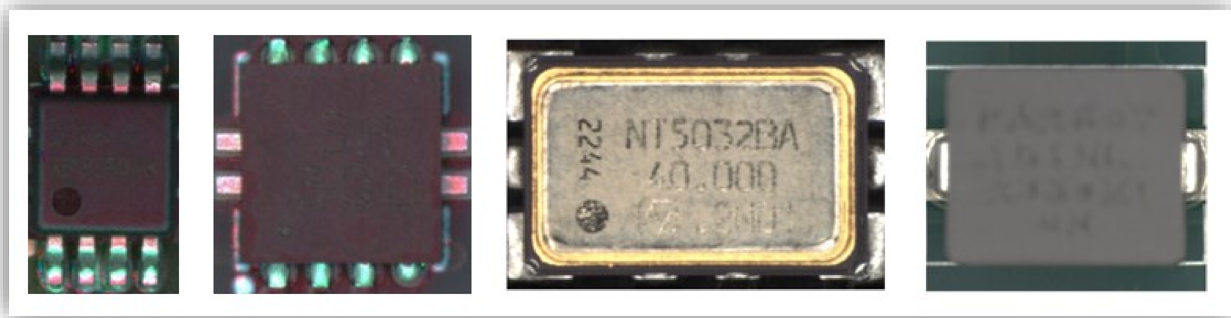
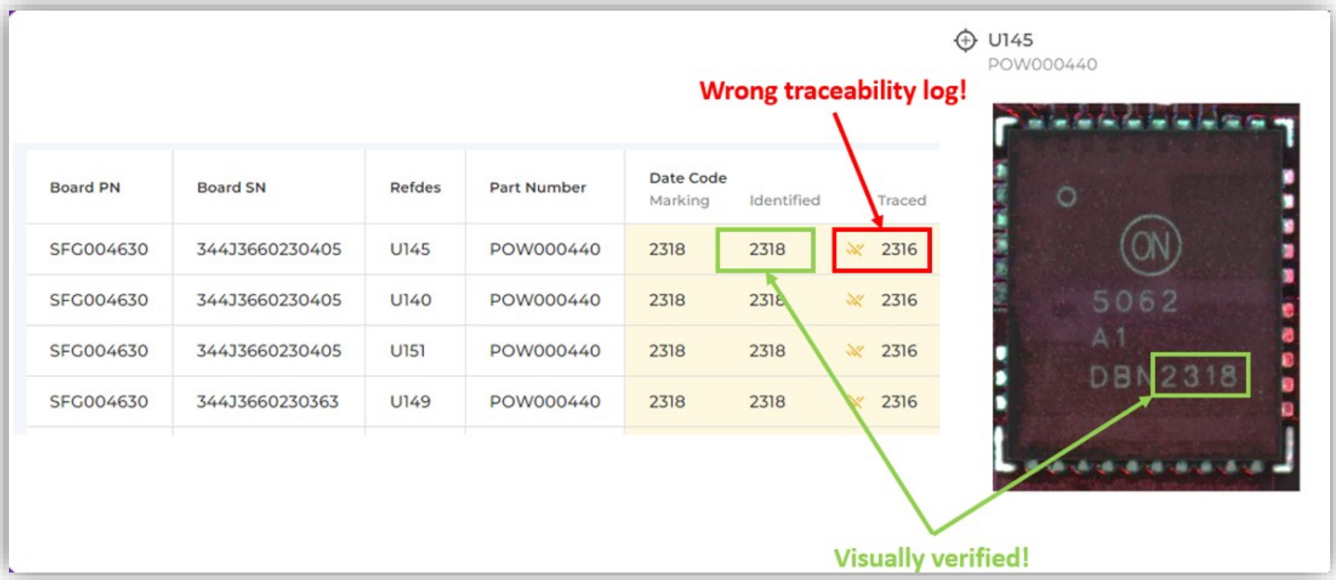


Figure 9: Examples of components with illegible markings automatically detected by the AIc algorithm.

Examples of wrong marking information are presented in Figure 10.



Board PN	Board SN	Refdes	Part Number	Date Code Marking	Identified	Traced
SFG004630	344J3660230405	U145	POW000440	2318	2318	2316
SFG004630	344J3660230405	U140	POW000440	2318	2318	2316
SFG004630	344J3660230405	U151	POW000440	2318	2318	2316
SFG004630	344J3660230363	U149	POW000440	2318	2318	2316

Figure 10: Examples of wrong marking information.