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IPC-8413-1

Specification for Process Carriers Used to Handle Optical Fibers in Manufacturing

IPC-8413-1

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A standard developed by IPC

2215 Sanders Road, Northbrook, IL 60062-6135

Tel. 847.509.9700 Fax 847.509.9701
www.ipc.org



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Specification for Process Carriers Used to Handle Optical Fibers in Manufacturing

Developed by the Optoelectronic Fiber Handling and Carrier Task Group (5-25a) (initially formed as NEMI Technical Working Group on Optical Fiber Carriers and Handling) of IPC

Users of this standard are encouraged to participate in the development of future revisions.

Contact:

IPC
2215 Sanders Road
Northbrook, Illinois
60062-6135
Tel 847 509.9700
Fax 847 509.9798



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Specification Hierarchy

This standard is a member of the family of IPC Standards and Guidelines for Optoelectronics.

IPC-0040 *Optoelectronic Assembly and Packaging Technology*

IPC-STD-8413-1 *Specification for Process Carriers Used to Handle Optical Fibers in Manufacturing*

FORWARD

In May 2001, at a joint meeting of IPC and NEMI, a technical interest group in Photonics Manufacturing was created. This group met twice in the summer of 2001 and identified several issues in photonics manufacturing that could be resolved by the creation of standards. At the same time, IPC began working on an overview standard for Optoelectronics, IPC-0040. This standard was largely educational in content and serves to provide an overarching framework for specific standards in optoelectronics, particularly in fiber optics. Out of these efforts, fiber handling and carriers for containing and controlling fiber in the component manufacturing process were identified as fundamental issues. The NEMI Technical Working Group was formed in September 2001, to address these issues. This standard is the result of that effort.

Acknowledgment

Any Standard involving a complex technology draws material from a vast number of sources. While the principal members of the Optoelectronic Fiber Handling and Carrier Task Group (5-25a) of the Optoelectronic Assembly and Packaging Technology Subcommittee are shown below, it is not possible to include all of those who assisted in the evolution of this standard. To each of them, the members of the IPC extend their gratitude.

Optoelectronic Assembly and Packaging Technology Subcommittee

Co-Chairs
Paul McGill
Optical Process Automation

and

Mel Parrish
Soldering Technology International

Optoelectronic Fiber Handling and Carrier Task Group

Chair
Daniel Nelson, PhD.
DGN Consulting

Technical Liaison of the IPC Board of Directors

Nilesh S. Naik
Eagle Circuits Inc.

Optoelectronic Fiber Handling and Carrier Task Group

Ed Agranat, Newport Corporation
Peter Arrowsmith, Celestica International Inc.
Mark Aude, Ksaria Corporation
Yossi Chay, Saggita
Pat Corrigan, Auer Precision
Mike Edwards, Pensar
Bill Emkey, Ksaria Corporation
Mike Formica, Palomar Photonics Automation
Alain Giraud, Nextrom Services SA

Dave Godlewski, NEMI
Mathias Grumm, Infineon Technologies
Robert Heckman, Celestica New England
Randy Heyler, Newport Corporation
John Lee, Zymation, Inc.
Nick Leonardi, Consultant
Greg Magel, Zyvex Corporation
Matt Maurer, Palomar Photonics Automation

Jim Mueller, Ksaria Corporation
Francisco Munoz, JDS Uniphase Corporation
Maxime Odiet, Nextrom Services SA
Richard Otte, PROMEX Industries, Inc.
Alan Rae, Cookson Electronics
Mark Rodighiero, Unitek Miyachi Corporation
John Stafford, JWS Consulting P.L.C.
Carl Witham, Adept Technology

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Specification for Process Carriers Used to Handle Optical Fibers in Manufacturing

1 SCOPE

The purpose of the specification is to define standard practices for handling various kinds of optical fiber and to define the specifications and guidelines to be used in the design of carriers for these fibers in component manufacturing.

1.1 Objective of This Standard The objective of this standard is not to define a particular carrier design, but to define enough requirements and guidelines to facilitate the use of fiber carriers in fiber optic component manufacturing, particularly in automated or semiautomated processes. It is the expectation of the authors of this standard that, over time, a variety of carriers will be designed that meet this standard. The marketplace will determine the subset of these designs that best satisfies the needs of the industry. Additional requirements will also emerge. These factors will lead to a small number of industry standard carriers.

1.2 Specifications and Guidelines The fiber carrier requirements contained in this standard have a wide range of specificity. The authors were confronted with the challenge of creating a useful standard for optical fiber carriers when these carriers will be used in a wide range of processes and products where there are no standards. A primary goal of this standard is to facilitate the development of standard automated equipment for manufacturing processes where optical fiber is utilized. Thus, carrier requirements that bear directly on automation, such as the frame of reference, fiducial marks, tooling holes, and clearances, are specified rather precisely. On the other hand, requirements such as the carrier's construction, how it is loaded with fiber, how the fiber is protected and contained, and how the fiber ends are captured, are very product and process dependent. Therefore, they are not exactly specified. In these cases only guidelines, which should be considered when these carrier features are being designed, are given.

1.3 Processes In determining the handling and carrier requirements specified here, only the fiber optic component and module manufacturing processes were considered. Processes for fabricating the fiber, before component manufacturing, or for assembling the resulting component or module onto a printed circuit board (after component or module assembly and test) were not considered. The processes within the scope of this standard begin with the removal the fiber from its bulk spool, through component assembly and test, and ending with optoelectronics module assembly and test. Mounting of fiber optic components or modules

on printed circuits boards, where fiber routing is required, was not considered as this is currently under consideration by another working group.

1.4 Manufacturing Process Carriers The carrier features specified here are for fiber carriers only. It is recognized that in component manufacturing, the fiber is one of several piece parts used. Often these other piece parts will have their own carriers. Also, there may be carriers used to hold the final assembly of which the fiber is part. This standard provides specifications and guidelines for fiber carriers. It also provides specifications and guidelines for features on other carriers that will facilitate the use of these other carriers with the fiber carrier. Features for piece part carriers or product carriers, unrelated to the fiber or its carrier, are not considered or specified.

1.5 Additional Process Requirements The requirements defined in this standard are not intended to meet the needs of all possible fiber optic component assembly processes. There are processes that have additional requirements beyond those given in the standard. For example, the requirements for temperature or chemical resistance given in this standard may be inadequate for certain processes. In these cases, it is expected that fiber carriers will be developed that meet the requirements given in this standard in most areas, but exceed them in others, to make that particular carrier design useful for these more specialized requirements. The working group recognized that burdening all carrier designs with the requirements for all possible processes would result in designs that are too expensive for many applications. The requirements picked here are those that the working group felt would meet most process needs.

1.6 Optical Fibers The specifications and guidelines in this standard are applicable to handling and carriers for the optical fibers with the following characteristics.

- Proof tested to >0.7 G Pa [100k psi]
- Primary buffer coat diameter >240 μm [0.009449 in]
- Overall jacket diameter <1.00 mm [0.03937 in]

2 APPLICABLE DOCUMENTS

The following documents are referred to in this standard.

2.1 IPC-0040 – Optoelectronic Assembly and Packaging Technology This is an overview standard, describing the state of the art and the technologies used in optoelectronic manufacturing.



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2.2 IPC-SMEMA Interface Standard 1.2 – SMEMA Mechanical Equipment Interface Standard Specifies standards for conveyor transport, carrier edge clearance, and tooling holes.

2.3 IPC-SMEMA 3.1 – SMEMA Fiducial Mark Standard Specifies dimensions and tolerances for fiducial marks.

2.4 National Institute of Safety and Health (NIOSH) STD 94-110-b Specifies an equation for calculating Recommended Weight Limit for manual lifting.

2.5 ANSI/ESDS20.20-1999 – ESD Association Standard for Development of an Electrostatic Discharge Control Program Specifies methods for measuring and controlling electrostatic discharge in manufacturing environments. Section 6.2 ESD - Control Program Technical Requirements, and Section 7 - Appendix A: Sensitivity Testing are particularly useful.

2.6 SEMI S8-0701 – Safety Guidelines for Ergonomic Engineering of Semiconductor Manufacturing Equipment Specifies ergonomic requirements and guidelines for material handling, carrier loading, and handle design. Appendix A, Section 1 (Manual Material Handling), Section 2 (Product loading), and Section 9 (Handle Design) are particularly useful.

2.7 ISO-14644-1 – Classification of Air Cleanliness Defines clean room classifications (Replaces FED-STD-209E).

3 REQUIREMENTS

3.1 Definitions The following terms are used in the specifications and guidelines given below. Other useful terms are given in the glossary in the Appendix.

- a) **Buffer** – A protective coating, usually plastic, applied directly on the fiber. See Primary Coating.
- b) **Carrier** – A device used to contain, position and orient an assembly during in its manufacture, application, or shipping. See Fiber Carrier, Primary Carrier, Subcarrier.
- c) **Fiber Carrier** – A device used to contain, position and orient optical fiber during in its manufacture, application, or shipping. See Carrier, Primary Carrier, Subcarrier.
- d) **Fixed Fiber End** – The end of a fiber that stays in a fixed location on the carrier during processing (not including carrier loading and unloading). This end may be a prepared bare fiber, a fiber in a ferrule, a fiber in a connector, or some other termination. If optical connections are made to it for testing, the launch or receiving element is brought into position with the fiber end. The fiber end's position relative to the carrier's frame of reference is unchanged. See Movable Fiber End.

- e) **Minimum Bend Radius** – The minimum radius that a fiber can be bent without causing undesirable effects. The minimum mechanical bend radius is that radius below which the fiber can become damaged due to the mechanical deformation. The minimum optical bend radius is that radius below which optical attenuation in the fiber due to bending becomes measurable.
- f) **Movable Fiber End** – A movable fiber end is a fiber end that is moved relative to its carrier's frame of reference for processing (not including carrier loading and unloading). This end may be a bare fiber, a fiber in a ferrule, a fiber in a connector, or some other termination. At some point in the process it is picked up by a gripper and moved to another location for processing. It may remain in that new location, be placed back in its original position, or placed in some other location when processing is finished. See Fixed Fiber End.
- g) **Primary Carrier** – A device used to contain, position, and orient a subassembly during manufacturing, when it has a subcarrier mounted on it. A carrier becomes a primary carrier when one or more subcarriers are mounted on it. See Carrier, Fiber Carrier, Subcarrier.
- h) **Primary Coating** – The plastic coating, usually acrylate, immediately covering the silica fiber. See Buffer.
- i) **Subcarrier** – A device used to contain, position, and orient a subassembly during manufacturing, when it is mounted on a carrier. A carrier becomes a subcarrier when it is mounted on another carrier. A carrier may have multiple subcarriers on it. See Carrier, Fiber Carrier, Primary Carrier.

3.2 Requirements for Handling Optical Fiber Below are listed the requirements for handling optical fiber, either manually or with tools or equipment, in fiber optic component manufacturing. These requirements also apply to fiber contained in a carrier, and therefore are requirements for the any carrier that comes into contact with the fiber.

3.2.1 Buffer Jacket Damage In handling fiber, care must be taken to not damage the primary buffer coating. If the fiber is not protected by a carrier, caution must be exercised to avoid hitting it with tools or bringing the fiber into contact with a sharp edge. If the fiber is contained in a carrier, the carrier should not have any sharp edges that can come in contact with the fiber. It should also contain the fiber to protect it from possible damage to the primary coating. Also, any device used to grip the fiber, such as a clamp or a robotic gripper must not damage the primary buffer coat. Processes where optical fibers are handled and carriers that hold optical fibers should not produce any defects (nicks, cuts, deformation, etc.) in the primary fiber coating that are visible at 10x magnification or less.

3.2.2 Bend Radius Two optical fiber bend radii are important in component assembly and test. The **Minimum Bend Radius** is the minimum radius that a fiber can be bent without causing undesirable effects. The **Optical Bend Radius** is the minimum radius below which optical attenuation in the fiber due to bending becomes measurable.

mechanical bend radius. A bend of tighter radius than this limit for longer than the prescribed time can cause permanent damage to the fiber, which affects its long-term reliability. The second bend radius is the optical bend radius. Bends with radii smaller than this limit produce measurable optical attenuation in the fiber. This can affect test results.

Since mechanical damage to optical fiber is a function of the stress applied to the fiber, the minimum mechanical bend radius that the fiber can experience without damage is a function of the time the fiber undergoes the resulting bending stress. A fiber bent with a relatively small radius can remain undamaged for a short time. If held at that same radius for a longer time, the resulting stress will eventually permanently damage the silica. The minimum mechanical bend radius varies for different fibers, but for the fibers defined in Scope above, the minimum mechanical bend radius is 25 mm [0.984 in] for a duration of up to three months.

As with the mechanical radius, there is some variation in the optical bend radius with different fiber types and with different operating wavelengths. For the fibers defined in Scope above, the minimum optical bend radius is 30 mm [1.18 in] for 20 turns or less.

3.2.3 Fiber Ends In preparation for splicing or testing, the ends of optical fibers are cleaved to form good optical and mechanical surfaces. The optical performance of a cleaved surface can be severely degraded by subsequent mechanical damage or from particles or other contamination. In most cases, these degrading influences are avoided by minimizing the time between cleaving the fiber end and splicing it or mating it with optical measurement equipment. However, even if this time can be minimized, the cleaved surface must be kept as clean as possible. Glass is a good generator and carrier of static electric charge which, in turn, attracts dust. Cleaving should be performed in a dust-free environment. If the optical connection cannot be made immediately, the fiber end should be covered to protect it from possible contamination. Fiber carriers and their components should be made of static dissipative material that does not produce dust or debris from use.

3.2.4 Fiber Load and Stress Limits The load placed on an optical fiber when it is being loaded onto a carrier, removed from the carrier, or otherwise handled must not exceed 0.4 kg-force [0.88 lbf]. This is equivalent to a tensile stress of 0.32 G Pa [46.4k psi], or approximately 50% of the proof test limit.

In winding, unwinding, handling or processing optical fiber, care must be taken to avoid applying torsional loads. Torsion in the fiber causes the fiber to wrap around itself creating tangles. Also, fiber under torsion can compromise the integrity of splices with other fiber or seals that are formed around the fiber.

3.3 Requirements for Optical Fiber Carriers Fiber carriers can be used to contain and control optical fiber as a stand-alone device, or used as a subcarrier with a larger primary carrier. When the fiber carrier is a subcarrier mounted on a larger primary carrier, the primary carrier usually contains other parts required for the component assembly. The ends of the fiber may be captured in features on the fiber carrier, or captured by features on the primary carrier. This standard specifies the requirements of the fiber carrier. It also specifies those features of a primary carrier that make the primary carrier compatible with the fiber carrier as a subcarrier. The requirements for fiber end capture, position, and orientation apply to any carrier on which the fiber end is located.

3.3.1 Form Factor

3.3.1.1 Carrier Size/Dimensions The upper limits on size for fiber carriers is 150 mm [5.906 in] wide by 325 mm [12.79 in] long. These limits are chosen to be consistent with many commonly used carriers and transport equipment and to provide adequate size for virtually all fiber optic components.

3.3.1.2 Origin and Frame of Reference The origin and frame of reference for a fiber carrier are shown in Figure 3-1. These are based in part on the requirements given for printed circuit board assembly equipment specified in IPC-SMEMA 2. The carrier frame of reference is determined by viewing the carrier from the top as in Figure 3-1. The edge of the carrier deck that is closest to the front of the process cell (or closest to the operator, or next to the fixed rail of the conveyor), is the reference edge. With this reference edge at the bottom of the top view as in Figure 3-1, the edge of the carrier at the right is the leading edge of the carrier. The origin of the carrier frame of reference is near the lower right corner of the carrier deck. This corner is formed by the reference edge and the leading edge. The exact location of the origin of the frame of reference is defined as the center of the primary tooling hole. The primary tooling hole is located in the region that is between 7.36 mm [0.2898 in] and 12.95 mm [0.50984 in] from the leading edge, and is 7.62 mm [0.3000 in] $\pm$ 0.25 mm [0.00984 in] from the reference edge. The primary tooling hole is 3.99 mm [0.1571 in] $\pm$ 0.25 mm [0.00984 in] in diameter.

The x-axis of the frame of reference runs parallel to the carrier's leading edge. + x is across the carrier deck from the origin, away from the reference edge. The y-axis runs parallel to the reference edge. + y is across the carrier deck from the origin, away from the leading edge. + z is given by the right-hand rule (x by y) and is upward from the carrier deck.

If a second tooling hole is required, the preferred location is on the y-axis at a distance from the origin that is a multiple of 12.7 mm [0.5000 in] and in the same direction