# ASME Y14.46 Standard
# Product Definition for Additive Manufacturing

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# ASME Y14.46 – Product Definition for Additive Manufacturing

ASME Y14.46 is an effort to develop a product definition tool that reflects all of the new capabilities that additive manufacturing affords. It is currently a “Draft Standard for Trial Use,” which allows it to be explored by users as it continues active development.

Just like additive manufacturing, this standard is evolving quickly. It continues to grow in response to the rapidly changing 3D printing capabilities.

# Composition

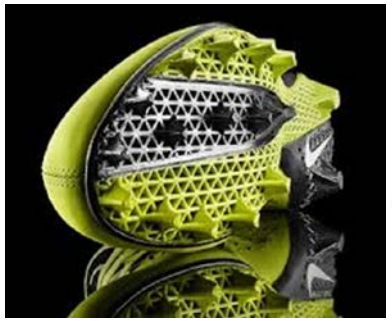
- **Current Leadership**
  - James Gardner, Chair, **Lockheed Martin**
  - Darrell Wallace, Vice-Chair, **Texas A&M University**
- **Founding Leadership**
  - Jennifer Herron, Chair, **Action Engineering, Inc.**
  - Paul Witherell, Vice Chair, **National Institute of Standards and Technology**
  - Donnie Alonzo, Secretary, **The American Society of Mechanical Engineers**

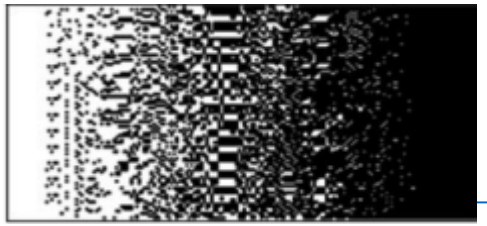
# Voting Members (2017 Standard)

- G. Ameta, **Dakota**
- L. Bergquist, **John Deere**
- C. Brown, **Honeywell FM&T**
- S. Casey, **The Boeing Co.**
- W. Cockrell, **Raytheon**
- K. Delaurentis, **U.S. Food and Drug Administration**
- A. Frey, **U.S. Army**
- R. Lipman, **National Institute of Standards and Technology**
- K. Losoncy, **Orbital ATK Space Systems Group**
- J. Michalowicz, **Stryker Orthopedics, Inc.**
- G. Nair, **Lloyd's Register**
- T. Pilewicz, **Rolls-Royce Corp.**
- S. Ramasamy, **Apple**
- J. Schmelzle, **Naval Air Systems Command**
- J. Sykes, **Profile Services**
- D. Wallace, **Youngstown State University**
- W. Weiss, **NASA (IBW)**
- E. F. Zwettler, **Rolls-Royce Corp.**

# Y14.46 Origins

In 2012, America Makes engaged ASME to discuss these challenges and the limitations for Y14.5 to address them.  Subsequently, the Y14.46 subcommittee was established.





Additive manufacturing differs from traditional processes in its ability to create components with:

- Highly complex organic geometries
- Internal features that may be inaccessible
- Material transitions and gradients
- Inseparable pre-assembled elements
- Material production and geometry production occurring concurrently
- Highly process-dependent properties

# Process Matrix – AM Product Definition Challenges

| | Powder Bed Fusion | Binder Jetting | Directed Energy Deposition | Material Extrusion | Material Jetting | Sheet Lamination | Vat Photo-polymer-ization |
|---|---|---|---|---|---|---|---|
| Build Orientation | ■ | ■ | ● | ■ | ● | ■ | ● |
| Deposition Path | ● | ● | ● | ■ | | | |
| Multi-material | ○ | ■ | ■ | ■ | ■ | ■ | |
| Integrated Assembly | ■ | ■ | | ■ | | | |
| Process Parameters | ■ | ■ | ■ | ■ | ■ | | ● |
| Complex / Organic Forms | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Internal Geometries | ■ | ■ | ■ | ■ | ■ | ■ | ■ |

■ Strong Impacts
● Moderate Impacts
○ Some Impacts

# Material and Process Specifications

- Traditional product definition separates:
  - **Geometry (Typically the limit of product definition)**
  - Material
  - Process

- AM processes blur the lines between these specifications. Designers may spatially vary many factors, including:
  - Material composition
  - Material properties (resulting from process parameter variations)
  - Deposition path

# Spatially Variable Characteristics

Some things we can currently control:

- Material composition
  - Discrete
  - Formulary
  - Functionally graded
- Micro/Macro structure
  - Microstructure
  - Gross anisotropy (build orientation)
  - Local anisotropy (tool path)
  - E-materials (multi-material deposition patterns)

# Key Elements

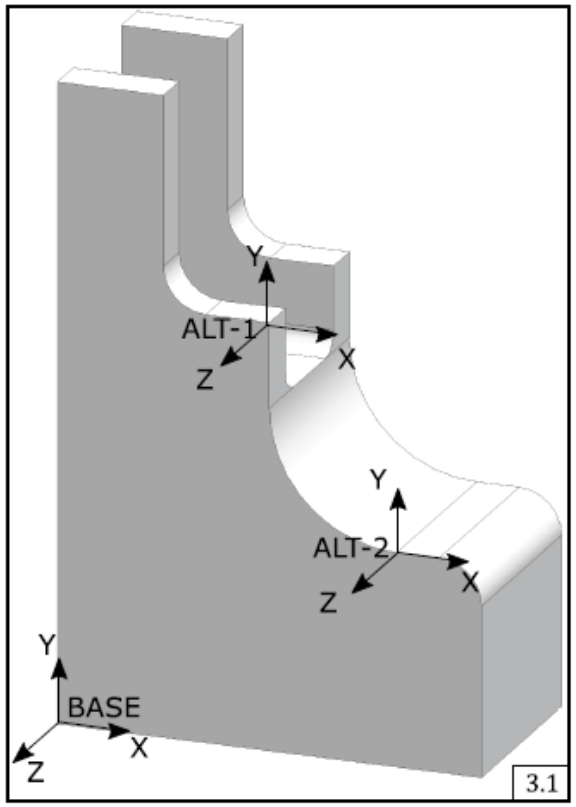
The Y14.46 standard leans heavily on existing standards, particularly Y14.5. Where existing standards lack required capability, 14.46 provides additional product definition tools specific to the needs of additive. Some of these tools include:

- Multiple coordinate systems
- Supplemental geometries
- Build and gravity direction specifications
- Theoretical Supplemental Surfaces (TSS)
- Bounded Volumes
- Transition regions and gradients
- Repeating structures (lattices and infills)
- Integrated assemblies
- Process parameter specifications

# Multiple Coordinate Systems

To accommodate different digital systems, multiple alternative coordinate systems may be defined. As needed, such coordinate systems may also be user-defined.

Figure 3-2 Multiple Coordinate Systems



# Build Direction and Gravity

The orientation of gravity relative to the build surface in the printer will affect the design of support structures required during printing. These support structures affect surface finish and manufacturability of the part and often are important design considerations.

Figure 3-5 A Surface Representing a Build Surface

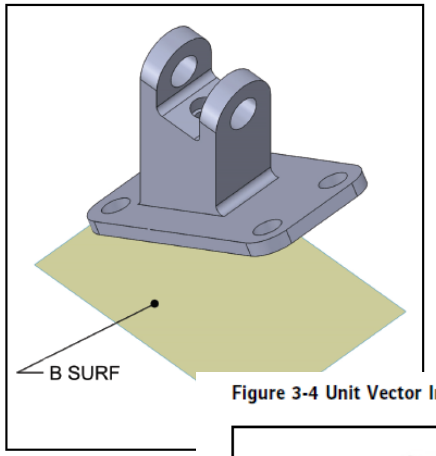
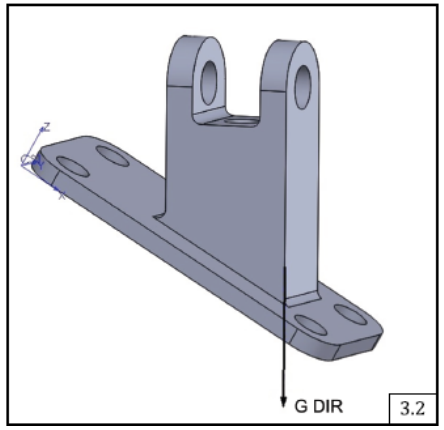
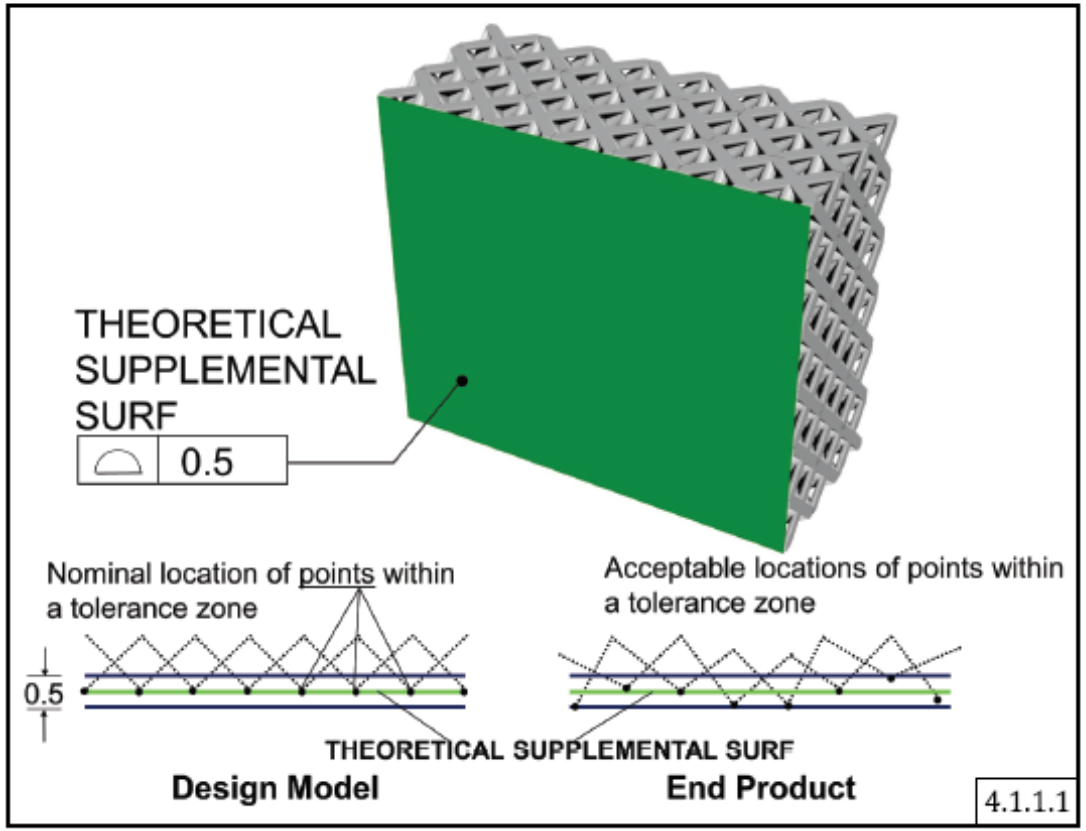



Figure 3-4 Unit Vector Indicating Gravity Direction



# TSS Example

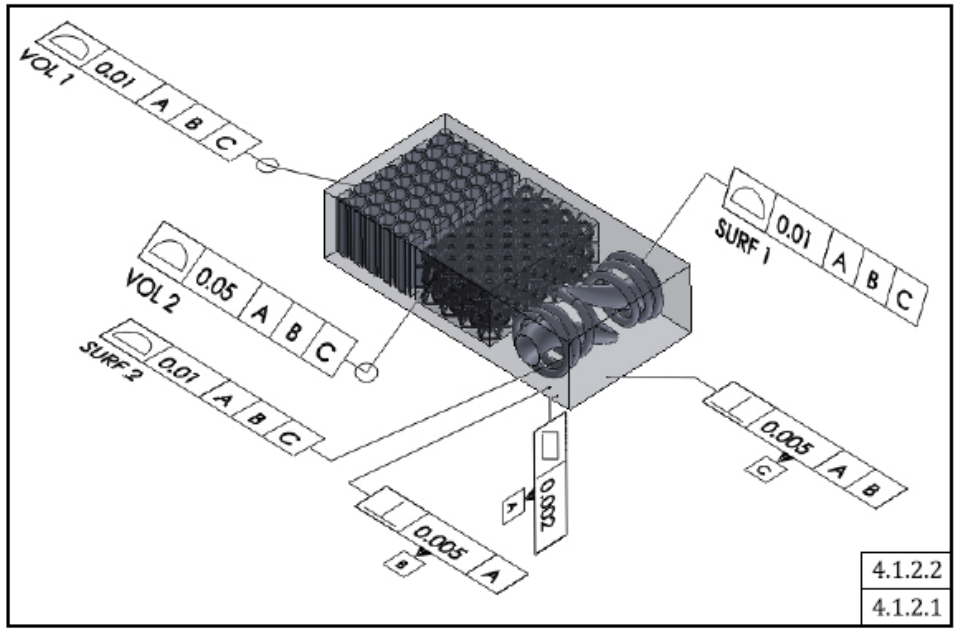
Figure 4-1 Example of a Theoretical Supplemental Surface Used on a Rectangular Lattice Cuboid



# Internal Features

Bounded Volumes and Surface Features can be used to define geometric features or regions that are fully encapsulated within the part and which may not have any exposed physical surfaces.

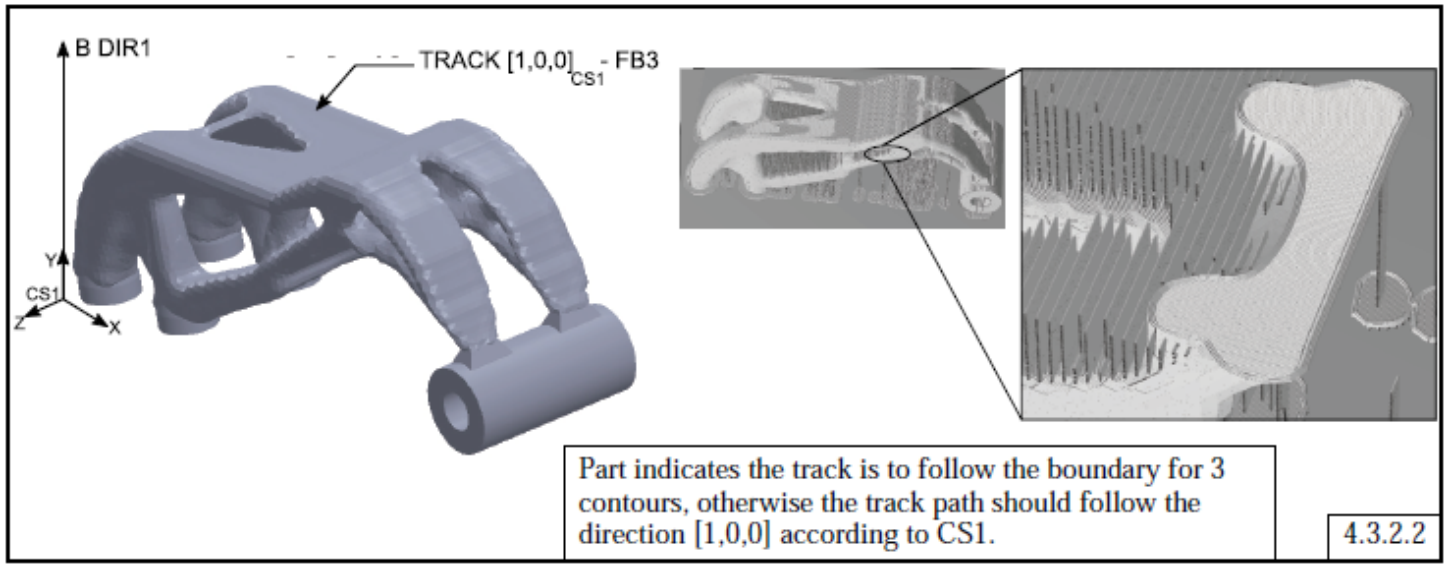
Figure 4-5 Both Bounded Volume and Surface Regions to Indicate Internal and External Surfaces and Volumes



# Track Path Specification

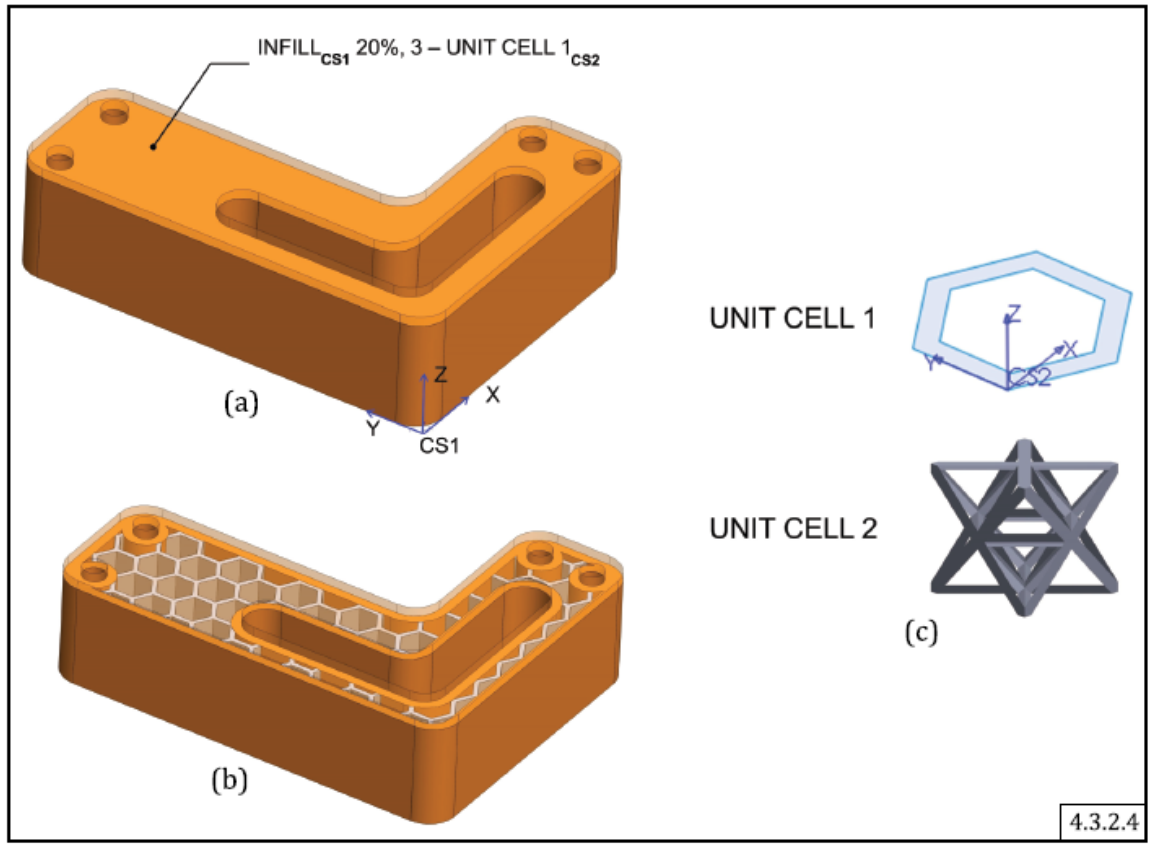
**4.3.2.2 Track Path Specification.** If required, track path shall be identified with "TRACK" and track path unit vector coordinates, followed by a subscript of the related coordinate system, e.g., CS1. See Figure 4-25. If a follow boundary track path is used, a note shall indicate a track path that follows a boundary contour by identifying "FB" (follow boundary); see Figures 4-25 and 4-26. A number following "FB" shall indicate the number of contours; absence of a number indicates that the entire layer is filled by following the contour. A "TRACK TABLE" annotation (or associated document) may also be included to specify layer numbers whose tracks are specified as unit vector notations. The "TRACK TABLE" concept introduced in Figure 4-27 provides flexibility to specify the contours using a table.

**Figure 4-25 Specification of a Track Path With Three Contours**



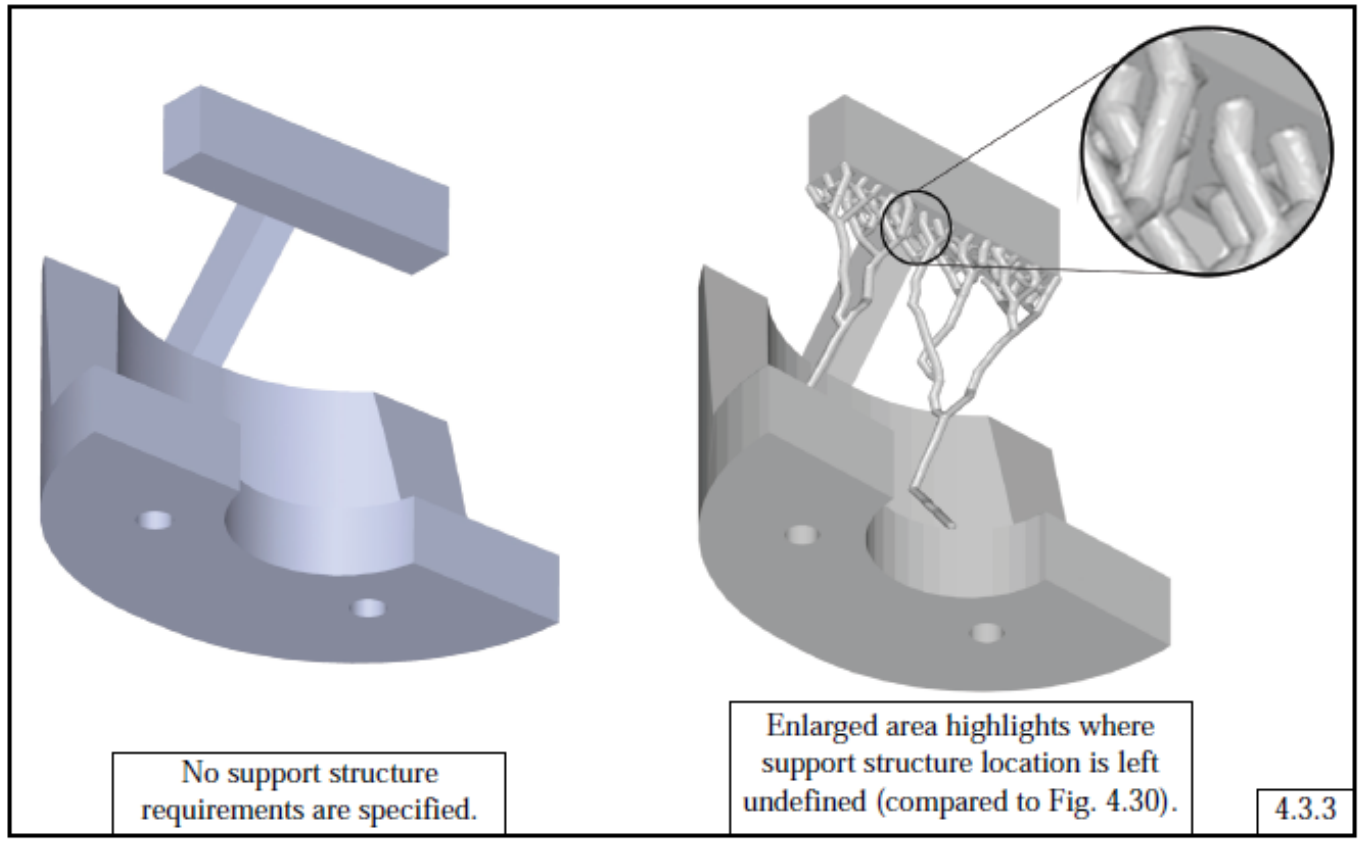
# Infill Unit Cells

**Figure 4-28 Examples of Infill and Unit Cells**



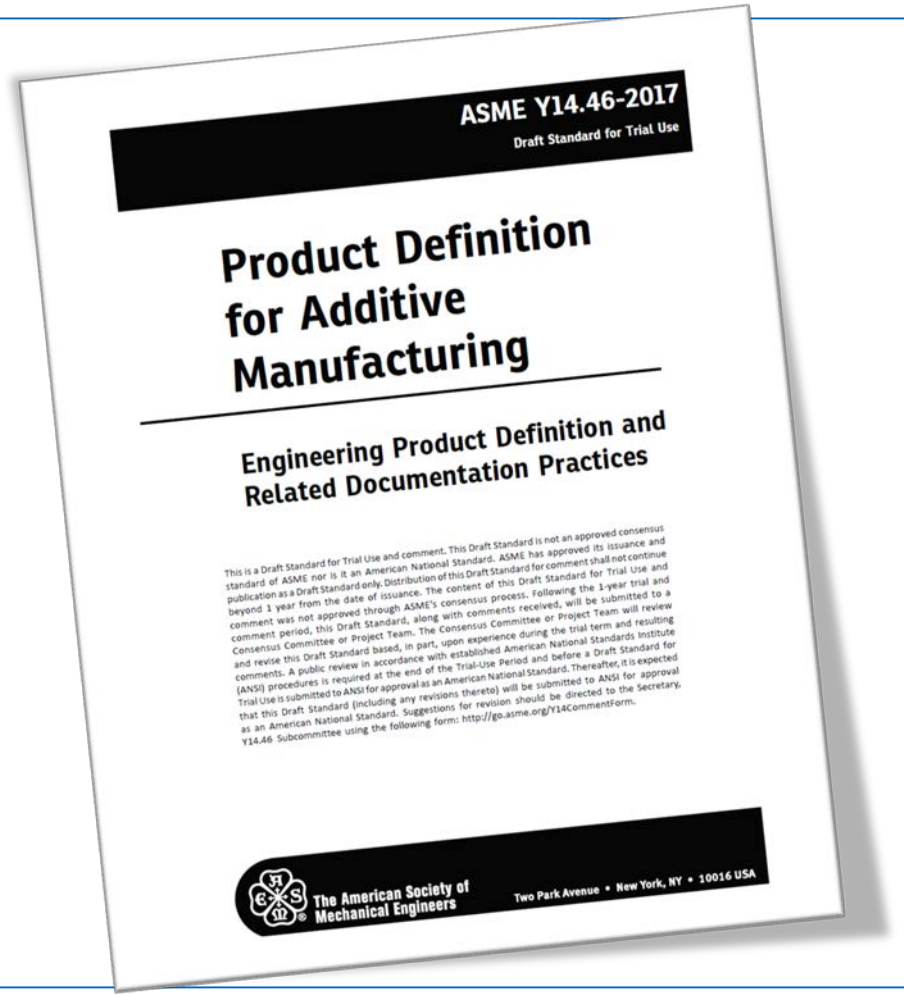
# Support Structures – Unspecified

**Figure 4-29 Example Where Support Structure Location Is Not Specified**



# Current Status

- Currently Draft Standard for Trial Use
- Incorporation of feedback and revisions complete
- Under formatting review at ASME
- Balloting for full standard release is imminent



# Questions?

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