



ASTM INTERNATIONAL
Helping our world work better

The Global Leader in Additive Manufacturing Standards

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Additive Manufacturing Standards Drive Innovation

Additive manufacturing (AM), also known as 3D printing, uses computer-aided design to build objects layer by layer. This contrasts with traditional manufacturing, which cuts, drills, and grinds away unwanted excess from a solid piece of material, often metal.

New equipment, technologies, and materials in AM are driving down the costs of building parts, devices, and products in industries such as aerospace, medicine, automotive, consumer products, and more.

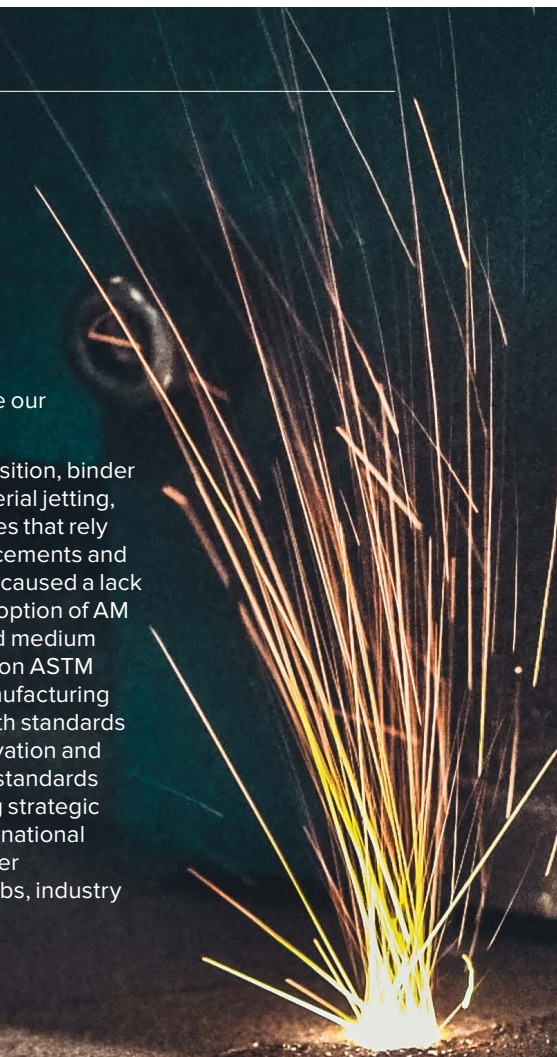
3D printers are proving to be useful in hard-to-reach locations, such as military bases, the International Space Station, and more. AM also helps with medical applications such as patient-specific orthopaedic implants. In addition, consumer products such as athletic shoes or custom lighting are being made through AM.

Several ASTM technical committees write standards related to this growing field with the support of the ASTM International Additive Manufacturing Center of Excellence (AM CoE).

The value of a shortened development cycle and a more efficient process means that products can be created more quickly than ever before, and design changes can be incorporated more easily. Moreover, additive manufacturing also holds the promise of creating new designs that simply can't be made through traditional manufacturing.

In sum, the vast potential for AM to change our lives is coming into full view.

Powder bed fusion, directed energy deposition, binder deposition, vat photopolymerization, material jetting, and material extrusion are AM technologies that rely on new technical standards. Rapid advancements and innovations during the past few years has caused a lack of standards which is hindering the full adoption of AM in the industry, specifically in the small and medium size enterprise level. Hundreds of experts on ASTM International's committee on additive manufacturing technologies (F42) are leading the way with standards that serve as a crucial foundation for innovation and growth. The AM CoE works to accelerate standards development and adoption by conducting strategic R&D. Through these activities, ASTM International has attracted partnerships in AM from other standards groups as well as innovation hubs, industry associations, and more.



Additive Manufacturing Technologies (F42)



Aerospace and Aircraft (F07)



Aircraft Systems (F39)



Fatigue and Fracture (E08)



General Aviation Aircraft (F44)



Medical and Surgical Materials and Devices (F04)



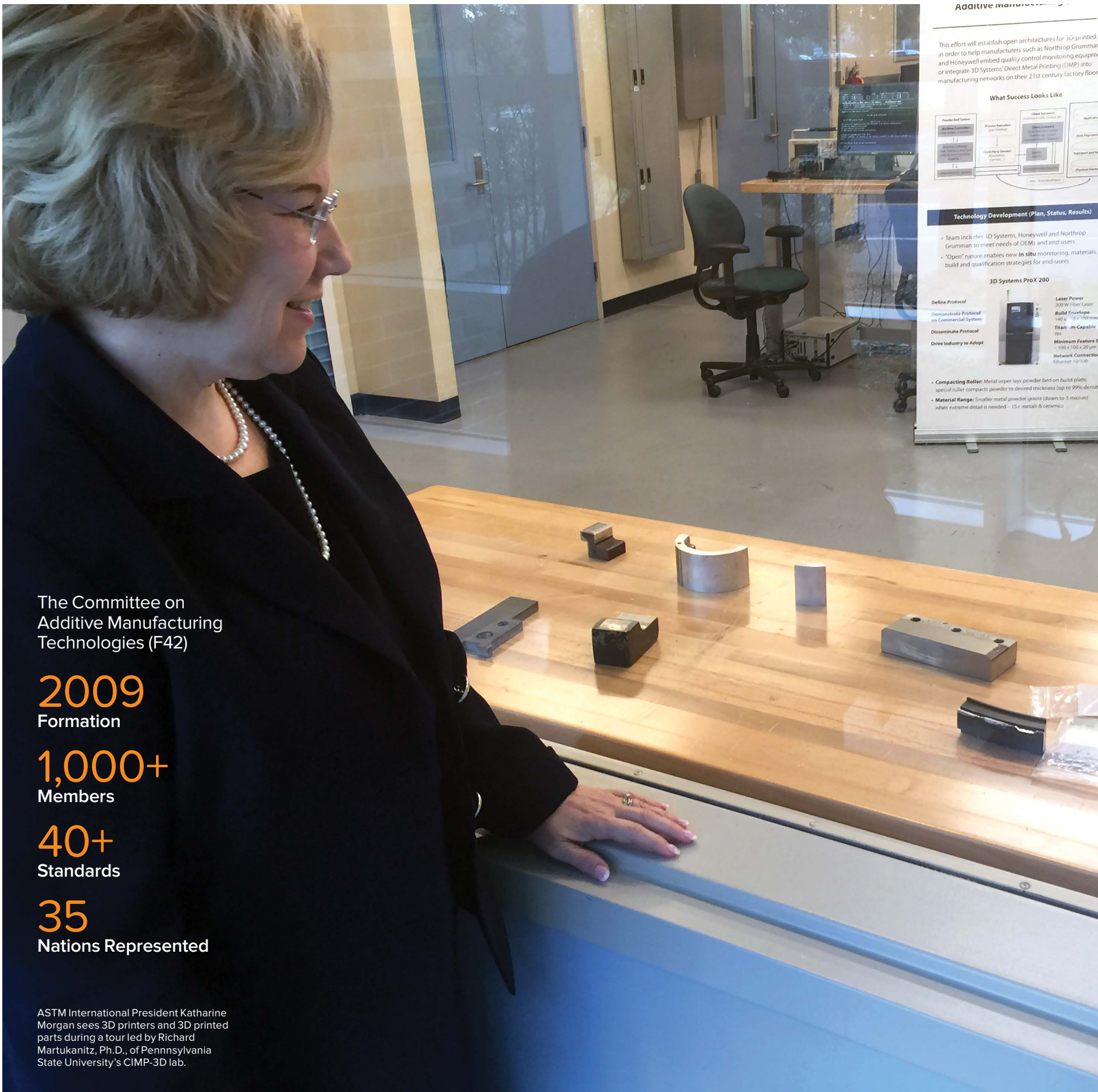
Plastics (D20)



Metal Powders and Metal Powder Products (B09)



Unmanned Aircraft Systems (F38)



The Committee on Additive Manufacturing Technologies (F42)

2009
Formation

1,000+
Members

40+
Standards

35
Nations Represented

ASTM International President Katharine Morgan sees 3D printers and 3D printed parts during a tour led by Richard Martukanitz, Ph.D., of Pennsylvania State University's CIMP-3D lab.

Additive manufacturing

This effort will establish open architectures for 3D-printed in order to help manufacturers such as Northrop Grumman and Honeywell embed quality control monitoring equipment or integrate 3D Systems' Direct Metal Printing (DMP) into manufacturing networks on their 21st century factory floors

What Success Looks Like

- Header: Best System
- Process: Automation
- Cloud System
- Application
- Cloud Party Services
- Equipment and Tools
- Production Data

Technology Development (Plan, Status, Results)

- Team includes: 3D Systems, Honeywell and Northrop Grumman to meet needs of OEMs and end users
- "Open" nature enables new in situ monitoring, materials, build and qualification strategies for end-users

3D Systems ProX 200

Define Protocol	Laser Power
Demonstrate Protocols on Commercial System	300W Fiber Laser
Disseminate Protocol	Build Envelope
Drive Industry to Adopt	140 x 10 x 100mm
	Titanium Capable
	Yes
	Minimum Feature Size
	100 x 100 x 20 µm
	Network Connection
	Ethernet 10/100

- Compacting Roller:** Metal roller lays powder bed on build plate; special roller compacts powder to desired thickness (up to 99% density)
- Material Range:** Smaller metal powder grains (down to 3 microns) when extreme detail is needed - 15+ metals & ceramics

Leading the Way with Innovation through Standards

Startups, established businesses, trade associations, academia, and government are all represented in the committee on additive manufacturing technologies (F42). The group has been meeting since 2009 when the vast potential for AM was coming to light.

The committee's founders recognized the need for robust international standards in this fast-growing field. The committee has developed standards that support the application and adoption of AM for diverse materials and processes. These standards are providing a common language, broadly accepted specifications for AM materials, guidance for using these new technologies, and more.

ASTM International's AM standards (see list of key standards) and proposed standards are becoming more robust, detailed, and application-specific. As a result, businesses around the globe are creating components and products with ever-increasing levels of quality and functionality.

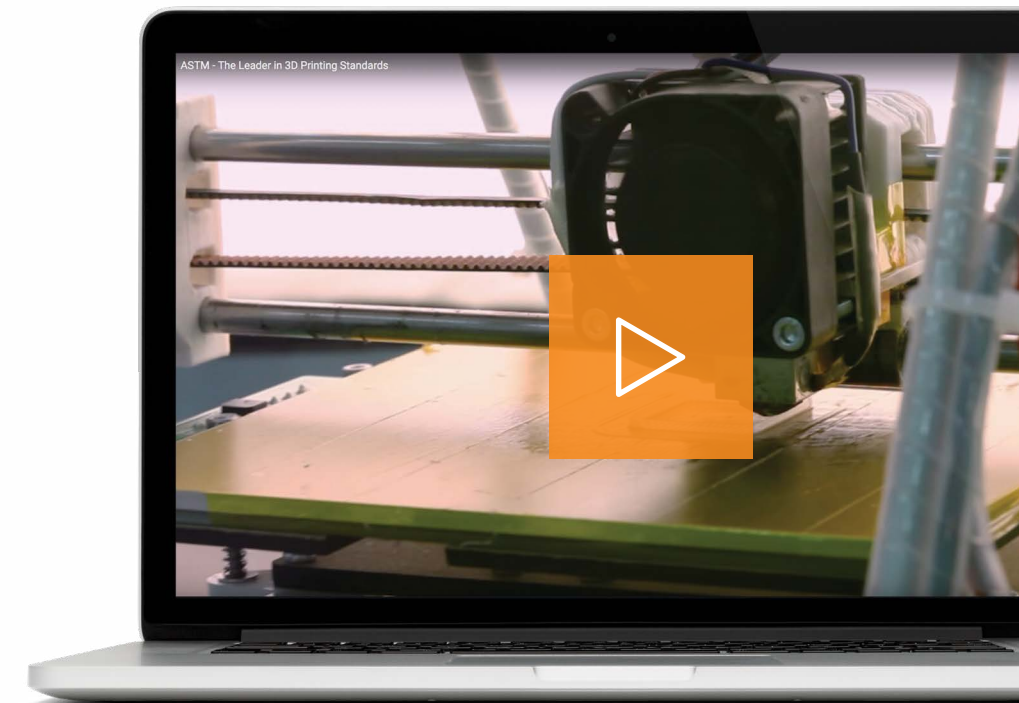
ASTM International provides the space and resources for all standards stakeholders to collaborate through in-person meetings as well as with 24/7 online tools,

collaboration areas, and balloting. The committee also provides an important forum for exchanging ideas, networking, and creating partnerships. This robust and inclusive process is open to anyone from anywhere in the world, giving a voice to every participant.

Key Standards

- Standard Guide for AM – General Principles – Requirements for Purchased AM Parts (ISO/ASTM 52901)
- Practice for Metal Powder Bed Fusion Process to Meet Critical Applications (ISO/ASTM 52904)
- System Performance and Reliability – Acceptance Tests for Laser Metal PBF Machine for Metallic Materials for Aerospace (ISO/ASTM 52941)
- Qualifying Machine Operators of Laser Metal Powder Bed Machines and Equipment used in Aerospace Applications (ISO/ASTM 52942)
- Installation, Operation, and Performance Qualification for Production (ISO/ASTM 52930)

Watch a video about AM standards: www.astm.org/video/F42



Accelerating Research to Standards in AM

Launched in 2018, the ASTM International Additive Manufacturing Center of Excellence (AM CoE) is a collaborative partnership among ASTM—and its 30,000 members—and representatives from government, academia, and industry that conducts strategic R&D to advance standards across all aspects of additive manufacturing which will accelerate the development and adoption of robust, game-changing technologies.

The AM CoE embodies ASTM’s continually growing leadership, keeping pace with rapid technological advancements in additive manufacturing. By tightly coupling the AM R&D and standards development processes, standards get into the hands of those who need them faster, drastically reducing time to market and increasing widespread adoption.

The AM CoE is not a technical committee, but rather a mechanism to accelerate standards development via the mantra of “research to standards”. The AM CoE is a

tool for F42 and other AM-related committees to use, bringing to bear a variety of R&D tools and resources that facilitate, through project calls, the development of content funneled through the ASTM consensus process.



America Makes — a U.S.-based innovation institute under Manufacturing USA and the national accelerator for additive manufacturing and 3D printing — and ASTM International signed a memorandum of understanding in October 2013. The partnership further solidified in 2017 when ASTM joined America Makes as a Silver Member. The work is building more and stronger connections between researchers and the standards community, with the goal of developing standards in tandem with the introduction of new AM technologies and innovations. Key to this is the role of ASTM as it fills gaps identified by the Standardization Roadmap for Additive Manufacturing, developed by the Additive Manufacturing Standards Collaborative, where ASTM has a leadership role.

01

Close standards gaps and meet standards needs

02

Carry out AM R&D to support all industries

03

Support education, training, proficiency testing, and certification

04

Host expert-oriented AM events, workshops, and symposia

Research and Development

Through the AM CoE, research priorities are identified by the top minds in the field and are matched from the start to the standards that need to be generated to ensure the resulting AM technology’s success. Under the leadership of the R&D team, the AM CoE partners plan and conduct coordinated R&D projects, prioritized annually and targeted to expedite the AM standards needed to address the most critical gaps in the AM ecosystem.

01



Accelerated Standards Development

Standards must keep up with the rapid rate of technology development.

02



Global Approach

Strong partnerships are vital to the successful advancement and adoption of new standards. The AM CoE leverages its global network to enable collaborations.

03



Direct Funding of Standards Research

Once standards needs have been prioritized, the AM CoE directly supports the research needed to develop them, rather than waiting.



CENTER of EXCELLENCE
Research to Standards

ADDITIVE MANUFACTURING

Industry Consortium

The AM CoE Industry Consortium co-funds material dataset development and greatly reduces the cost to member organizations. Global Industry Consortia enables companies of all sizes from across the entire additive manufacturing ecosystem to collaborate on generating and managing the data needed to accelerate standardization, qualification, and certification, facilitating full adoption and industrialization of AM technologies.

Workforce Development

The AM CoE provides comprehensive programs that educate and train the additive manufacturing workforce at all levels, while continually incorporating new advances to respond to industry needs and leverage standardization, certification, and AM CoE partner expertise. Programs include specialty workshops, webinar series, and personnel certificate programs.

The AM CoE also hosts the International Conference on Additive Manufacturing (ICAM), ASTM International’s annual flagship event related to standardization, qualification, and certification with an emphasis on industry specific requirements addressing the entire AM process chain. This international conference is designed with multiple symposium tracks to bring in stakeholders from all applicable areas for additive manufacturing.

AMPM PTP

The Additive Manufacturing and Powder Metallurgy Proficiency Testing Program (AMPM PTP) is designed as a statistical quality control tool that enables participating laboratories to assess their performance in conducting ASTM or other committee approved test methods, such as ISO, IP, EN, UOP, AATCC, etc.

Global Partnership

The AM CoE partnership supports activities in locations worldwide, directly involving global experts. While all the partners work collaboratively, each has a primary role, based on demonstrated capabilities and expertise.

ASTM International
Pennsylvania, Washington, D.C.

Auburn University
Alabama

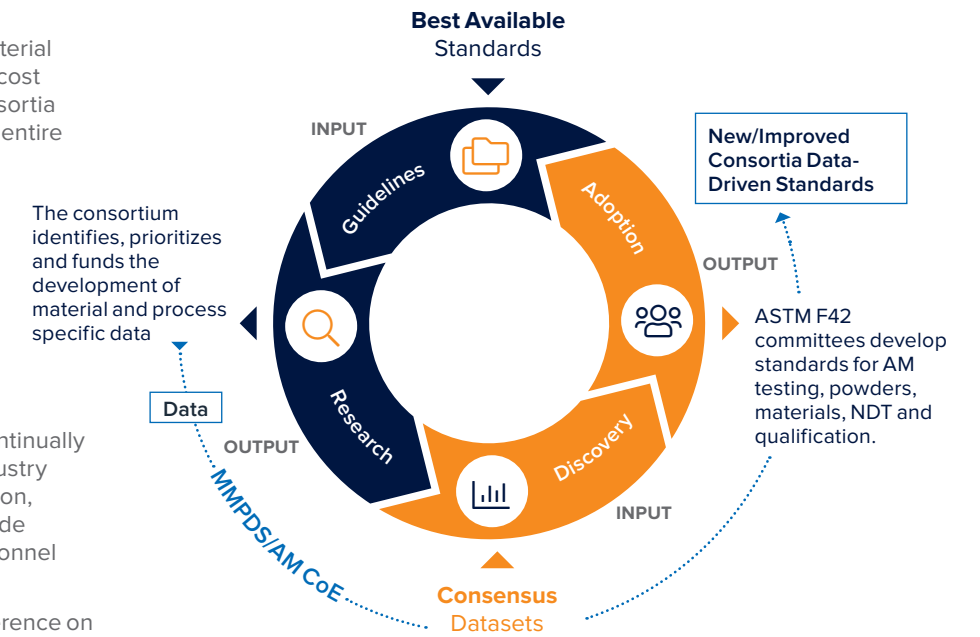
EWI
Colorado, New York, Ohio

MTC
United Kingdom

NAMIC
Singapore

NASA
Alabama

NIAR
Kansas

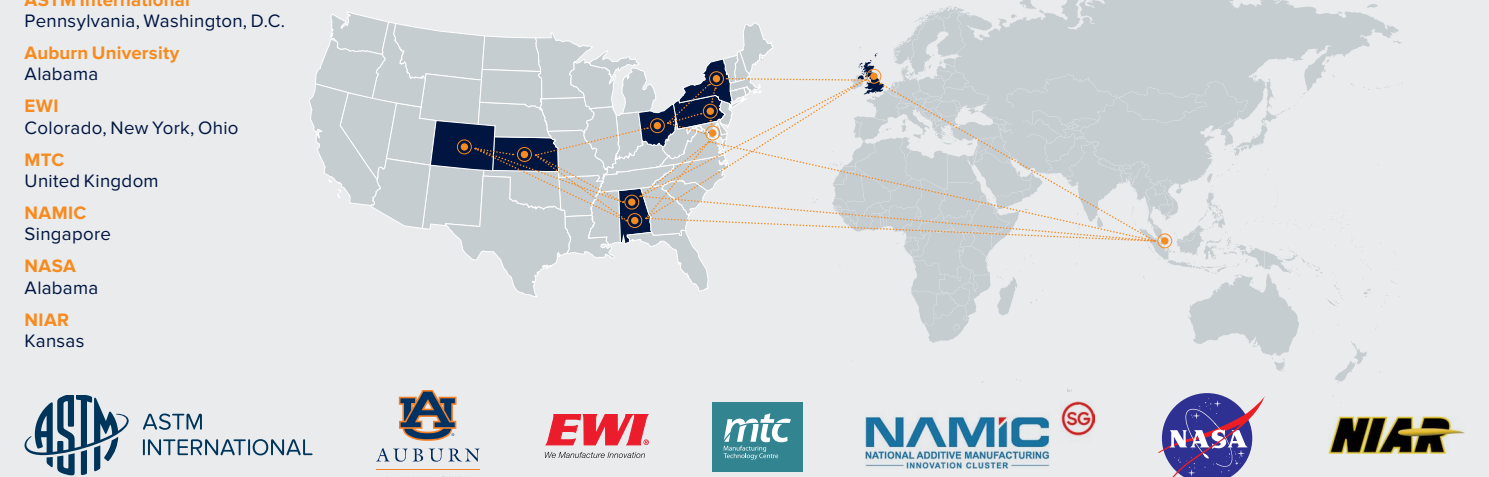


The ASTM Proficiency Testing Program includes various facets and material types such as petroleum products, plastics, metals, textiles, insulating fluids, engine coolants, aromatic hydrocarbons, and more.

We provide uniform, homogenous samples that are analyzed by participating labs using specified methods and results are reported for statistical treatment. Post testing, participants receive program-specific statistical reports summarizing the testing performed by labs across the world.

Learn more at www.astm.org/AMPMPPTP.

Learn more about the ASTM International Additive Manufacturing Center of Excellence: www.amcoe.org.



The ASTM International/ISO Partner Agreement

A Partner Standards Developing Organization (PSDO) agreement between ASTM International and the International Organization for Standardization (ISO), signed in 2011, paved the way to create joint AM standards.

Through the agreement, joint standards can be created where none have existed. Also part of the partnership are:

- Fast-tracking the adoption process of an ASTM International standard as an ISO final draft standard;
- Formal adoption of a published ISO standard by ASTM International; and
- Maintenance of published standards.

The agreement aims to make the best use of experts and resources to drive AM standards development while reducing duplication of effort. (See infographic.) Specifically, the PSDO allows for synergy between ASTM International's committee on additive manufacturing technologies (F42) and the ISO committee on additive manufacturing (TC 261).

The agreement's goal was to respond to this burgeoning industry's need for a set of AM standards that would be recognized worldwide. To do this, they began to develop a common roadmap and organizational structure for AM standards, which was announced in 2016.

These standards have been approved under the agreement:

- Guide for AM – General Principles – Requirements for Purchased AM Parts (ISO/ASTM 52901);
- Guidelines for Design for AM (ISO/ASTM 52910);
- Specification for AM File Format (AMF) Version 1.2 (originally published as F2915-11) (EN ISO/ASTM 52915);
- Terminology for AM – General Principles – Terminology (EN ISO/ASTM 52900); and
- Terminology for Additive Manufacturing – Coordinate Systems and Test Methodologies (originally published as F2921-11) (EN ISO/ASTM 52921).



“This structure will help experts worldwide interact in a more streamlined and meaningful way, leading to the integration and application of new technologies at an accelerated rate. In the future, we could see even more benefits, such as uniform workforce training and a stronger ability to focus on constant quality improvement rather than potential confusion surrounding specifications.”

Carl Dekker
president of MET-L-FLO Inc. and former chair of ASTM International's committee on additive manufacturing technologies (F42)

ASTM INTERNATIONAL Building the Bridge from Innovation to Market



Additional standards are underway under the ISO/ASTM umbrella, including documents that will specify metal powders, characterize flow properties, and guide property measurements, among others.

The ISO/ASTM standards are also being published as European Standards (EN). These EN ISO/ASTM standards include the AM file format and terminology documents plus several more standards in process. The work is happening through the European Committee for Standardization (CEN) to help ensure consistent, harmonized international standards. CEN also plans for ongoing close cooperation between its Technical Committee on Additive Manufacturing (TC 438) with the ISO and ASTM work on AM standards. As part of CEN's approach, CEN will propose new ideas for European standards to the ISO/ASTM group according to a recently approved Additive Manufacturing Standards Development Structure.

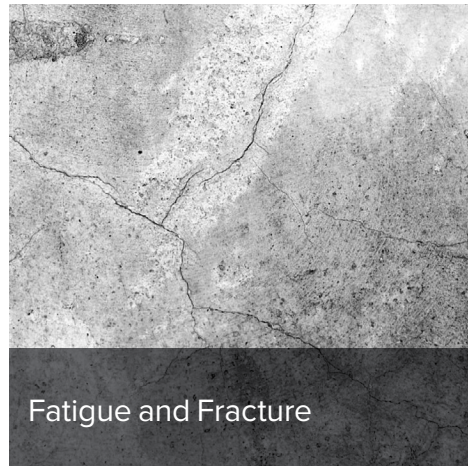
ISO and ASTM International published the jointly crafted Additive Manufacturing Standards Development Structure, a framework to help meet the needs for new technical standards in this fast-growing field. The structure was approved by the organizations' additive groups in July 2016.

The structure will help:

- Guide the work of global experts and standards development organizations involved in AM standardization;
- Identify standards-related gaps and needs in the AM industry;
- Prevent overlap and duplicative efforts in AM standards development;
- Ensure cohesion among AM standards;
- Prioritize AM standards areas; and
- Improve usability and acceptance among the AM community, including manufacturers, entrepreneurs, consumers, and others.

Collaboration across Committees

Beyond the committee on additive manufacturing technologies (F42) include:



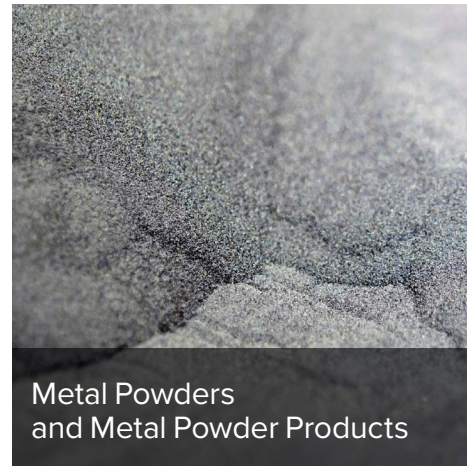
Fatigue and Fracture

The committee on fatigue and fracture (E08) leads fatigue-related work on AM to further validate use and adoption. Programs are being held to share research in areas such as strength, strain life, crack growth, and other parameters. The group of more than 450 members from 25 countries oversees about 40 standards.



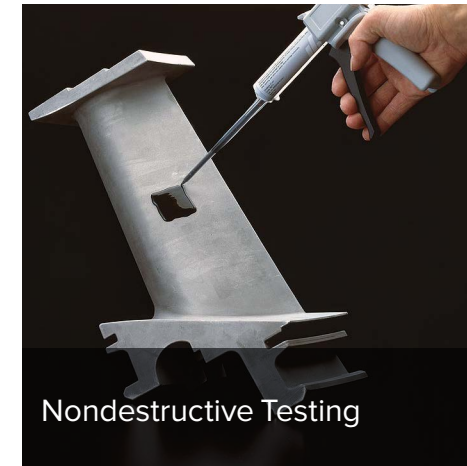
Medical and Surgical Materials and Devices

AM opens up design possibilities for many medical applications such as cutting guides, bone augments, artificial joints, hearing aids, and dental crowns. ASTM International's committee on medical and surgical materials and devices (F04) has approved a standard to assess cleanliness of medical devices made by AM techniques and another standard to guide the design of AM devices for cleanability. More than 1,000 F04 members from 30 countries oversee more than 300 standards.



Metal Powders and Metal Powder Products

The committee on metal powders and metal powder products (B09), works on powder metallurgy standards that apply to materials frequently used for AM. The standards cover methods and practices related to a variety of base metal powders as well as specifications and tests for various powder metallurgy parts used in mechanical applications. The group has about 60 standards, with 100 members from about 10 countries participating.



Nondestructive Testing

AM is increasingly used for turbine blades, engine parts, pumps, and other products in the aviation and aerospace industry. Experts from the committee on nondestructive testing (E07) are looking at developing standards and test methods that could help understand how AM relates to part defects, damage tolerance, and more. With 600 members from about 35 countries, the committee oversees about 225 standards.



Plastics

An important material used for AM, plastics are the focus of another committee (D20). This group works on standards related to raw materials, components, and compounding ingredients as well as finished products made from plastics. The committee is exploring ways to apply existing ASTM International test methods for plastics to AM. They are also determining how their members' expertise might best help meet the growing need for polymer-related AM standards. A dedicated subcommittee section facilitates information exchange and updates related to this critical topic. The group of 1,000 members from 45 countries oversees about 500 standards.

Additional Committees

Additively manufactured products have particular interest for aerospace, aviation, and military purposes, industries in which ASTM International has always led the way. Committees that are exploring potential AM standards – often in collaboration with F42 and others – include:

- Aerospace and aircraft (F07),
 - Aircraft systems (F39),
 - Commercial spaceflight (F47),
 - General aviation aircraft (F44), and
 - Unmanned aircraft systems (F38).
- Additional ASTM International technical committees develop standards for materials, parts, and components used worldwide to make products.

ASTM International: Solutions and Services

A robust, enterprise-level family of services that strengthen organizations – in addition to standards – are available from ASTM International. Specific available offerings that may be customized for additive manufacturing are highlighted here.

Proficiency Testing Programs

Statistical quality assurance programs available through ASTM International help laboratories assess their performance in conducting test methods in their own laboratories by comparing data against that of other participants. Nearly 5,000 labs, more than half of which are non-U.S., use these programs. Programs in

plastics, metals, and petroleum products are among the options. Programs are accredited in accordance with the recognized International Standard ISO/IEC 17043: 2010, Conformity Assessment - General Requirements for Proficiency Testing, by the American Association for Laboratory Accreditation.

Training and eLearning

ASTM International's practical, hands-on training programs – accredited by the International Accreditors for Continuing Education and Training – bring together industry-respected standards and instructors who helped develop those standards. These include self-paced eLearning courses, webinars, and in-person courses in industries such as construction, coal, petroleum, and plastics. One e-seminar, for example, covers Statistics in ASTM Standard Test Method Development, Application, and Quality Assurance.



The Safety Equipment Institute

As AM moves into more and more product areas, certification will play a growing role. The Safety Equipment Institute (SEI) tests and certifies a broad range of safety and protective products used in work and recreational settings. An ASTM International affiliate, SEI leads in certifying products such as sports and athletic equipment, safety and protective products used by first responders, and eye and face protection for industrial workers.

Interlaboratory Study Program

ASTM International's Interlaboratory Study Program (ILS) helps committees create precision statements for test methods. The ILS program also helps with interlaboratory study design, volunteer labs, samples and suppliers, collecting and analyzing data, and compiling research report information.

Journal: Smart and Sustainable Manufacturing Systems

Smart and Sustainable Manufacturing Systems – launched in 2017 by ASTM International – is an online publication that fosters research that crosses the boundaries of information science, systems engineering and engineering design, manufacturing, and product life cycle. Papers are encouraged from those studying and advancing AM. Learn more at www.astm.org/SSMS.

Smart Manufacturing Advisory Committee

Dozens of technical leaders from about 15 ASTM International committees meet quarterly via video conference as part of the Smart Manufacturing Advisory Committee (SMAC). They discuss technologies, innovations, and related standards work, and they hear from guest speakers on cutting-edge advances in new fields. This includes AM as well as nanotechnology, pharmaceutical and biopharmaceutical manufacturing, exo technology, and more.

www.astm.org/smartmanufacturing



ASTM INTERNATIONAL

Helping our world work better

Committed to serving global societal needs, ASTM International positively impacts public health and safety, consumer confidence, and overall quality of life. We integrate consensus standards, developed with our international membership of volunteer technical experts, and innovative services to improve lives — Helping our world work better.

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