Additive Manufacturing Safety Solutions

UL Solutions

Safety. Science. Transformation.™

Additive manufacturing services from UL Solutions span the full AM ecosystem

Additive manufacturing (AM) has expanded steadily into multiple disciplines and modes of production in recent years, notably with the 3D printing of industrial, medical and construction materials and components. The technology is rapidly evolving, and new equipment and materials are constantly under development, undergoing testing and entering the market.

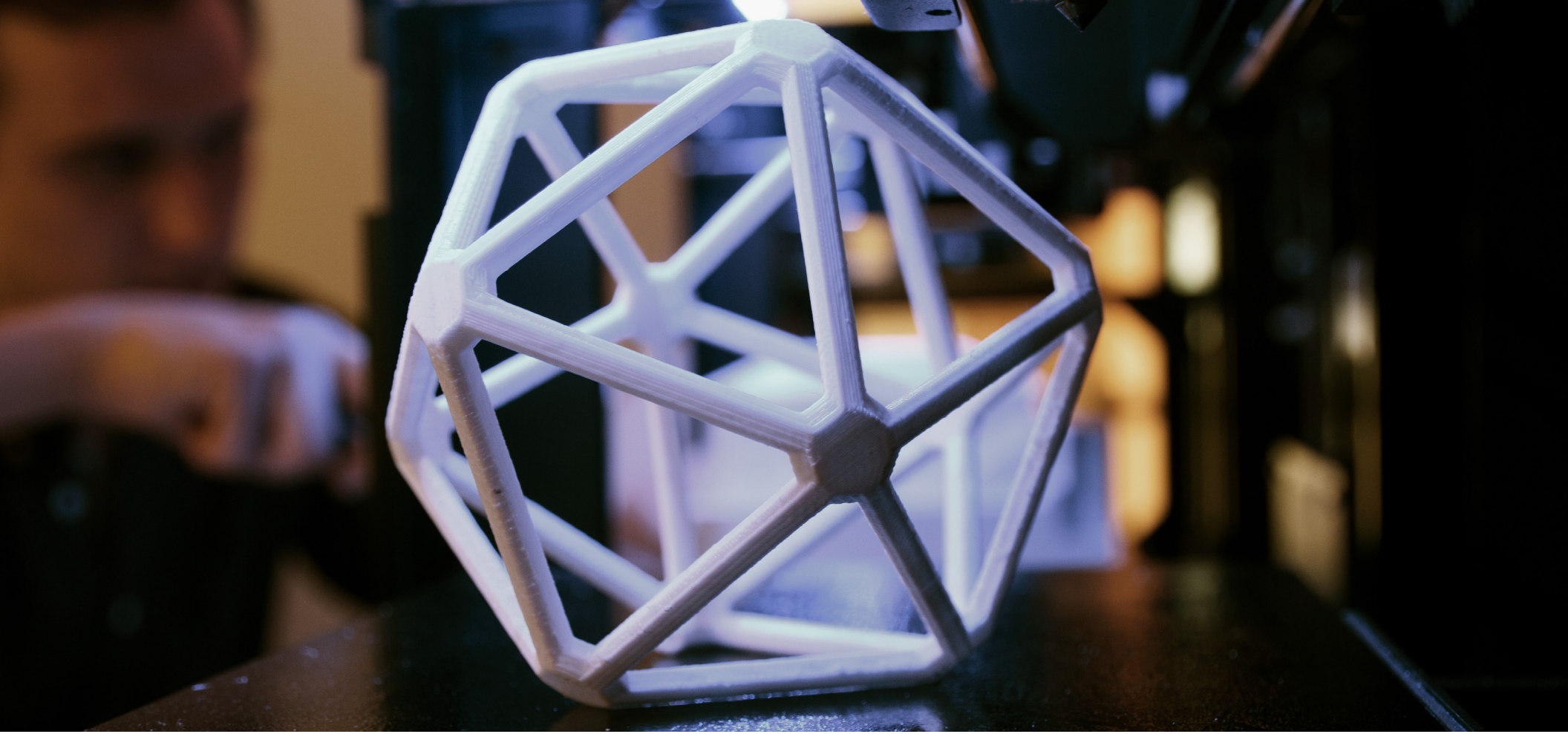
Growth and innovation in AM generate a range of opportunities for manufacturers and suppliers, but the pace of development also creates challenges and impediments to market access. Businesses in AM-related industries and supply chains are concerned about:

- Speed to market and understanding requirements to access global markets
- Compliance with regulatory, sustainability and procurement requirements
- Training personnel in safety requirements
- Risk management, system simplification and cybersecurity
- Working toward net zero
- Providing safer and healthier buildings and workplaces
- Global supply chain transparency and data acquisition (Scope 3)
- Minimizing production and supply chain disruptions
- Developing products and systems for a connected and autonomous world
- ESG initiatives and goals

UL Solutions is a global leader in applied safety science, with extensive knowledge of and expertise in AM and the particular set of issues that make this technology increasingly complex but potentially rewarding. We are a single source for all your certification, performance testing and sustainability needs.

Our integrated solutions for AM include:

- AM material recognition
- Industrial 3D-printing equipment safety
- Consumer, office and medical 3D-printing equipment safety
- Environmental compliance
- AM facility safety
- Supply chain insights
- Construction applications
- Medical applications and biocompatibility



AM material recognition

Manufacturers need to confirm the suitability of 3D-printed materials and parts used in safety-critical applications. They also have to identify how materials, printers and processes affect performance, quality and reliability. They require support to identify and deploy printers and settings to secure safety and save time and money in production processes.

UL Solutions can help manufacturers demonstrate the safety of 3D-printed material by evaluating, testing and certifying to provide safety performance data of 3D-printed material with technical datasheets, research test data and quality control.

UL Solutions Services

- Material and part testing to standards (ISO, ASTM, IEC, UL, OEM-specific)
- UL Verified performance claims
- Blue Card recognition and certification for 3D-printed materials
- Flammability certification of materials in accordance with UL 94, the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
- Performance properties of plastics evaluation in accordance with UL 746A-D, Standards for Polymeric Materials
- Verification and inspection services to help demonstrate safety performance

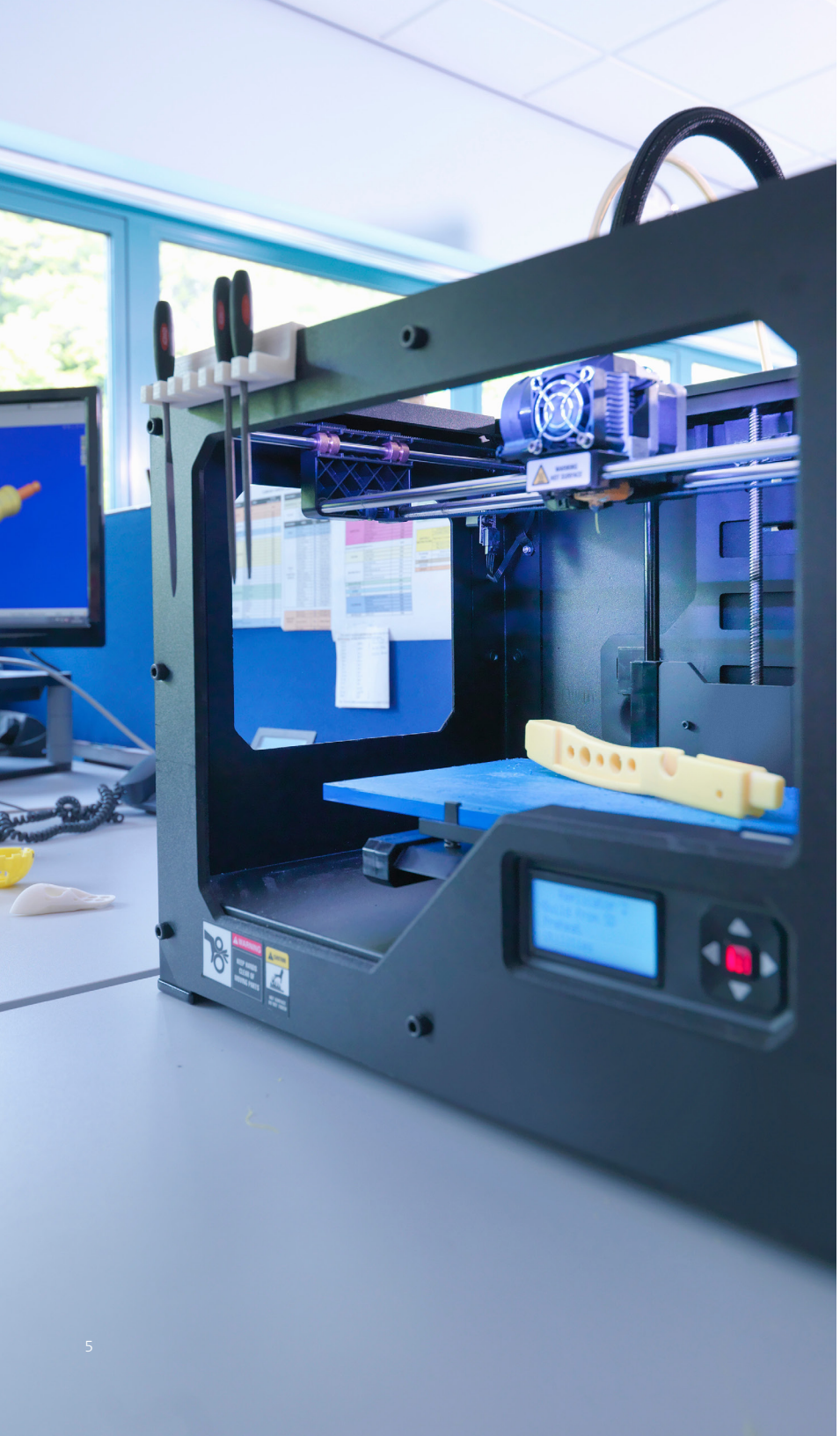
Industrial 3D printers - equipment safety

Manufacturers need to ensure safety compliance for industrial 3D printers, support equipment and operators for code authority acceptance for local facilities and expanded market access for selling in multiple countries and regions.

UL Solutions can help manufacturers demonstrate the safety of industrial 3D-printing machines and operators with engineering support, testing and certification services from a trusted and respected global safety compliance leader.

UL Solutions Services

- Certification to UL 2011, the Outline of Investigation for Machinery
- Certification to IEC 60204-1; UL 508A, the Standard for Industrial Control Panels; EU Machinery Directive
- Field inspection for certification
- Preliminary evaluation of design in accordance with compliance requirements



Consumer, office and medical 3D printers - equipment safety

Manufacturers must ensure safety compliance for consumer, office and medical 3D printers while meeting workplace electrical safety standards under OSHA's Nationally Recognized Testing Laboratory (NRTL) program. They must also meet applicable U.S. Food and Drug Administration (FDA) requirements for medical and patient care use.

UL Solutions can help manufacturers demonstrate the safety of 3D-printing machines and operators with engineering support, testing and certification services from a trusted and respected global safety compliance leader.

UL Solutions Services

- Certification to UL/IEC 60950-1, the Standard for Information Technology Equipment – Safety – Part 1: General Requirements, and UL/IEC 62368-1, the Standard for Audio/Video, Information and Communication Technology Equipment – Part 1: Safety Requirements, for home and office use
- Certification to UL/IEC 60601-1, the Standard for Medical Electric Equipment, Part 1: General Requirements for Safety, for clinical and medical applications
- Certification to UL/IEC 61010-1, the Standard for Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use – Part 1: General Requirements
- Center for Devices and Radiological Health (CDRH) test report to meet FDA requirements in the U.S. for laser safety
- Certification to IEC 60825 for laser safety

Environmental compliance - chemical and particle emissions

Manufacturers need to demonstrate low chemical and particle emissions for consumer and office 3D printers to confirm that users can operate them in existing buildings without requiring additional ventilation.

UL Standards & Engagement developed ANSI/UL 2904, the Standard Method for Testing and Assessing Particle and Chemical Emissions from 3D Printers, to provide an industry-harmonized test method as well as VOC and particle emission limits for 3D printers. Printers and materials that meet the UL 2904 emission limits can earn UL GREENGUARD Certification to help purchasers find low-emission products.

UL Solutions Services

- Testing to ANSI/UL 2904
- UL GREENGUARD Certification for 3D printers and materials

AM facility safety

Metal 3D printing can create complex safety considerations due to risks associated with facilities, materials and equipment. Understanding these risks plays a key role in developing safety management systems to protect life, property and the environment. Code authorities may be unfamiliar with the particular risks associated with AM.

UL Solutions has developed an AM facility safety management program that offers evaluation to help protect operational safety and help customers identify and mitigate risks and hazards.

We offer workforce support for safety training and standard operating procedure protocol development to help improve the safety of industrial 3D-printing machines and operators.

UL Solutions Services

- AM facility safety certification – UL 3400, the Outline of Investigation for Additive Manufacturing Facility Safety Management
- AM facility safety preliminary assessment and gap analysis

Supply chain insights

The global supply chain is complex and constantly evolving, requiring manufacturers and suppliers to consider the entire life cycle of a product from design to market entry to disposal. It is also imperative to protect confidential business information during the transfer of data throughout the product's life cycle.

UL Solutions can help manufacturers fulfill requirements for proper and compliant shipping, storage, handling, use and disposal of products. We provide tools for creating and implementing chemical management policies with the aid of regulatory experts, data provision and management, and software.

Furthermore, our tools can help you source materials, products and components that meet quality, safety and performance requirements and provide early insight regarding compliance during the research and development phase.

UL Solutions Services

- Regulatory advisory services
- Chemical data management software (including SDS creation, management, distribution and chemical regulatory compliance assessments)
- Technical product datasheet creation, management and distribution software
- Material data collection management (UL Supply Chain Network)
- Material and certification searchable databases (UL Prospector® and UL Product iQ®)

3D-printed building construction safety

Builders and manufacturers need to ensure the suitability of 3D-printed construction components and their compliance with model building codes and test standards to gain acceptance from code authorities as an alternate material for local facilities. They also must deliver consistent additive manufacturing materials (AMM) across multiple regions and provide a record of adherence of printed components to their tested designs.

UL Solutions can help builders and manufacturers demonstrate the safe operation of construction 3D-printing equipment, compare and provide testing and certification of the construction component (walls, roof, ceiling, columns) and provide a report of findings that code authorities recognize and trust.

UL Solutions Services

- Certification to UL 3401, the Outline for 3D Printed Building Construction
- Certification to UL 2011, the Outline of Investigation for Machinery
- Field inspection for construction sites to assist local officials

AM medical applications and biocompatability

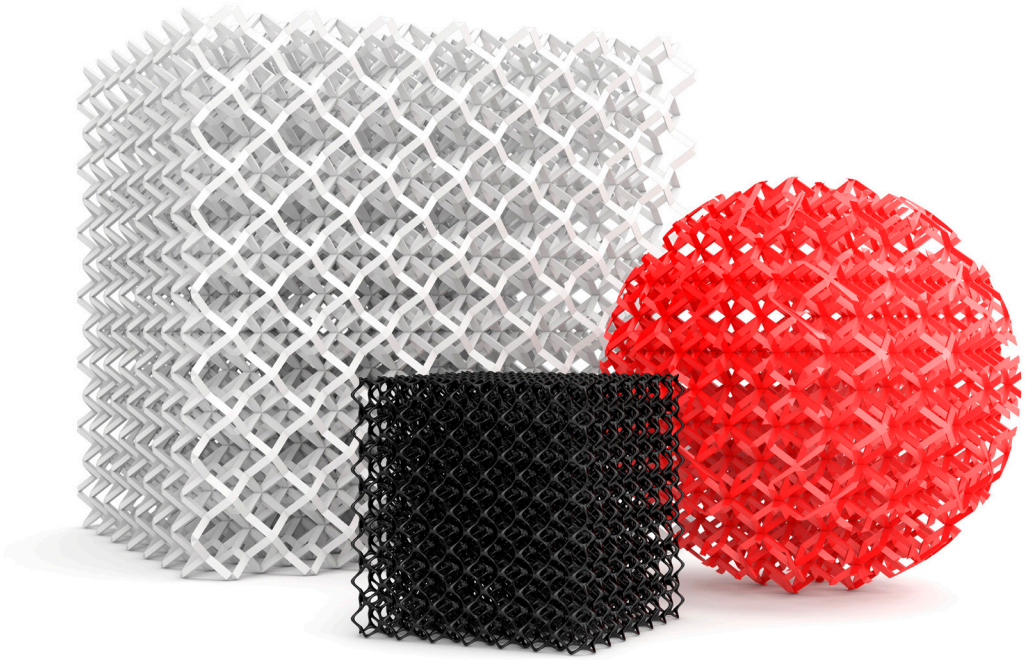
Regulations in many countries, including the U.S., Japan, South Korea and members of the EU, require medical devices in direct or indirect contact with the human body to be biocompatible. The finished device generally undergoes testing, including processes like packaging and sterilization, per the ISO 10993 series of standards. Testing raw materials or components warrants special consideration, especially considering the requirements established in ISO 10993-18:2020.

UL Solutions offers a nonclinical service that evaluates the biocompatibility of end products and components in our laboratory in Germany. We also have a worldwide network of partners. Our team members actively participate in standard-writing committees such as NA 027-07-12 AA (ISO 10993-1, ISO 10993-18) and NA 053-03-01 AA (ISO 18562-4).

The latest version of ISO 10993-18 provides specific guidance on chemical characterization conducted on the material of construction used to form a component and at the component level. This chemical characterization, applied at the component level, can serve as a powerful tool to support your customers during their biocompatibility evaluation processes.

UL Solutions Services

- Toxicity and biocompatibility testing services
- Chemical characterization per ISO 10993-18, e.g., GC/MS, Headspace GC/MS, HPLC/MS TOF, ICP MS/OES — ideal for determining actual chemical release in the evaluation step and cytotoxicity per ISO 10993-5 as a screening test
- Other in vitro/in vivo tests for all biological endpoints through our partners



Why UL Solutions?

A trusted global safety science leader, UL Solutions is a leading developer of standards and testing frameworks with a history of integrity and procedural rigor. Together, we can help you:

- Access global markets and increase speed to market while protecting brand reputation
- Simplify the complexities of component and product ecosystems
- Drive confidence in innovation
- Anticipate and solve your most complex challenges
- Optimize quality, safety, security, sustainability and health across the entire supply chain

UL Solutions for AM

As an independent, globally trusted third party, UL Solutions has extensive knowledge of additive manufacturing and the specific challenges in this fast-developing market sector.

- Product, system and facility expertise
- Comprehensive risk and compliance management solutions
- Participation in code and standards organizations
- Trusted by code authorities, consumers and manufacturers

For more information on UL Solutions AM services, visit ul.com/additivemanufacturing.

UL.com/Solutions

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