

First edition
2023-06

Additive manufacturing of metals — Non-destructive testing and evaluation — Defect detection in parts

*Fabrication additive de métaux — Essais et évaluation non destructifs
— Détection de défauts dans les pièces*



Reference number
ISO/ASTM TR 52905:2023(E)

© ISO/ASTM International 2023



COPYRIGHT PROTECTED DOCUMENT

© ISO/ASTM International 2023

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester. In the United States, such requests should be sent to ASTM International.

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11

Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

ASTM International
100 Barr Harbor Drive, PO Box C700
West Conshohocken, PA 19428-2959, USA
Phone: +610 832 9634
Fax: +610 832 9635
Email: khooper@astm.org
Website: www.astm.org

This is a preview of "ISO/ASTM TR 52905:20...". Click here to purchase the full version from the ANSI store.

Contents

	Page
Foreword	v
Introduction	vi
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 NDT potential for authentication and/or identification	2
5 List of abbreviated terms	3
6 Typical flaws/defects in AM	4
6.1 Flaw origins/causes.....	4
6.2 Flaw/defects classification.....	4
6.3 Defect classification strategies for AM.....	12
7 NDT standards review	13
7.1 Post-process NDT standards.....	13
7.1.1 ISO review.....	13
7.2 In-process NDT review.....	15
8 Standard selection structure for AM	18
9 NDT techniques potential for AM only defects	19
10 AM artefacts	28
10.1 Design.....	28
10.1.1 Star artefact.....	28
10.1.2 À la carte artefact.....	34
10.2 Manufacturing.....	36
10.2.1 Star artefact.....	36
10.2.2 À la carte artefact.....	37
11 NDT method trials and validation using star artefact	38
11.1 Experimental trials.....	38
11.1.1 X-ray Computed Tomography – XCT (MTC & GE & EWI).....	39
11.1.2 Neutron Imaging — NI and Synchrotron radiation — SX (HZB & ESRF).....	43
11.1.3 Thermography Testing — TT (University of Bath).....	50
11.1.4 Resonant Ultrasound Spectroscopy methods — RUS.....	59
11.1.5 Ultrasonic testing — UT and Phase Array UT — PAUT (EWI and NIST and LNE).....	75
11.1.6 Residual stress — RS (ILL).....	80
12 Defect built validation star artefact (Cut-off MTC)	85
12.1 Summary of procedure by XCT.....	85
12.1.1 Apparatus.....	86
12.1.2 Significance of data/interpretation of results.....	87
12.2 Summary of procedure by metallography.....	90
12.2.1 Apparatus.....	91
12.2.2 Significance of data/Interpretation of results.....	91
12.3 Comments/observations.....	93
13 NDT trials for à la carte artefact	94
13.1 Summary of procedure.....	94
13.2 Apparatus.....	94
13.3 Significance of data/interpretation of results.....	94
13.4 Comments/observations.....	97
14 Summary of the trials findings by material	97
15 Main conclusions	101

This is a preview of "ISO/ASTM TR 52905:20...". [Click here to purchase the full version from the ANSI store.](#)

Annex A (informative) Causes and effects of defects in wire DED and PBF process	104
Annex B (informative) Review of existing NDT standards for welding or casting for application of post build AM flaws	106
Annex C (informative) Star artefacts using during the trials	111
Annex D (informative) Summary of star artefact manufacturing and NDT technologies for trials	115
Annex E (informative) XCT parameters and XCT set up used for inspection and validation	118
Annex F (informative) Parameters and set up for Neutron Image (NI) and Synchrotron (Sx) inspection	135
Annex G (informative) Set up for PT and SHT inspection	141
Annex H (informative) Ultrasonic test	144
Annex I (informative) Residual stress characterisation of Ti6Al4V by Neutron diffraction	155
Bibliography	157

This is a preview of "ISO/ASTM TR 52905:20...". Click here to purchase the full version from the ANSI store.

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

The committee responsible for this document is ISO/TC 261, *Additive manufacturing*, in cooperation with ASTM Committee F42, *Additive manufacturing technologies*, on the basis of a partnership agreement between ISO and ASTM International with the aim to create a common set of ISO/ASTM standards on additive manufacturing, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 438, *Additive manufacturing*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

In response to the urgent need for standards for Additive Manufacturing (AM), this document initially indicates Non-Destructive Testing (NDT) methods with potential to detect defects and determine residual strain distribution that are generated in AM processes. A number of these methods were verified. The strategy adopted was to review existing NDT standards for matured manufacturing processes which are similar to AM, namely casting and welding. This potentially reduces the number of standards required to comprehensively cover the defects in AM. For identified AM unique defects, this document proposes a two-level NDT approach: a star artefact as an Initial Quality Indicator (IQI) and *à la carte* artefact where an example shows the specific steps to follow for the very specific unique AM part to be built, paving the way for a structured and comprehensive framework.

Most metal inspection methods in NDT use ultrasound or X-rays, but these techniques cannot always cope with the complicated shapes typically produced by AM. In most circumstances X-ray computed tomography (CT) is a more suitable method, but it also has limitations and room for improvement or adaptation to AM, on top of being a costly method both in time and money.

This document includes post-process non-destructive testing of additive manufacturing (AM) of metallic parts with a comprehensive approach. It covers several sectors and a similar framework can be applied to other materials (e.g. ceramics, polymers, etc.). In-process NDT and metrology standards are referenced as they are being developed. This document presents current standards capability to detect which of the Additive Manufacturing (AM) flaw types and which flaws require new standards, using a standard selection tool. NDT methods with the highest potential will be tested.