Technical Report

ISO/TR 23247-101

First edition
2026-05

Automation systems and integration — Digital twin framework for manufacturing —

Part 101: Use case on management of robotic multilayer and multipass gas-shielded metal arc welding process

Systèmes d'automatisation industrielle et intégration — Cadre technique de jumeau numérique dans un contexte de fabrication —

Partie 101: Cas d'utilisation concernant la gestion d'un procédé robotisé de soudage à l'arc sous protection gazeuse multicouche et multipasse

Reference number
ISO/TR 23247-101:2026(en)

© ISO 2026



COPYRIGHT PROTECTED DOCUMENT

© ISO 2026

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.

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

Contents

Page

Foreword ..... **iv**
Introduction ..... **v**
1 Scope **1**
2 Normative references **1**
3 Terms and definitions **1**
4 Overview **2**
5 Operational sequences **5**
5.1 Process flow 5
5.2 Phase 1: Select and provisioning 6
5.3 Phase 2: Welding preprocessing 6
5.4 Phase 3: Welding operation 7
5.5 Phase 4: Inspection and operations after welding 7
5.6 Phase 5: Document 8
6 Mapping to the framework **8**
6.1 Overview 8
6.2 Implementation using the framework 9
6.3 Mapping of the process digital twin to the digital twin entity 11
6.4 Mapping of the welding equipment digital twin to the digital twin entity 13
6.5 Mapping of the workpiece digital twin to the digital twin entity 15
7 Conclusion **17**
Bibliography **18**

© ISO 2026 – All rights reserved

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 document 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).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights.

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.

This document was prepared by Technical Committee ISO/TC 184, *Automation systems and integration*, Subcommittee SC 4, *Industrial data*.

A list of all parts in the ISO 23247 series can be found on the ISO website.

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.

© ISO 2026 – All rights reserved

Introduction

Multilayer and multipass gas-shielded metal arc welding is a critical process for thick plate welding, which is widely used in the welding of large metal structures in engineering machinery, ships, aerospace and other fields.

Although robotic technology has enhanced automation, reduced manual intervention, and improved quality in multilayer and multipass gas-shielded metal arc welding, the process remains challenging for highly customized, large-scale workpieces such as tunnel boring machine cutterheads. Key issues include reliance on manual parameter optimization and insufficient real-time process control, leading to poor adaptability, inconsistent weld quality, and unplanned downtime.

A digital twin of robotic multilayer and multipass gas-shielded metal arc welding can effectively address these challenges. By simulating and optimizing the entire process in a virtual environment, it reduces reliance on manual experience and enables real-time monitoring, early warning, and dynamic adjustment of welding parameters. This significantly enhances welding quality control and process stability.

The application of a digital twin for monitoring and controlling the robotic multilayer and multipass gas-shielded metal arc welding offers the following advantages:

— Monitoring and early warning: A digital twin facilitates continuous real-time monitoring of the welding process, displaying key parameters - such as current, voltage, travel speed, and molten pool state - and triggers immediate alerts upon anomaly detection to prompt corrective operator actions.

— Process parameter optimization: A digital twin can analyse the influence of groove forms (e.g. V-groove, J-groove) and their geometry parameters on stress, heat input, and deformation to optimize selection and design. Additionally, it monitors weld quality and joint characteristics layer-by-layer, enabling predictive optimization of subsequent welding parameters.

— Process plan optimization: A digital twin can evaluate the deformation and residual stress under various welding sequences to identify the optimal welding sequence scheme. Using sensor-derived deformation data, it also simulates straightening strategies to determine the most effective pressure, temperature, and positioning parameters.

— Predictive maintenance of equipment: A digital twin enables predictive maintenance of welding equipment by continuously monitoring and analysing its operational status. This allows for early detection of potential faults, facilitating proactive interventions that minimize unplanned downtime.

— Training and simulation: A digital twin supports operator and engineer training through a virtual environment that simulates diverse welding scenarios without physical equipment, improving skills, enabling solution testing, and enhancing risk response capabilities.

A digital twin enhances precision in monitoring and optimizing the robotic multilayer and multipass gas-shielded metal arc welding process, reducing defects and facilitating intelligent management of the full workflow. By leveraging this technology, manufacturers achieve deeper process insight, improved parameter optimization, strengthened quality control, and enhanced overall productivity and efficiency.

This document is structured into an overview, operational sequences, framework mapping and a conclusion. Following the ISO 23247 series, the use case analysis yields a systematic implementation view and a high-level digital twin design, ready for direct implementation with standard-compliant tools and languages.

© ISO 2026 – All rights reserved

Automation systems and integration — Digital twin framework for manufacturing —

Part 101:
Use case on management of robotic multilayer and multipass gas-shielded metal arc welding process

1 Scope

This document describes a digital twin system for monitoring and managing the robotic multilayer and multipass gas-shielded metal arc welding process.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 23247-1, *Automation systems and integration — Digital twin framework for manufacturing — Part 1: Overview and general principles*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 23247-1 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
welding
joining process in which two or more parts are united producing a continuity in the nature of the workpiece material(s) by means of heat or pressure or both, and with or without the use of filler material

3.2
gas-shielded metal arc welding
metal arc welding using a wire electrode in which the arc and the weld pool are shielded from the atmosphere by a shroud of gas supplied from an external source

3.3
multipass welding
welding process in which the entire weld is completed using more than two weld passes

Note 1 to entry: The weld beads of multipass welding are usually deposited continuously within the same layer. Special attention can be paid to adjusting welding parameters such as welding current and welding voltage to ensure the compactness and mechanical properties of the weld joint.

© ISO 2026 – All rights reserved