ASME B89.4.23-2025
(Revision of ASME B89.4.23-2020)

X-Ray Computed Tomography (CT) Performance Evaluation

AN AMERICAN NATIONAL STANDARD

The American Society of Mechanical Engineers

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FOREWORD

The application of X-ray computed tomography (CT) for dimensional metrology has become common in many industries. This is primarily due to the ability of CT systems to measure inside a workpiece without requiring tactile or optical access. However, there are currently no standards that address the performance evaluation of CT systems in a way that includes material influence, which is a dominant source of error when these systems are used to evaluate typical workpieces. For this reason, The American Society of Mechanical Engineers (ASME) decided to form the B89.4.23 Working Group to produce a standard for CT performance evaluation. This Standard is the result of significant effort by the working group to develop a performance evaluation that includes all known sources of error in CT systems.

This Standard provides definitions and a test procedure for the performance evaluation of X-ray CT systems used for dimensional measurements. Manufacturers and users of CT systems may use the results of the test procedure to fulfill contractual requirements or to compare the performance of systems from different suppliers or over time.

The test procedure described in this Standard is intended to report errors that are representative of typical use cases of CT systems. Users of this Standard seeking to determine measurement error or uncertainty for a particular workpiece or system configuration should perform a specific study for that case.

This Standard is available for public review on a continuing basis. This provides an opportunity for additional public review input from industry, academia, regulatory agencies, and the public-at-large.

The first edition of ASME B89.4.23 was approved by the American National Standards Institute (ANSI) on September 3, 2020.

In response to industry feedback, ASME B89.4.23-2025 contains a new Nonmandatory Appendix D, which describes an abbreviated test protocol that may be performed as an interim test. This revision was approved by ANSI on September 23, 2025.

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(2) to provide alternative requirements

(3) to allow users to gain experience with alternative or potential additional requirements prior to incorporation directly into the Standard

(4) to permit the use of a new material or process

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(3) the Standard and the paragraph, figure, or table number

(4) the editions of the Standard to which the proposed case applies

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ASME B89.4.23-2025
SUMMARY OF CHANGES

Following approval by the ASME B89 Standards Committee and ASME, and after public review, ASME B89.4.23-2025 was approved by the American National Standards Institute on September 23, 2025.

ASME B89.4.23-2025 includes the following changes identified by a margin note, **(25)**.

Page	*Location*	*Change*
3	3	Updated
4	4	Definition of *base material* revised
8	7.1.1	Last paragraph revised
9	7.1.2	First paragraph revised
29	Nonmandatory Appendix D	Added

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X-RAY COMPUTED TOMOGRAPHY (CT) PERFORMANCE EVALUATION

1 SCOPE

This Standard specifies the dimensional measurement accuracy of industrial X-ray computed tomography (CT) systems for length, size, and form measurands of sphere-based test objects made of homogeneous materials. Medical CT systems are outside the scope of this Standard. The material properties of the measured test objects are restricted to three classes of material selected to be representative of industrial materials: plastic polymers, aluminum alloys, and steel alloys; other materials are outside the scope of this Standard. However, this Standard may be used as a guide for testing the performance of a CT system for other materials. The evaluation of workpieces composed of multiple materials or of materials with density gradients, i.e., gradual density variations within the material, is outside the scope of this Standard.

This Standard is applicable to dimensional measurements made at the surface of the workpiece, i.e., at the workpiece material–air interface, including those of internal cavities. The effect of complex workpiece-material influence is simulated by test objects composed of spheres (serving as the metrological geometric elements) and an obstructing body; the obstructing body's dimensions are uncalibrated and its shape may be arbitrary. The spheres and obstructing body shall be of the same class of material and their combined length shall not exceed the maximum penetration length for this class of material, as stated by the CT system manufacturer.

This Standard applies to a variety of CT systems that may vary by scanning mode and system components involved in the acquisition of images. In cases where a system provides multiple configurations of X-ray sources, detectors, and scanning modes, the dimensional measurement accuracy may be specified for each scanning mode.

This Standard does not mandate testing (by either the CT manufacturer or the user) to verify CT performance. The amount of testing, and which party will bear the cost of testing, is a business decision and must be negotiated between the two parties. Calibrated test objects can be expensive; hence, the parties should recognize the costs involved and plan the testing accordingly.

Due to contrast sensitivity issues that can arise when X-rays must penetrate through large amounts of material, this Standard does not provide maximum permissible error specifications that apply to detecting high spatial-frequency form errors.

2 INTRODUCTION

ASME B89 performance evaluation standards for dimensional coordinate measuring systems specify the dimensional measuring accuracy for common measurements of industrial workpieces. Ideally the uncertainty associated with each point coordinate within the system's measurement work zone would be reported, but because the accuracy of an individual point coordinate in space is impossible to experimentally verify, ASME B89 standards typically use a point-to-point length measurand that is both realizable and practical for system testing. The advantage of evaluating test objects with point-to-point length measurands is twofold: first, test objects are simple to manufacture and calibrate, and second, different point-to-point length measurands can be used to evaluate different effects. Long-range effects are evaluated by the point-to-point length error between the center of two spheres on a test object, which can span the entire work zone. Short-range effects are evaluated by the errors in the point-to-point distance from the center of the test spheres to various points on their surface, i.e., sphere form measurands. Image thresholding issues that are associated with the determination of a surface are evaluated by the error of the size of the test spheres.

A primary goal of ASME B89.4 standards is to define maximum permissible error (MPE) specifications and their associated rated operating conditions, which are useful when the user is measuring similar measurands on a typical workpiece. For example, although a CT system might be tested with a calibrated steel test object, the user should be confident that the combined MPE specifications for center-to-center length, form, and size error would limit the error if a point-to-point length measurement were composed of a point on the exterior of a steel workpiece and a point on an interior surface of a fully enclosed cavity of the workpiece.