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# Testing coordinate measuring arms with a geometric feature-based gauge: *in situ* field trials

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**Abstract**

This work describes in detail the definition of a procedure for calibrating and evaluating coordinate measuring arms (AACMMs or CMAs). CMAs are portable coordinate measuring machines that have been widely accepted in industry despite their sensitivity to the skill and experience of the operator in charge of the inspection task. The procedure proposed here is based on the use of a dimensional gauge that incorporates multiple geometric features, specifically designed for evaluating the measuring technique when CMAs are used, at company facilities (workshops or laboratories) and by the usual operators who handle these devices in their daily work. After establishing the procedure and manufacturing the feature-based gauge, the research project was complemented with diverse *in situ* field tests performed with the collaboration of companies that use these devices in their inspection tasks. Some of the results are presented here, not only comparing different operators but also comparing different companies. The knowledge extracted from these experiments has allowed the procedure to be validated, the defects of the methodologies currently used for *in situ* inspections to be detected, and substantial improvements for increasing the reliability of these portable instruments to be proposed.

Keywords: coordinate measuring arms, geometric feature-based gauge, CMA, AACMM, calibration, *in situ* trials

(Some figures may appear in colour only in the online journal)

## 1. Introduction

In the last decade, coordinate measuring arms (CMAs) have experienced an unprecedented boom. Undoubtedly, the fact that CMAs have inherited certain properties of coordinate measuring machines (CMM) has allowed this increase in their use. Among the advantages of CMAs can be cited the possibility of 3D coordinate measurements, the use of automated reports, learning-based programming, the incorporation of the CAD geometry, etc. Moreover, features of CMAs such as accessibility and portability can explain their rapid implementation and expansion at the enterprise level in many sectors involving metal processing, boilers, facilities, and assemblies, etc, where these instruments compete with other *in situ* measurement techniques such as photogrammetry or structured white light systems.

However, the rapid expansion of the use of CMAs has not been accompanied by a solid international standardization (ISO) that dissipates doubts about the reliability of the measurements performed with these instruments. As will be discussed later, there are currently ASME and VDI standards (ASME B89.4.22-2004 [1], VDI/VDE 2617-9 [2]) for evaluating CMAs, but these standards do not consider any control of the operator through *in situ* tests that follow an evaluation similar to the usual measurement operation. CMA manufacturers evaluate their different CMA models in their facilities, in laboratories where ambient conditions are under strict control, thus under very different conditions to those under which

 