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Measurement Process Qualification

Gage Acceptance and Measurement Uncertainty According to Current Standards

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Hanser Publishers, Munich Hanser Publications, Cincinnati

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Distributed in the USA and in Canada by
Hanser Publications
6915 Valley Avenue, Cincinnati, Ohio 45244-3029, USA
Fax: (513) 527-8801
Phone: (513) 527-8896 or 1-800-950-8977
www.hanserpublications.com

Distributed in all other countries by
Carl Hanser Verlag
Postfach 86 04 20, 81631 München, Germany
Fax: +49 (89) 98 48 09
www.hanser.de

Library of Congress Cataloging-in-Publication Data

Dietrich, Edgar, 1951-
[Eignungsnachweis von Pruffprozessen. English]
Measurement process qualification : gage acceptance and measurement uncertainty according to current standards / Edgar Dietrich, Alfred Schulze.
p. cm.
Includes bibliographical references and index.
ISBN-13: 978-1-56990-505-0 (hardcover)
ISBN-10: 1-56990-505-3 (hardcover)
ISBN-13: 978-3-446-42407-4 (hardcover)
1. Measurement. 2. Tolerance (Engineering) 3. Gages. I. Schulze, Alfred, 1952- II. Title.
T50.D53613 2011
620‘.0044--dc22
2011010487

Bibliografische Information Der Deutschen Bibliothek
Die Deutsche Bibliothek verzeichnet diese Publikation in der Deutschen Nationalbibliografie; detaillierte bibliografische Daten sind im Internet über <http://dnb.d-nb.de> abrufbar.

German ISBN: 978-3-446-42407-4
US-ISBN: 978-1-56990-505-0
E-Book-ISBN: 978-3-446-42955-0

www.hanser.de
Lecturer: Dipl.-Ing.Volker Herzberg
Production Management: Der Buch*macher*, Arthur Lenner, München
Typesetting: Heide Mesad
Coverconcept: Marc Müller-Bremer, www.rebranding.de, München, Germany
Coverillustration: Atelier Frank Wohlgemuth, Bremen
Coverrealisation: Stephan Rönigk
Printed and bound by Druckhaus »Thomas Müntzer« GmbH, Bad Langensalza, Germany
Printed in Germany

Preface

Measurement process capability studies gained in importance during the last years. At the end of the 1980s, there were only few company guidelines referring to the significance of gages and only some of them required capability studies. Over the years, new and further guidelines were added. The procedure was more and more refined and its application improved. After the methodology had established itself, more and more requirements were added from quasi-standards, such as the QS-9000 or VDA 6.1 guidelines. From now on, measurement process capability studies have to be conducted regularly in order to obtain the respective QM system certificate.

Today, the field of capability studies also includes the determination of measurement uncertainties that is to be applied in production. As an example, ISO 14253 [29] requires the determination of the measurement uncertainty for measures of length. This uncertainty must be taken into account at the specification limits. Hence, more and more companies are obliged to include the calculation of the measurement uncertainty in their QM system and to administer it in the respective application. In order to facilitate these procedures as much as possible, the German Association of the Automotive Industry (VDA) has already published the “Measurement Process Capability” guideline (VDA 5 [70]). As the title indicates, this guide does not only deal with measuring devices. It is also about all the influencing factors affecting the measuring device.

The second and third edition of our book “Statistical Procedures for Machine and Process Qualification” [13] contains a chapter about “gage capability”. Due to the variety of procedures for measurement process capability studies, we decided to leave out this topic in the fourth edition and to publish this book instead. In order to better define this subject in detail.

Special thanks go to Mr. Ofen (Robert Bosch GmbH, Bamberg) for the long-term cooperation and his professional support. Major parts of the book “Sonderfälle bei der Beurteilung von Messverfahren” (special cases in the evaluation of measurement procedures) [67] are penned by him. Upon his approval, we adopted some passages in this book.

Our thanks also go to Ms. Mesad for the layout and the textual and graphical presentation of this book.

In case of questions, please contact us directly. Q-DAS® GmbH, Eisleber Str. 2, 69469 Weinheim, Germany, phone: +49 6201 3941 0, fax: +49 6201 3941 24, hotline: +49 6201 3941 14, e-mail: q-das@q-das.de.

Weinheim, April 2003

Edgar Dietrich and Alfred Schulze

Preface to the 2nd Edition

The subject this book received a great many response. We received a significant amount of feedback on the first edition including many suggestions and proposals. In particular, our thanks goes to those readers who advised us of some inconsistencies. We acted on these suggestions and the new edition considers that helpful input.

By now, VDA 5 “Measurement Process Capability” has been published. It caused many discussions among experts but also raised many questions. Hence, we expanded on this particular subject and added some sample calculations.

In many conversations and seminars, people have always expressed the wish to have a different procedure for the determination of the “extended measurement uncertainty”. This procedure is to be structured in a similar way as the widely-used “R&R” procedure for the determination of gage capability. So we developed AIO procedure (all-in-one method) for the determination of extended measurement uncertainty. This procedure is based on current draft standards and facilitates the determination of individual standard uncertainties in a step by step proceedure. The final result is the calculated extended measurement uncertainty.

Graduate engineer Michael Radeck supported us in providing new sample calculations. He also edited the “attribute gage” subject. We would like to thank him for his assistance.

Weinheim, Mai 2004

Edgar Dietrich and Alfred Schulze

Preface to the 3rd Edition

The second edition already contained the determination of the measurement uncertainty according to the “Guide to the Uncertainty in Measurement” (GUM [32]) but its application was uncommon in industrial production. However, things have changed lately.

Particularly due to the new ISO 10012:2004 [29] “Measurement Management Systems - Requirements for Measurement Processes and Measuring Equipment” standard, this subject has gained in importance. As the standard’s subheading indicates, the measurement uncertainty must be determined for the respective measurement process. The standard says: “The measurement uncertainty must be estimated for every measurement process that is monitored by the measurement system. The Guide to the Expression of Uncertainty in Measurement (GUM) [32] contains the methods to be applied.”

Due to this fact, we decided to deal with measurement uncertainty in more detail in this book.

Since the publication of the second edition in May 2004, further company guidelines about “measurement process capability studies” have been launched. We added the DaimlerChrysler LF05 guideline and the Robert Bosch GmbH booklet 10 in this edition. Both guidelines implemented the procedures and methods for measurement process capability studies that this book describes in theory. Today, companies and suppliers have gained experience in using these methods by applying these guidelines. The practical benefit of the determination of measurement uncertainty is confirmed.

Graduate engineer Stephan Conrad supported us in writing the “Determination of Measurement Uncertainty” chapter. We would like to thank him for his assistance.

In case of questions, please contact us directly. Q-DAS® GmbH, Eisleber Str. 2, 69469 Weinheim, Germany, phone: +49 6201 3941 0, fax: +49 6201 3941 24, hotline: +49 6201 3941 14, e-mail: q-das@q-das.de.

Weinheim, September 2006

Edgar Dietrich and Alfred Schulze

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1 Measurement Process Capability

1.1 Introduction

1.1.1 Why Measurement Process Capability?

One sentence can answer this question. “It is the necessity to have appropriate measurement processes available for the correct evaluation of manufacturing and production processes.” The measurement values determined in the measurement process are the basis of the evaluation and have to reflect the actual situation quite realistically. A non-capable measurement process does not give a true picture of reality and does not allow reliable conclusions to be drawn.

Hence, the following question has to be answered: “What does a capable measurement process mean?” Today, several standards and guidelines (see Figure 1-1), answer this question. These standards and guidelines require capability studies and describe procedures how to conduct them.

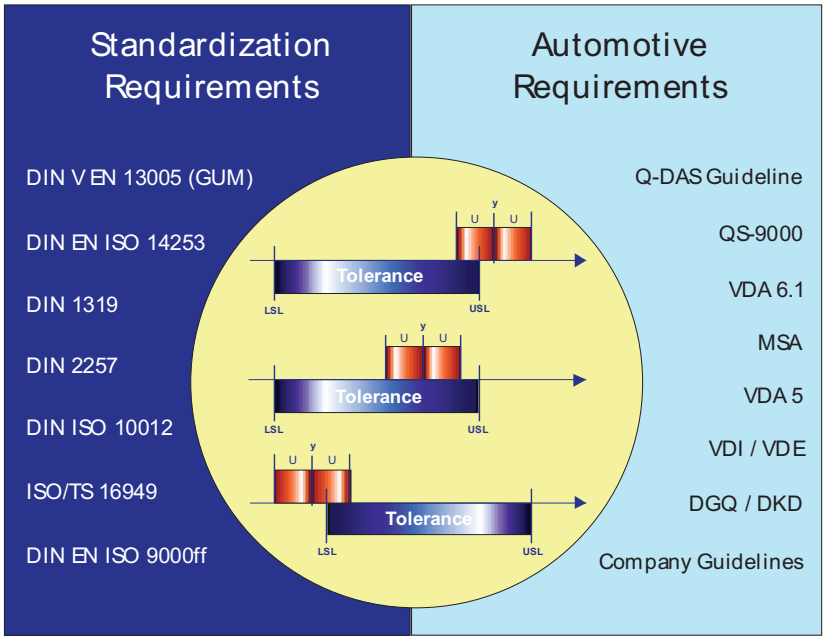

Figure 1-1: Important requirements of automotive and standardization guidelines in connection with measurement process capability

Figure 1-1 displays important requirements of automotive and standardization guidelines.

For the evaluation of measurement systems, ISO/TS 16949:2002 [37] requires:

“Each kind of measurement system demands statistical studies in order to analyze the variation of the measurement results. This requirement applies to all measurement systems that are referred to in the production control plan. The applied methods and acceptance criteria have to correspond to the criteria mentioned in the customer’s reference guide for the evaluation of measurement systems. Other analytical methods and acceptance criteria may only be applied on the customer’s authority.”

The statement that other methods are possible on the customer’s authority is not relevant to many suppliers because they cannot make individual agreements with all their customers. In order to certify the QM system, they can only consult general standards (e.g. MSA [1] or VDA [70]) and use them as the basis for process capability.

Chapter 1.2 “Historical Retrospect and Prospect“ illustrates the context and the development of the indivdual documents. Machine and production facilities acceptance, evaluation of processes and products or continuous process monitoring are based on the evaluation of qualitative and quantitative product characteristics. The analysis focuses on quantitative or variable characteristics. However, another chapter deals with capability studies for qualitative or attribute characteristics.

In case of qualitative characteristics, measurement systems provide measurement values of the characteristics of the produced parts or process parameters. This requires task-related measurement systems, specific sensors and customary standard measuring devices.

In order to draw the right conclusions from the measurement values, the values must be recorded with sufficient measurement accuracy“ relating to the characteristic’s tolerance or the process. In the past, the suitability of a measuring device was tested by means of minimum values given in standards or the manufacturer’s specifications were monitored. Today, clear specifications are available. The ISO 10012:2004 [29] requires the determination of the measurement uncertainty according to EN 13005 [32]. However, testing the gage under ideal conditions is only one single component when determining the measurement uncertainty of the measurement process, e.g. in the metrology lab, tested by trained staff, using idealized parts such as a standard master or calibration master, and in standardized facilities. The VDI / VDE / DGQ guideline 2618 [74] provides examples of the procedure and test methods in the form of test instructions. Continuous monitoring (gage monitoring) and new devices for the inspection of manufacturer’s specifications require this proceeding in order to detect changes or errors at the device.

The determined “capability“ does not reveal anything or hardly anything about the behavior of the device under real conditions (see Figure 1-2).