TESTING MACHINE TOOLS

For the use of Machine Tool Makers,
Users, Inspectors and Plant Engineers

By

DR. GEO. SCHLESINGER

With 53 Inspection Charts

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Foreword to the Fourth Edition

THE first English edition of this book was published in 1932 in response to the request of many engineers, designers, inspectors and users of machine tools in Great Britain and America. It was intended to provide a guide for the machine tool builder in making and assembling his machines, and, from the user's point of view, to afford a basis for the standard of accuracy governing the acceptance of a machine. The wide popularity which the book has already achieved, affords ample evidence that it has fulfilled its purpose. The tolerances specified therein are now accepted as a basis in assessing the quality of machine tools in Russia, Italy, Switzerland, Germany, Czechoslovakia, Poland, Hungary, Belgium, Holland, and Scandinavia, as well as in many shops in Great Britain, Canada and France. It is significant, moreover, that, since 1927, more than 500,000 machine tools have been bought, inspected and rebuilt according to these specifications, and during this period the author has received no general criticism but only constructive suggestions regarding the modification of a few individual tolerances which have been found in practice to be too coarse or too fine. This was confirmed by the I.S.A. Conferences in Paris and Stockholm of 1937-38, and the suggestions were taken into consideration in preparing the fourth edition. The lathe section of the National Machine Tool Builders Association, Cleveland, Ohio, U.S.A. accepted in their publication of 1940, almost entirely the way and the limits of this book.

Advantage has also been taken of the opportunity afforded to amplify the introductory chapters in certain respects. Thus, on the one hand, every effort has been made to render the specifications so explicit that there is no possibility of misunderstandings arising due to differences of interpretation by the buyer and the seller. Since the subject is necessarily somewhat complicated it is essential that the earlier chapters should be carefully studied in order that the significance of the various tests may be fully appreciated. On the other hand, bearing in mind that the book is also intended for the use of fitters, inspectors, and foremen, who actually carry out the tests, care has been taken to make the diagrams as clear and self-explanatory as possible so that the methods of testing can be readily understood. Additional information has also been included regarding the measuring instruments to be used and the way in which they should be applied, both for new and rebuilt machines. Finally the latest results of surface analyses are included.

The book is subdivided so that any desired section can be readily found, and the system of tolerances given in the charts has been maintained uniform throughout the whole series. As in the first edition, metric figures are used in the charts, but numerous conversion tables enable the inch equivalents of tolerances and reference lengths to be readily obtained.

GEORG SCHLESINGER.

Loughborough, 1945.

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INTRODUCTION

THE instructions for the inspection and testing of machine tools as herewith presented serve as a basis in the trial tests of high-grade machines. They are the result of a long experience, and they were adopted and fixed by consent of the leading Continental machine tool builders as well as users. These instructions for testing are valid only for new machines, but they are also used to-day in many shops in reconditioning and rebuilding worn machine-tools and for maintenance.

Closer Tolerances than those Specified

Machine tools embodying the accuracies specified meet the high requirements of modern production with respect to the standardised fits. Should, however, for any reason, closer tolerances be needed, this will be only possible by expensive additional operations and tedious selective assembly. This applies, for example, to lead screws for lathes and dividing heads for milling machines and grinding machines. Higher accuracies which are required actually only in exceptional cases result in additional costs.

Wider Tolerances than those Specified

Where only medium or even coarse fits are required, the use of high-grade machine tools as prescribed in this treatise will not always be necessary. In such cases, wider tolerances or limits exceeding the values given, *e.g.*, by 50 to 100 per cent will be sufficient, depending on the work to be performed. The increase in tolerance, however, will not apply to all measurements of a test chart equally. Thus, in any such case for which the tolerances given will not constitute the basis of the trial test to be made with a machine tool, particular arrangements as to the closeness of the tolerance factors should be made before signing the contract between maker and customer, and the price of the machine will, of course, depend on the arrangement regarding such factors.

Principles of Trial Tests

Where and How Precision Trial Tests are to be made

It is hardly possible for the machine tool builder to assume the responsibility for the consequences of treatment to which machine tools are subjected while being transported from the works to their destination. Machine tools are very sensitive to impact or shock; even heavy cast-iron standards are not always solid and rigid enough to withstand stresses due to a fall during transportation, so that deformations may be set up. Sometimes even, cracks will be found in a machine frame so that the entire machine is rendered useless.

Moreover, the machine is always carefully adjusted and aligned when on the test stand or in the assembly department of the maker, whereas it is well known from experience that erection in the workshop of the user is not always done with sufficient care so that the inaccuracies of the work resulting from faulty erection are wrongly blamed on the machine. Sometimes, particularly in the case of heavy machines, foundations, by reason of economy, are made too light and are not extended to sufficient depth.

At the manufacturers' plant, moreover, skilled men as well as the necessary testing equipment are available which, outside the testing department, is only obtainable with difficulty.

Obviously the purchaser of a machine is fully entitled to repeat the tests in his own works, but if it is his intention to do so he should have at his disposal all the necessary testing equipment and an experienced inspection staff. The test chart for a machine of small or medium size, a copy of which is supplied to the buyer with the machine, should afford a guarantee that it has been tested in the maker's works under precisely the same conditions (on a concrete foundation or cast iron plate) as it will later operate. As a rule cast iron foundation plates are unsuitable for heavy machines because they cannot be provided with the necessary openings. On the other hand it is undesirable to install expensive permanent foundations which may have to be removed at a later date.

Machine tools are required to-day to produce components of high precision, which, in many cases, must be of the same order of accuracy as the machine itself. The maker of the machine, therefore, must so produce the individual parts that any inaccuracies resulting from the essential tolerances thereon, do not result in an inadmissible cumulative error on assembly.

If the machine has been transported without sufficient care from the works of the maker to those of the purchaser, or if it has been faultily erected, deformations may result. In the event of any complaint, therefore, the maker may refer to his own test records, and may insist that in the user's plant the same conditions are established as those under which the machine was originally tested. Tests carried out by the user are then to be regarded merely as a confirmation of the charts supplied by the maker.

The precision tests cover the grade of accuracy of the machine tool itself, and, whenever feasible, also the working accuracy of the same. Primarily, the degree of the manufacturing accuracy of the machine tool itself is to be tested, *i.e.*, the grade of accuracy with which the machine is assembled. This grade of accuracy is measured while the machine is idle and in the unloaded condition.

In the majority of cases the specified working limits to be attained with the machine in operation are stated at the end of the test charts. The working tolerance specifications apply to finishing operations only. A finishing cut on a lathe, for example, has been defined (I.S.A. Committee 39 of 1937) as a chip of about 0.1 to 0.2 mm. (0.004 to 0.008 in.) depth and 0.05 to 0.1 mm. (0.002 to 0.004 in.) feed, taken with the highest permissible speed, depending on the work material. In cases where, as a result of high costs involved, or because of the lack of the necessary foundation for heavy machines or by other reasons, it is not practicable to carry out trial operations, the degree of working accuracy may be "assured" or "promised."

The grade of working accuracy, besides depending on the machine itself, depends also upon other factors, such as:—

(1) The type of cutting tool and its condition (cutting angles, hardening process, eccentricity of milling cutter, correctness of shape). (2) Cutter arbors. (3) Cutting speed, feed and sectional area of chip. (4) Material to be machined. (5) Shape and rigidity of work piece. (6) Chucking or holding equipment. (7) Degree of skill of the operator.

It is therefore not always practicable absolutely to guarantee the attainable grade of working accuracy, but only limited or conditional "assurances" or "promises," not binding in law, can be given to the effect that the machine, when properly erected and used in conformity with its design and with the proper tools will meet the specified grades of working accuracies.

In the case of milling machines on which the factors stated above have as much influence as the quality of the machine itself, promises concerning the grade of working accuracy can only be made with a certain reserve. Neverthe-