International Standard ISO 5393

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Rotary pneumatic assembly tools for threaded fasteners — Performance test

Outils pneumatiques rotatifs pour l'assemblage d'éléments de fixation filetés — Essai des caractéristiques de fonctionnement

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Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 5393 was developed by Technical Committee ISO/TC 118, *Compressors, pneumatic tools and pneumatic machines*, and was circulated to the member bodies in September 1980.

It has been approved by the member bodies of the following countries :

Austria
Belgium
Bulgaria
Czechoslovakia
Finland
France
Germany, F. R.
India
Netherlands
Poland
Romania
Sweden
United Kingdom
USA

No member body expressed disapproval of the document.

Rotary pneumatic assembly tools for threaded fasteners — Performance test

0 Introduction

This International Standard covers the performance test methods for measurement of installation torque of pneumatic assembly tools for tightening of threaded fasteners and how such tests should be evaluated and presented.

Such methods are important for the following purposes :

a) to enable manufacturers of pneumatic assembly tools to offer their products under correlated technical specifications;

b) to give users standardized technical information on torque output and consistency of pneumatic assembly tools for threaded fasteners.

The test method is designed to measure the capability of assembly tools with the level of accuracy that is needed in assessing type data. The test is not intended as a routine in-plant inspection test.

An example of a test joint is given in annex B.

1 Scope and field of application

This International Standard specifies a performance test method for pneumatic assembly tools for installing threaded fasteners and gives instructions on how measured data should be statistically evaluated and presented.

This International Standard is not applicable to impact wrenches, ratchet wrenches or wrenches with ratcheting clutches, because their applied torque cannot be measured with conventional types of instrumentation.

2 References

ISO 31, *Quantities, units and symbols.*

ISO 1000, *SI units and recommendations for the use of their multiples and of certain other units.*

ISO 2787, *Rotary and percussive pneumatic tools — Acceptance tests.*

ISO 3534, *Statistics — Vocabulary and symbols.*

ISO 5941, *Compressors, pneumatic tools and machines — Preferred pressures.*

3 Definitions and symbols

The following definitions and symbols are specific to this International Standard

3.1 Definitions[1)]

3.1.1 torque control tool : Pneumatic assembly tool for tightening of threaded fasteners, which is provided with torque sensitive control means that limit the magnitude of the output torque or cut it off altogether as a predetermined torque level is reached.

3.1.2 stall type tool : Pneumatic assembly tool for tightening of threaded fasteners, which is not provided with any torque sensitive control means, and which delivers an output torque as long as the trigger or supply valve is actuated.

1) Where reference is made to this International Standard, it is to be understood that indicated values of "torque", "rated torque", "standard deviation" and "mean shift" correspond to measurements made at an effective inlet pressure of 6,3 bar and the tool adjusted in such a way that the "test torque level" equals the rated torque. If for any reason the test pressure is other than 6,3 bar, then the test pressure must be specified each time a torque is cited.

3.1.3 mean torque : Arithmetic mean calculated from several torque readings on a specific joint and at stated conditions.

3.1.4 test torque level : Mean torque measured under actual test conditions when the tool is tested on the low torque rate joint (see 4.2.4).

3.1.5 rated torque : Specific term used for mean torque when measured on the low torque rate joint at an effective test pressure of 6,3 bar[1].

For torque control tools, the rated torque value is determined with the highest setting of the torque control means in accordance with the manufacturer's recommendation and 6,3 bar test pressure.

3.1.6 torque range : Comprises all torque values between and including the rated torque and the lowest mean torque recommended by the manufacturer.

NOTE — Provided that the available air pressure is at least 6,3 bar, the mean torque delivered by a tool for tightening threaded fasteners, can normally be adjusted to any desired value within the torque range. Such adjustment is made by regulating the air pressure or manipulating the torque control means.

For some torque control tools, the torque output is adjusted in a limited number of steps within the torque range.

3.1.7 torque rate : The torque rate of a screw joint is a measure of joint stiffness, defined as required torque increase per angular displacement (expressed in newton metres per revolution) as the joint is tightened.

The torque rate varies widely in practical applications and can vary on a specific joint due to variances in component parts which make up that joint. These variances are due to factors such as lubrication, elasticity, quality of threads, compressibility of material, etc.

For this test method, the test joints or the test rig must have controlled constant torque rates to give consistent test results.

The torque rate is measured by simultaneous recording of the applied torque and the angular displacement of the input of the test fixture or threaded fastener, at a speed which is sufficiently low to exclude dynamic effects.

3.1.8 mean shift : The mean torque on the high torque rate joint (see 4.2.4) minus the mean torque on the low torque rate joint, at otherwise identical test conditions, notably same pressure level and same setting of torque control means.

3.1.9 rated mean shift : The mean shift when the test conditions are such that the test torque level equals the rated torque.

3.2 Symbols

3.2.1 Symbols and units are to be according to ISO 31 and ISO 1000 when applicable.

3.2.2 Subscript H is used to denote high and subscript L to denote low torque rate joint conditions.

4 Method for measurement of performance

4.1 General rules for performance tests

4.1.1 All measurements carried out in compliance with this International Standard shall be performed by competent persons and with accurate instrumentation, which is calibrated against existing standard methods.

4.1.2 The performance of pneumatic tools is affected by different ambient conditions such as atmospheric pressure and temperature. For this reason ambient conditions shall be kept within limits stated in ISO 2787.

4.1.3 During the performance tests the air pressure measured at the inlet to the tool must be kept within the following limits :

- free running conditions : between nominal value and −4 % of nominal value;
- approaching maximum torque : ± 2 % of nominal value.

No adjustments are to be made during the course of a given test. An example of a suitable test installation is shown in figure 2.

4.1.4 If torque output is adjusted by other means than variation of pressure, the adjustment shall be constant throughout the test and such that the torque control mechanism operates each time.

4.1.5 It is recommended that torque control tools are subjected to complete tests at the levels of adjustment that correspond to the highest and the lowest torque levels within the torque range of the tool. Performance tests may also be carried out at any test torque level within the torque range.

No test should be performed outside the torque range recommended by the manufacturer.

4.1.6 During the test run of the tool, lubrication consistent with manufacturer's specification shall be provided.

4.2 Torque measurement

4.2.1 The torque increase per revolution, or torque rate, of a threaded joint varies widely from application to application and can vary appreciably on a specific assembly. Any test of torque performance of a tool must be conducted on joints having controlled torque rates. The test shall include a joint where the torque rate is very low and a joint where the torque rate is high as per 4.2.4. The high and low torque rates straddle the range of conditions which affect the torque output of the tool.

1) 1 bar = 100 kPa

On a low torque rate joint, the tightening is usually accomplished with several revolutions of the fastener. In this case the torque delivered to the fastener approximates the stall torque of the tool or its torque setting.

On a high torque rate joint, the tightening is accomplished in a fraction of a revolution. On a high torque rate joint, the kinetic energy of the rotating parts of the tool may cause the torque delivered to the fastener to be higher than on a low torque rate.

4.2.2 To satisfy the above conditions, test fixtures for use with this International Standard must comply with the following :

a) In a diagram where the required torque is plotted as a function of the angular displacement of the input drive of the test joint, the resulting curve must essentially be a straight line between 50 % and 100 % of the test torque level. The slope of this straight line is used to calculate the torque rate of the joint. Between the limits of 20 % and 100 % of the test torque level, plotted values shall not deviate from a straight line by an amount of more than 10 % of the test torque level;

b) The torque rate of any test joints shall remain within plus or minus 10 % of the torque rate stated in the test report (see 4.4.2);

c) The moment of inertia of rotating parts in the test joint shall be as small as possible in relationship to the effective moment of inertia of the rotating parts of the tool.

4.2.3 When the torque rate of a test joint is measured, the joint shall be tightened slowly but evenly in order to exclude inertia effects and stick-slip problems.

4.2.4 Each assembly tool shall be tested on both a high (designated H) and a low (designated L) torque rate joint, where

a) the high torque rate joint (H) shall be such that the torque increase from 50 % to 100 % of the test torque level corresponds to an angular displacement of less than 30°, see figure 1;

b) the low torque rate joint (L) shall be such that the torque increase from 50 % to 100 % of the test torque level corresponds to an angular displacement of not less than one full turn (360°), see figure 1.

NOTE — It is a minimum requirement that each tool shall be tested on a high torque rate joint and on a low torque rate joint as defined above, however, the test procedure can be applied to any specified torque rate.

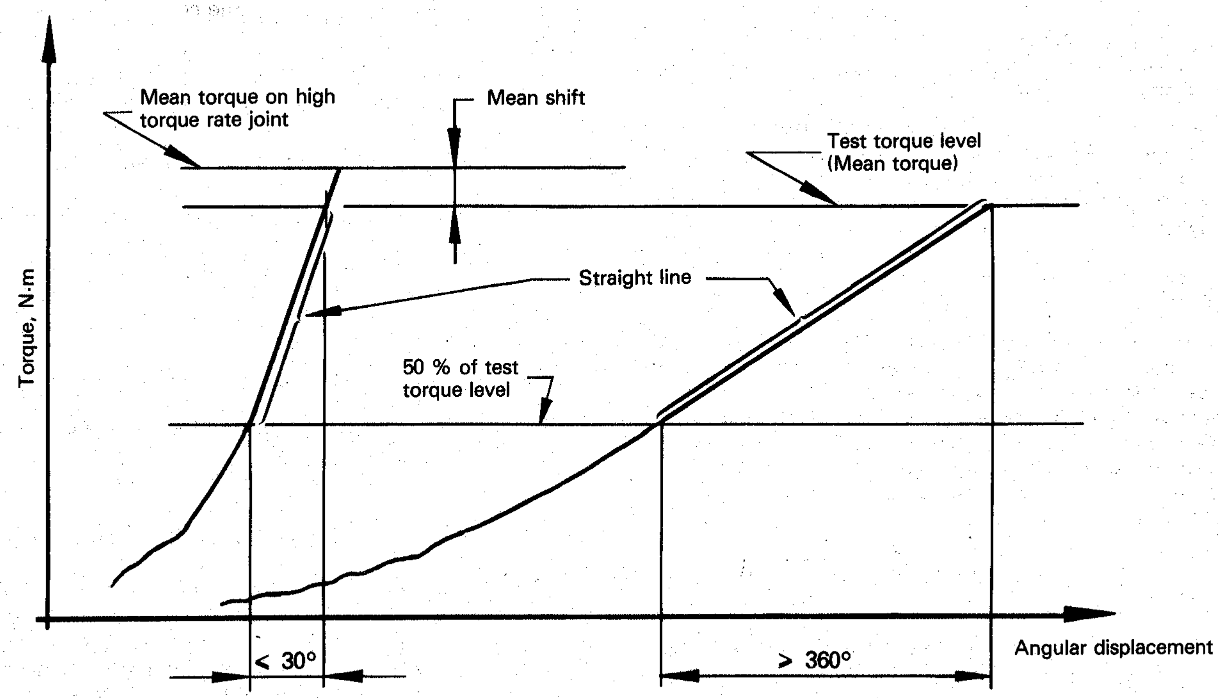

Figure 1 — High and low torque rate joint

4.2.5 The values of torque rate that will appear from measurements made during actual test runs may — because of inertia effects — differ from torque rates measured according to 4.2.3. For this reason, torque rate values calculated from simultaneous recordings of torque and angle at tool testing conditions, may vary within ± 20 % of the torque rate stated in the test reports (see 4.4.2) without invalidating the test.

4.3 Test method and evaluation

4.3.1 This International Standard recognizes that static, residual torque measurements give poor correlation to joint condition (tension). Accordingly, all performance measurements in accordance with this International Standard are to be taken dynamically, during the tightening process.

Torque measurements are to be made by means of a torque transducer and a peak reading amplifier. The torque transducer shall be mounted in line between the tool drive and the joint. The transducer and amplifier shall have flat frequency response within ± 1 % from 0 to 1000 Hz.

The tool shall be rigidly fixed in the test stand to prevent any influence from the operator. Peak torque values should be displayed on a digital voltmeter or corresponding fast response equipment.

4.3.2 A complete test is composed of two different test sequences as specified under 4.2.4 and a minimum of 100 torque readings shall be taken for each test sequence.

All data readings shall be taken after a sufficient break-in of the fixture to achieve consistent torque rate as specified in 4.2.2.

NOTE — If the purpose of a particular test is to determine only one or several **mean torque** values a much smaller number of torque readings may be acceptable.

A reduced number of test runs is however not sufficient to determine **torque scatter** within reasonable error margins. It has for example, been repeatedly demonstrated that standard deviation values calculated from different test sequences with one and the same nutrunner can vary within a 1 to 2 ratio, when the number of run downs in each test sequence is restricted to 25. Statistical analysis confirms that such results are to be expected from a nutrunner with perfectly consistent performance.

In order to obtain standard deviation values, which are repeatable within reasonable margins of stochastical error, it therefore is necessary to take a large number of readings, and whenever a standard deviation value is given with reference to this International Standard it shall be calculated from a minimum of 100 readings. (The number 100 has been chosen with the purpose of making it possible to compare two or more nutrunners with standard deviation values that are 15 to 20 % apart. If the standard deviation difference between two nutrunners is less than 15 %, a still greater number of readings is required in order to determine which one is the most accurate of the two).

4.3.3 Tools to be tested shall be run sufficiently before starting the test to function properly.

4.3.4 In all test runs the tool shall be allowed at least two full turns of free running with a torque not exceeding 5 % of the rated torque, before the tool is slowed down by the test joint.

4.4 Evaluation of test results

4.4.1 All tests according to this standard shall be subjected to mean torque and torque variance calculations in the following way :

— As stated in 4.2.4, the tool shall be tested on a high torque rate joint (H) and a low torque rate joint (L).

— A hundred torque readings X_{Hi} from tests on joint H and a hundred torque readings X_{Li} on joint L have been recorded. (Subscript "i" refers to the number of the reading in the test sequence. In this case "i" stands for any number from 1 to 100. The letter X is used to indicate the actual torque value. X_{Hi} thus means the torque reading of test number "i" on the high torque rate joint (H). Similarly X_{Li} indicates torque reading number "i" on the low torque rate joint).

— The mean values $\bar{X}_H$ and $\bar{X}_L$ are then calculated as

$$\bar{X}_H = \frac{1}{100} \sum_{i=1}^{100} X_{Hi}$$

$$\bar{X}_L = \frac{1}{100} \sum_{i=1}^{100} X_{Li}$$

The standard deviation is calculated as

$$s = \sqrt{\frac{1}{99} \sum_{i=1}^{100} (X_i - \bar{X})^2}$$

Both standard deviation for the high torque rate test sequence (s_H) and the standard deviation for the low torque test sequence (s_L) are to be determined.

For convenience a sample calculation will be found in annex C.

4.4.2 The following data and test results shall be presented together with other relevant tool data in a test form as per 4.5.

a) Actual torque rate of the test joints used in test :

— high torque rate in newton metres per revolution

— low torque rate in newton metres per revolution

b) Mean torque value :

— on high torque rate joint H, in newton metres

— on low torque rate joint L, in newton metres

c) Standard deviation s of the torque :

— on high torque rate joint H, in newton metres

— on low torque rate joint L, in newton metres

d) The difference between mean torque on high torque rate joint and mean torque on low torque rate joint, i.e. the mean shift, should if stated be given in newton metres and as a percentage of the test torque level on the low torque rate joint.

e) Effective air pressure in inlet (test pressure).

4.5 Test form

The following test has been made in accordance with the International Standards ISO 5393 and ISO 2787.

1 Subject

Manufacturer .... Type of machine ....

Model .... Serial number ....

Type of control ....

Rated torque.................. N·m

Torque range .... N·m .... N·m

2 Operating conditions

Effective air pressure in inlet .... bar

Setting of torque control means (if other than air pressure) : ....

....

Test torque level (= mean torque on low torque rate joint) : .... N·m

Compressed air temperature : .... °C

Length of hose and internal diameter : .... m ϕ .... mm

Type of lubricant..

3 Test conditions

Barometric pressure .... bar Ambient temperature .... °C

Relative humidity .... %

4 Instrumentation

....

....

5 Air consumption measured at free speed .... l/s (at 20 °C and 1 bar absolute pressure)

6 Free speed.. min^{-1}

7 Torque measurements

High torque rate test

Mean torque .... N·m

Standard deviation s_H .... N·m

Actual torque rate .... N·m/rev

Mean shift.. N·m or .... % of the test torque level.

Low torque rate test

Mean torque .... N·m

Standard deviation s_L .... N·m

Actual torque rate .... N·m/rev

8 Test remarks : ....

....

....

NOTE — Where reference is made to this International Standard, it is to be understood that indicated values of "torque", "rated torque", "standard deviation" and "mean shift" correspond to measurements made at an effective inlet pressure of 6,3 bar and the tool adjusted in such a way that the "test torque level" equals the rated torque. If for any reason the test pressure is other than 6,3 bar, then the test pressure must be specified each time a torque is cited.

Reported by : .... Date : ....

Approved by : .... Date : ....

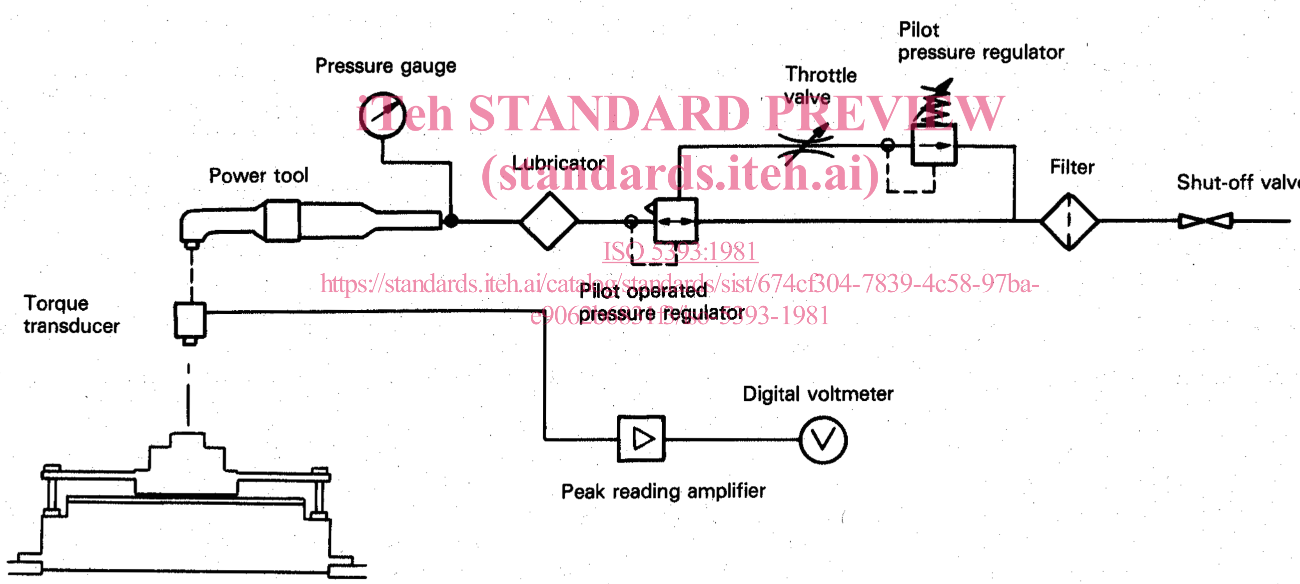

Figure 2 — Typical test installation

Annex A

Test fixture for rotary pneumatic assembly tools — Performance test

The test fixture should preferably be capable of receiving several different test joint assemblies.

Test fixtures may be of any suitable design to meet with requirements of this International Standard.

For convenience, one design is presented in annex B.

The test fixture is constructed on a fixture base. On the base is fixed a test bolt machined very accurately with a hardened and ground precision thread. A test disc is supported on its lower outside diameter by the OD-support. The test disc is deflected by means of a nut with a large lower base surface which transmits the bolt load via the ID-support to the disc. The plates (discs) which are interchangeable to reproduce various torque rates are designed not to be deflected more than that a deflection proportional to the bolt load and the applied torque. Specified torque rates (joint stiffnesses) are obtained by means of a set of plates with a variation of diameters and thicknesses. In order to meet specified data on test joints, the supports, the test bolts and nuts may also be varied.

The thread and the friction surfaces are preferably lubricated by means of MoS_2 (molybdenum disulphide) grease.

The power tool to be tested is supported rigidly when run on the test fixture to avoid operators influence.

Annex B

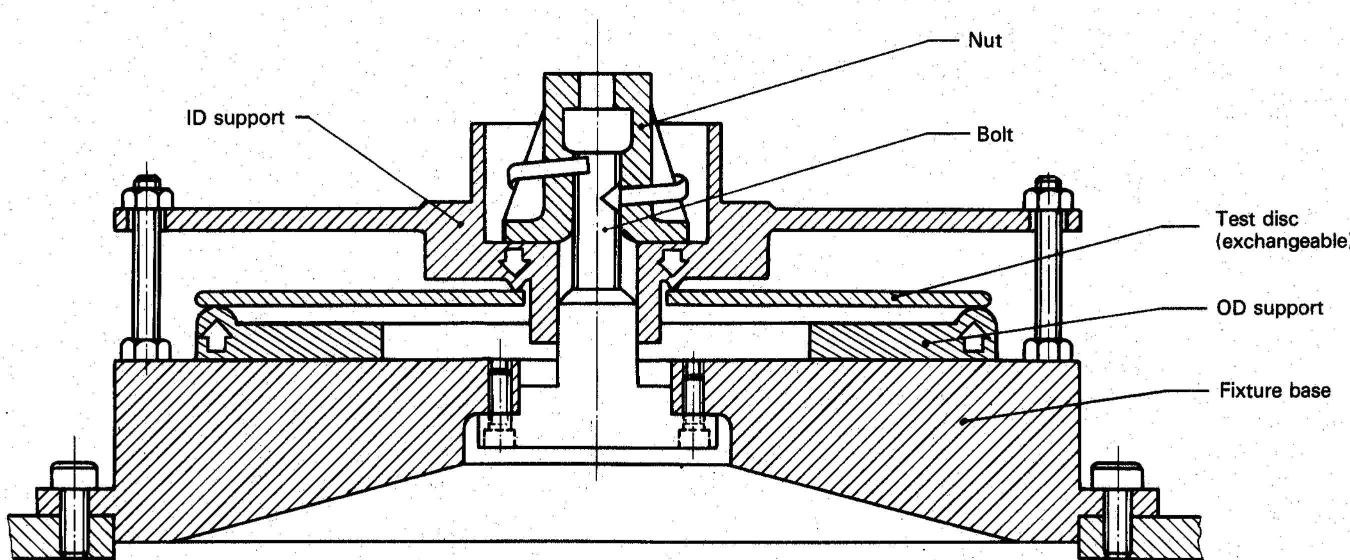

Figure 3 — Test fixture for rotary pneumatic assembly tools — Example of design