International Standard 6544

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Hand-held pneumatic assembly tools for installing threaded fasteners — Reaction torque and torque impulse measurements

Outils pneumatiques à main pour l'assemblage d'éléments de fixation filetés — Mesurages du couple de réaction et de l'impulsion de couple

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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 6544 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	France	Romania
Belgium	Germany, F. R.	Sweden
Czechoslovakia	United Kingdom	United Kingdom
Egypt, Arab Rep. of	Netherlands	USA
Finland	Poland	

No member body expressed disapproval of the document.

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Hand-held pneumatic assembly tools for installing threaded fasteners — Reaction torque and torque impulse measurements

0 Introduction

This International Standard covers the test method for measurement of reaction torque and torque impulse from hand-held pneumatic assembly tools for installing threaded fasteners and specifies how such measurements should be evaluated.

Such methods are important for the following purposes

a) enabling manufacturers to measure reaction torque impulse from assembly tools in accordance with a standardized method and to offer their products under correlated technical specifications;

b) giving users standardized technical information on reaction torque and torque impulse from pneumatic tools for threaded fasteners.

The values of reaction torque and torque impulse are measured on test joints with standardized torque rates that are in accordance with those specified in the performance test of ISO 5393.

1 Scope and field of application

This International Standard specifies a test method for evaluation of reaction torque and torque impulse from hand-held pneumatic tools for installing threaded fasteners and gives instructions on how measured data should be evaluated and presented.

This International Standard is directly applicable to assembly torque control tools.

In the case of stall type tools, only the reaction torque can be measured. Impacting, pulsing or ratcheting assembly tools are not covered.

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 5393, *Rotary pneumatic assembly tools for threaded fasteners — Performance test.*

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 installed torque : The peak torque transmitted to the joint when installing a threaded fastener by use of a hand-held pneumatic assembly tool.

3.1.2 reaction torque : The peak torque transmitted to the operator when installing a threaded fastener by use of a hand-held pneumatic assembly tool.

3.1.3 reaction force : The peak force transmitted to the operator when installing a threaded fastener by use of a hand-held pneumatic assembly tool.

1) Where reference is made to this International Standard, it is to be understood that indicated values of reaction torque, reaction force, reaction torque impulse and reaction force impulse 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 of the tool. If for any reason the test pressure is other than 6,3 bar, the test pressure must be specified each time a torque is cited.

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3.1.4 reaction time : Duration of reaction torque exceeding threshold torque values specified in this International Standard during a tightening cycle. The reaction time is the time span between a low time limit t_u and a high time limit t_d corresponding to the threshold torque level on the torque time curve (see figure 1).

3.1.5 reaction torque impulse (I_M) : The torque impulse over the reaction time span of the tightening cycle defined by

$$I_M = \int_{t_u}^{t_d} M_r \, dt$$

3.1.6 reaction force impulse (I_F) : Applicable to angle wrenches, pistol grip wrenches and other wrenches when the force in the handle is of primary interest

$$I_F = \int_{t_u}^{t_d} F_r \, dt$$

3.1.7 test torque level : The mean torque measured at actual test conditions, when the tool is tested on the low torque rate joint.

3.1.8 rated torque : The 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 an effective test pressure of 6,3 bar.

3.2 Symbols

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

3.2.2 The symbols and units used in this International Standard are given in table 1.

3.2.3 The subscripts used in this International Standard are given in table 2.

Table 1 — Symbols and units

Symbol	Quantity	Unit
M_A	Installation torque	N·m
M_R	Reaction torque	N·m
F_R	Reaction force	N
t	Reaction time	s
b	Effective length of tool (length of lever arm of an applicable type wrench measured from the centre of the grip handle to the spindle centre)	m
R_M	Reference torque rate for the low torque rate test joint	N·m/rev
R_L	Actual torque rate for the low torque rate test joint	N·m/rev
I_L	Torque impulse measured on joint with torque rate R_L	N·m·s
I_M	Reaction torque impulse	N·m·s
M_T	Threshold torque	N·m
I_F	Reaction force impulse	N·s

Table 2 — Subscripts

Subscript	Designation	
u	Low time limit for impulse measurements	
d	High time limit for impulse measurements	
M	Torque	
A	Installation	
R	Reaction	
a	Momentarily applied	
r	Momentary reaction	
F	Force	
H	High torque rate joint	
L	Low torque rate joint	
T	Threshold	

1) 1 bar = 100 kPa

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4 Methods for measurement of reaction torque

4.1 General rules for 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 Air supply and lubrication consistent with the manufacturer's specification shall be provided.

4.2 General observations

4.2.1 High torque rate joints

On high torque rate joints, the tightening process is of extremely short duration. Torque is applied to the fastener for a very short period of time, which is determined by the time required to reach the present torque level and the delay time of the torque release mechanism.

It has been demonstrated that the relationship between installed torque and the reaction torque and reaction force is influenced by the mass inertia of the tool, the size of the operator and the way the tool is held by the operator. The reaction torque can be both higher and lower than the installed torque. Likewise the reaction force can be both higher and lower than the installed torque divided by the effective length of the tool.

Various attempts of measuring reaction force and reaction torque on high torque rate joints in a test rig that simulates standard operator characteristics have not been encouraging. It is considered to be beyond the scope of this International Standard to determine such standard operator conditions that would yield results which are in complete correspondence with the actual stress experienced by human operators.

Nor are there, at the time of writing this International Standard, any known devices for measuring torque and force that can be used between the tool and the operator.

As a consequence it must be realized that for high torque rate joints, accurate values of reaction torque and reaction force can only be obtained in the special case when the tool is rigidly mounted. No dynamic effects are present in this case and the following relations are valid :

$$M_R = M_A$$

$$F_R = \frac{M_A}{b}$$

These relations are also approximately true when the operator holds the tool in such a way that the direction of the reaction force coincides with his straight arm.

4.2.2 Low torque rate joints

On low torque rate joints, the dynamic effects are negligible and consequently the reaction torque is equal to the installed torque and the reaction force is equal to the installed torque divided by the effective length of the tool

$$M_R = M_A$$

$$F_R = \frac{M_A}{b}$$

These relationships are valid regardless of how the tool is held or mounted.

4.3 Torque and torque impulse measurements

4.3.1 The reaction torque impulse is defined by

$$I_M = \int_{t_u}^{t_d} M_r \, dt$$

But for a rigidly mounted tool $M_r = M_a$, and in this case

$$I_M = \int_{t_u}^{t_d} M_a \, dt \qquad \text{(See figure 1)}$$

The reaction torque impulse is recorded by means of a torque-time integrator. Alternatively the torque is plotted as a function of time for evaluation of the torque impulse from the torque-time curve shown in figure 1.

Time limits t_u and t_d are triggered by a threshold torque setting on the torque-time integrator or the torque amplifier.

4.3.2 The reaction force impulse is defined by

$$I_F = \int_{t_u}^{t_d} F_r \, dt$$

but $F_r = \frac{M_a}{b}$, for a rigid mount.

$$I_F = \frac{1}{b} \int_{t_u}^{t_d} M_a \, dt$$

$$I_F = \frac{I_M}{b}$$

The reaction force impulse can consequently be calculated from the reaction torque impulse.

4.3.3 When the reaction torque impulse is measured on a low torque rate joint the result is a function of the torque rate of the joint.

Ideally the measurement of reaction torque impulse on the low torque rate joint should be performed on a joint with the torque rate corresponding to an angular displacement of 360° as the torque is increased from 50 % to 100 % of the test torque level. The corresponding torque rate is denoted R_M.

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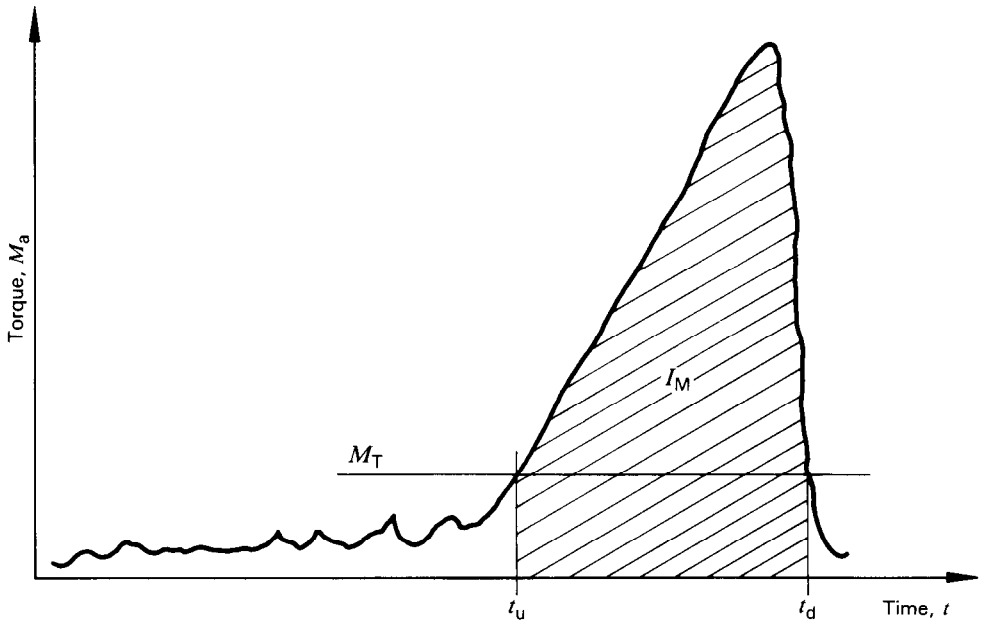

Figure 1 — Torque-time curve

For practical reasons it is acceptable to measure reaction torque impulse on a low torque rate joint with a lower torque rate than R_M. The actual torque rate of the low torque rate joint is denoted R_L.

The corresponding measured value of the reaction torque impulse is denoted I_L.

The reaction torque impulse corresponding to torque rate R_M can then be calculated from

$$I_M = I_L \times \frac{R_L}{R_M}$$

4.3.4 The assembly tool shall be rigidly mounted in the test stand.

4.3.5 The assembly tool shall be tested on both a high and a low torque rate joint.

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.

The torque rate of the high torque rate joint 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° of rotation.

The torque rate of the low torque rate joint 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 2).

4.3.6 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.

4.3.7 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.

4.3.8 Threshold torque settings (M_T) for torque impulse evaluation shall be 10 % of the test torque level.

4.3.9 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 end 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.

4.3.10 Torque impulse measurements are to be made by means of a torque transducer and an amplifier as specified in 4.3.9. The torque-time curve may be recorded on a sufficiently fast recording device to provide the basis for calculation of the torque impulse over the time when torque exceeds threshold values specified in 4.3.8. Alternatively torque impulse over the same time span is directly recorded by means of an electronic torque-time integrator and displayed on a digital voltmeter.

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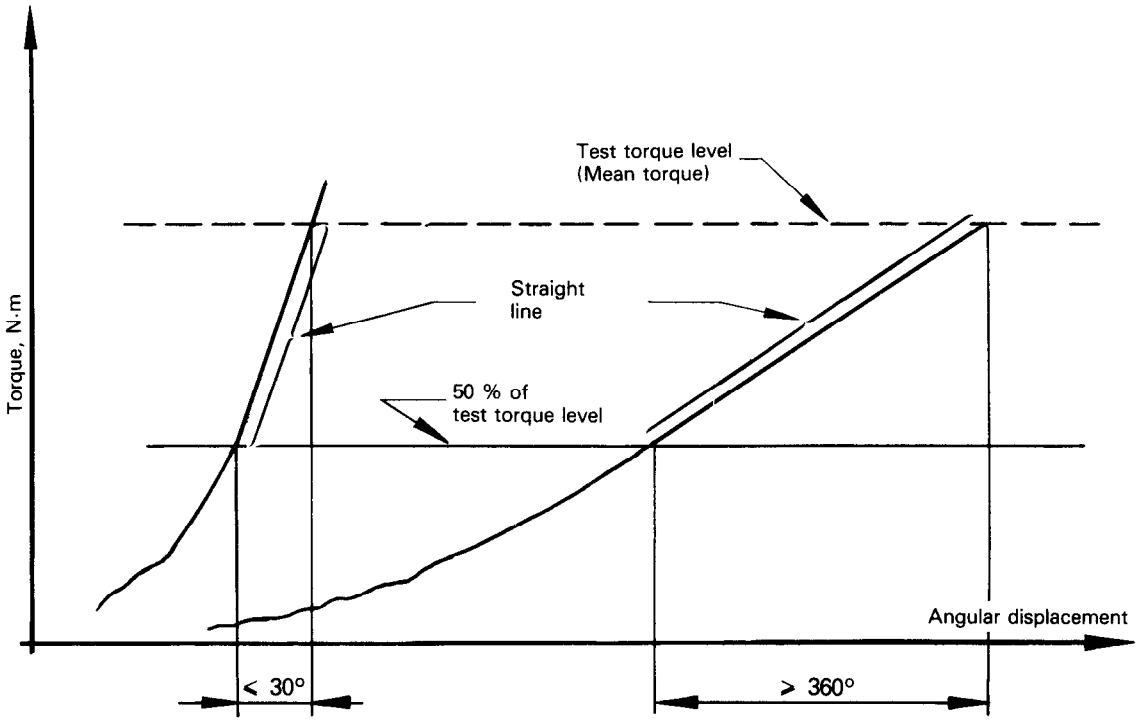

Figure 2 — High and low torque rate joints

4.3.11 A complete test is composed of two different test sequences, one recording torque and torque impulse on a high torque rate joint and a second sequence on a low torque rate joint. It is recommended to run the tool ten times on each test joint.

4.4 Evaluation of test results

4.4.1 The test results shall be calculated as mean values of readings taken as per 4.3.11.

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 joint used in the test :

— high torque rate, in newton metres per revolution

— low torque rate in newton metres per revolution

b) Mean reaction torque :

— on high torque rate joint in newton metres

— on low torque rate joint in newton metres

c) Where applicable, mean reaction force shall be calculated from recorded installation torque in accordance with 4.2 :

— mean reaction force on high torque rate joint in newtons

— mean reaction force on low torque rate joint in newtons

d) Mean reaction torque impulse at 6,3 bar effective pressure recorded as applied torque over the time span of the tightening cycle when torque exceeds threshold values specified in 4.3.8 :

— mean reaction torque impulse on high torque rate joint in newton metre seconds

— mean reaction torque impulse (I_M), adjusted to the reference low torque rate joint in newton metre seconds

— mean measured reaction torque impulse (I_L) on actual low torque rate joint in newton metre seconds

e) Where applicable, mean reaction force impulse shall be calculated from recorded mean torque impulse in accordance with 4.3.4 :

— mean reaction force impulse on high torque rate joint in newton seconds

— mean reaction force impulse on low torque rate joint in newton seconds

f) Effective air pressure at inlet (test pressure).

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4.5 Test form

The following test has been made in accordance with International Standards ISO 2787, ISO 5393, and ISO 6544.

1 Subject

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

Model ..... Serial number .....

Weight : ..... kg Free speed at 6,3 bar supply pressure : ..... min^{-1}

Rated torque ..... N·m

Type of torque control : .....

Torque range : ..... N·m .....N·m

2 Operating conditions

The tool is rigidly mounted.

Effective air pressure at inlet ..... bar

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

.....

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 Reaction torque measurements

High torque rate test

Mean torque ..... N·m

Actual torque rate ..... N·m/rev

Low torque rate rate test

Mean torque ..... N·m

Actual torque rate ..... N·m/rev

6 Calculated reaction force (for applicable wrenches only)

Effective tool length, b, used in calculation : ..... m

High torque rate test

Mean force : ..... N

Low torque rate test

Mean force : ..... N

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7 Reaction torque impulse measurements

High torque rate test	Low torque rate test
Mean torque impulse : ..... N·m·s	Mean torque impulse : ..... N·m·s (adjusted to the reference low torque rate)
Set threshold torque : ..... N·m	Mean measured torque impulse: ..... N·m·s
	Set threshold torque : ..... N·m

8 Calculated reaction force impulse (where applicable)

Effective tool length, b, used in calculation ..... m

High torque rate test	Low torque rate test
Mean force impulse ..... N·s	Mean force impulse ..... N·s

9 Test remarks

.....

.....

NOTE — Where reference is made to this International Standard, it is to be understood that indicated values of reaction torque, reaction force, reaction torque impulse and reaction force impulse 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 of the tool. If for any reason the test pressure is other than 6,3 bar, the test pressure must be specified each time a torque is cited.

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