TECHNICAL SPECIFICATION

ISO/TS 17104

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Rotary tool for threaded fasteners — Hydraulic impulse tools — Performance test method

Outils rotatifs pour éléments de fixation filetés — Outils hydraulique à impulsion — Méthode d'essai des caractéristiques de fonctionnement

Reference number
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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

In other circumstances, particularly when there is an urgent market requirement for such documents, a technical committee may decide to publish other types of normative document:

— an ISO Publicly Available Specification (ISO/PAS) represents an agreement between technical experts in an ISO working group and is accepted for publication if it is approved by more than 50 % of the members of the parent committee casting a vote;

— an ISO Technical Specification (ISO/TS) represents an agreement between the members of a technical committee and is accepted for publication if it is approved by 2/3 of the members of the committee casting a vote.

An ISO/PAS or ISO/TS is reviewed after three years in order to decide whether it will be confirmed for a further three years, revised to become an International Standard, or withdrawn. If the ISO/PAS or ISO/TS is confirmed, it is reviewed again after a further three years, at which time it must either be transformed into an International Standard or be withdrawn.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO/TS 17104 was prepared by Technical Committee ISO/TC 118, *Compressors and pneumatic tools, machines and equipment*, Subcommittee SC 3, *Pneumatic tools and machines*.

Introduction

The test method specified in this Technical Specification is designed to measure the overall performance and capability of hydraulic impulse tools.

This ISO/Technical Specification is intended to give users of impulse tools a means for measuring and comparing the performance of hydraulic impulse tools under controlled conditions.

Every effort has been made to specify all critical characteristics of the test fixtures conforming to this Technical Specification. However, test results from different test fixtures can be affected by differences in dynamic characteristics, thereby making direct comparisons difficult.

The ISO/TS can be used for comparing the torque capabilities of impulse tools. It has not so far been possible to achieve acceptable reproducibility of the correlated torque scatter and it is hoped that data accumulated through experience of using the ISO/TS enables improvements to be made when it is reviewed three years after publication. In the meantime, when comparing the performances of different tools, quoted differences in correlated torque scatter (as a percentage of mean correlated torque) of fewer than ten percentage points should be viewed with caution/treated as insignificant, until verified by the potential user or purchaser of the tools.

Rotary tool for threaded fasteners — Hydraulic impulse tools — Performance test method

1 Scope

This Technical Specification specifies a laboratory performance test method for hydraulic impulse tools for installing threaded fasteners. It gives instructions on the procedure, performance parameters to test and how to evaluate and present the test data.

Justification for the test method is found in Annex A.

The test method is not intended as a routine in-plant inspection method.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 2787, *Rotary and percussive pneumatic tools — Performance tests*

ISO 5393, *Rotary tools for threaded fasteners — Performance test method*

3 Terms, definitions and symbols

For the purposes of this document, the following terms, definitions and symbols apply.

3.1
hydraulic impulse tool
powered assembly tool for tightening threaded fasteners, which applies torque to a fastener in discontinuous increments through a hydraulic impulse unit

3.1.1
automatic shut-off tool
powered assembly tool for tightening threaded fasteners, which is provided with a control mechanism or system that shuts off or disconnects the power to the motor when a predetermined output level is attained

3.1.2
non shut-off tool
powered assembly tool for tightening threaded fasteners, which continues to apply torque impulses as long as the throttle remains in the “on” position

3.2
standard deviation
s
measure of the dispersion (scatter) based on the mean-squared deviation from the arithmetic mean derived from a sample of a statistical population

3.3
six sigma

$6s$

range of probability, plus and minus three standard deviations from the mean, derived from a sample of a statistical population

NOTE For a normally distributed statistical population, 99,73 % of all members of that population are encompassed.

3.4
diameter

D

nominal diameter of a bolt

NOTE The diameter is expressed in millimetres.

3.5
angle

measure of the angular displacement through which a fastener is turned

NOTE The angle is expressed in degrees.

3.6
clamp force

F_C

result of the force achieved by turning a bolt in the tightening direction after the bolt head makes contact with the joint bearing surface

NOTE The clamp force is expressed in newtons.

3.6.1
peak clamp force

F_{CP}

peak value of the clamp force measured during a tightening cycle

NOTE The peak clamp force is expressed in newtons.

3.6.2
target clamp force

F_{CT}

clamp force required to achieve the test torque when testing a hydraulic impulse tool on a test joint based on Equation (1):

$$F_{CT} = T_T / \left(\overline{K} \times D\right) \qquad (1)$$

where T_T is defined in 3.7.10, $\overline{K}$ is defined in 3.9.1, and D is defined in 3.4.

3.7
torque

product of the force turning the fastener and the perpendicular distance between the line of force and the centre of the fastener

3.7.1
dynamic torque

T_D

torque recorded during the calibration of the test joint as described in 4.2.2 and 4.2.6

NOTE 1 For test joint analysis, dynamic torque is measured with an in-line, rotary torque and angle transducer, placed between a continuous drive spindle and the socket/driver bit.

NOTE 2 Dynamic torque is expressed in newton-metres.

3.7.2
peak dynamic torque
T_{DP}
peak value of the dynamic torque recorded during a tightening cycle performed during the test joint calibration procedure described in 4.2.6

3.7.3
correlated torque
T_C
torque derived from a peak clamp force measurement based on Equation (2):

$$T_C = K \times D \times F_{CP} \quad (2)$$

where K is defined in 3.9, F_{CP} is defined in 3.6.1 and D is defined in 3.4

NOTE The correlated torque is expressed in newton-metres.

3.7.4
mean correlated torque
$\overline{T_C}$
arithmetic mean of a number of correlated torque readings on a specific joint as defined in 3.7.3

3.7.5
6*s*-correlated torque scatter
S_{6s}
predictable range of correlated torque over which a tool performs at a given setting using a single torque-rate joint under controlled conditions

NOTE 1 For the practical purposes of this Technical Specification, 6*s* correlated torque scatter of a tool is the total probable range of torque of a tool run on a single joint at the same setting of the tool torque adjustment.

NOTE 2 6*s*-correlated torque scatter is calculated according to 5.1.

3.7.6
6*s*-correlated torque scatter as a percentage of the mean correlated torque
$S_{6s,p}$
single numerical percentage value designating the correlated torque capability of a tool run on a single torque rate joint under controlled conditions

NOTE 6*s*-correlated torque scatter as a percentage of the mean correlated torque is calculated according to 5.1.

3.7.7
combined mean correlated torque
$\overline{T_C}_{comb}$
midpoint between the lowest and highest predictable correlated torque readings of a tool at a given setting when tested on both test joints

NOTE The combined mean correlated torque is calculated according to 5.2.

3.7.8
combined correlated torque scatter
$\Delta T_{C comb}$
predictable range of correlated torque over which a tool performs, encompassing 99,73 % or more of all possible correlated torque readings, taken on a range of joints of varying torque rates from a defined high torque rate through a defined low torque rate

NOTE For the practical purposes of this Technical Specification, combined correlated torque scatter of a tool is the total probable range of torque of a tool run on all joints used in practice at the same setting of the tool torque adjustment. It is calculated according to 5.2.

3.7.9
correlated torque scatter as a percentage of combined mean correlated torque
single numerical value designating the correlated torque capability of a tool run on joints of varying torque rate, from a defined high torque rate through a defined low torque rate at the same setting of the tool torque adjustment

NOTE The correlated torque scatter as a percentage of combined mean correlated torque is calculated according to 5.2.

3.7.10
test torque
T_T
torque level at which the tool's correlated torque scatter capability is determined, e.g., the torque level at which the test is carried out

3.7.11
upper test torque
test torque equal to the upper limit of the defined torque adjustment range over which a tool's correlated torque scatter capability is determined as described in 4.3.3.2

3.7.12
lower test torque
test torque equal to the lower limit of the defined torque adjustment range over which a tool's correlated torque scatter capability is determined as described in 4.3.3.2

3.8
torque rate
rate of increase of torque relative to angular displacement while tightening a fastener in a threaded joint.

NOTE The torque rate is expressed in newton-metres per revolution.

3.9
torque coefficient
K
constant relating clamp force and dynamic torque in a test joint, based on Equation (3):

$$K = T_{DP} / \left(F_{CP} \times D \right) \quad (3)$$

using peak dynamic torque (T_{DP}) and corresponding peak clamp force (F_{CP}) measurements on the test joint at the test torque level as described in 4.2.6

NOTE T_{DP} is defined in 3.7.2, F_{CP} is defined in 3.6.1 and D is defined in 3.4. See also Annex C.

3.9.1
mean torque coefficient
$\overline{K}$
mean of the 25 torque coefficient values obtained in the calibration process for each test joint at each test torque level

3.10
mean shift
difference in mean correlated torque of a tool run on threaded joints of two different torque rates at the same setting of the tool torque adjustment

NOTE The mean shift is calculated according to 5.2.

3.11
pulse count
number of pulses produced by a hydraulic impulse tool to tighten a specific joint

NOTE For automatic shutoff tools, it is the number of pulses to achieve shutoff. For non-shutoff tools, it is the number of pulses to tighten a specific joint until the fastener stops rotating. The pulse count can be affected by the adjustment of the tool.

3.12
tightening time
time required for a hydraulic impulse tool to tighten a specific joint, excluding the free run down

NOTE 1 For automatic shutoff tools, it is the time required to achieve shutoff.

NOTE 2 For non-shutoff tools, it is the time required to tighten a specific joint until the fastener stops rotating, measured in seconds. The tightening time can be affected by the adjustment of the tool.

3.13
symbols

Symbol	Description	Unit
D	diameter	mm
F_C	clamp force	N
F_{CP}	peak clamp force	N
F_{CT}	target clamp force	N
K	torque coefficient	
$\overline{K}$	mean torque coefficient	
s	standard deviation	
$6s$	six sigma	
S_{6s}	$6s$-correlated torque scatter	
$S_{6s,p}$	$6s$-correlated torque scatter as a percentage	
T_C	correlated torque	Nm
T_D	dynamic torque	Nm
T_{DP}	peak dynamic torque	Nm
T_T	test torque	
$\overline{T_C}$	mean correlated torque	Nm
$\overline{T_C}_{comb}$	combined mean correlated torque	Nm
$\Delta T_{C comb}$	combined correlated torque scatter	Nm

4 Method for measurement of performance

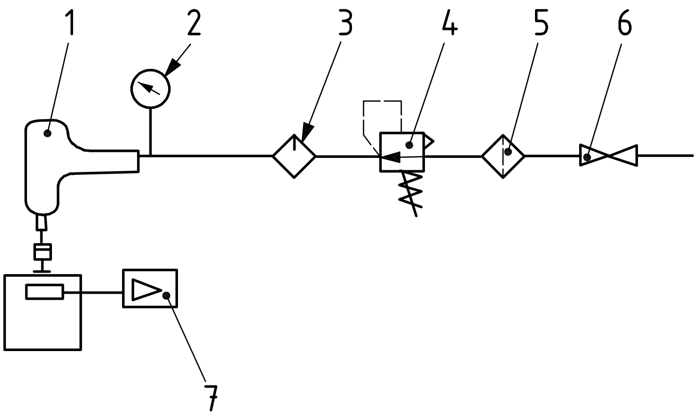
4.1 General rules for performance tests

4.1.1 All measurements carried out in conformity with this Technical Specification 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 the ambient conditions such as atmospheric pressure and temperature. For this reason, the ambient conditions shall be kept within the limits specified in ISO 2787.

4.1.3 During the test, the tool shall be in good working order. The lubrication shall be in accordance with the manufacturer's specifications. Electric impulse tools shall be tested under their rated conditions.

4.1.4 During performance tests of pneumatic impulse tools, a special pressure gauge with glycerine filling should be used to stabilize the gauge pointer. The air pressure at the inlet of the tool shall not vary more than 2 %. An example of a suitable test installation is shown in Figure 1. A pressure regulator with a small hysteresis provides a more constant pressure to the impulse tool and is not so much affected by a pressure change in the system.

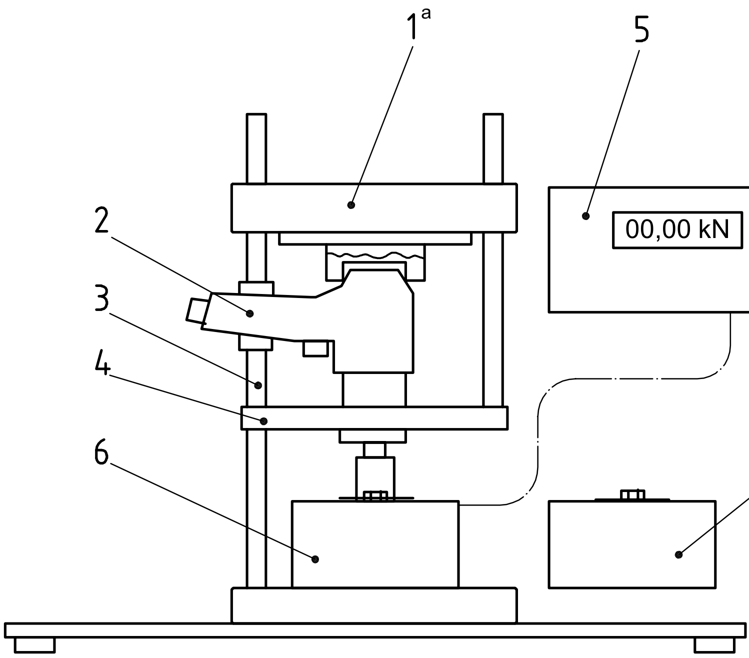


Key

1 impulse tool under test
2 pressure gauge
3 lubricator
4 pilot-operated pressure regulator
5 filter
6 shutoff valve
7 clamp force measuring device with amplifier with peak-hold circuit and visual display or printout capability

Figure 1 — Example of a suitable test installation

4.1.5 The performance of hydraulic impulse tools can be affected by misalignment with the fastener. The tool shall be fixed in a test stand and aligned to reduce influence by the operator. Figure 2 shows an example of a test stand used to support the tool and align it with the test joint; more information can be found in Annex B. The axial load on the tool shall not exceed two times the weight of the tool.



Key

1 upper tool support
2 impulse tool under test
3 test device
4 lower tool support
5 electronic device
6 test joint for 60°
7 test joint for 360°

a Axial load maximum two times tool weight.

Figure 2 — Example of test stand to align tool and reduce influence by the operator

4.1.6 Prior to a performance test, the tool shall be adjusted to the test torque level in accordance with the manufacturer's instructions. The adjustment shall be constant throughout the test and in the case of an automatic shutoff tool; the adjustment shall be such that the shutoff mechanism operates each time.

4.1.7 Adjustments can be made by manipulating the torque control mechanism, or for some pneumatic tools, by adjusting the motor performance (adjusting air pressure, throttling exhaust, etc.). Some pneumatic tools require adjustment of both the torque control mechanism and the motor performance to cover their adjustment range. Adjustments over the range may be continuous, or in some tools, may be made in a finite number of steps.

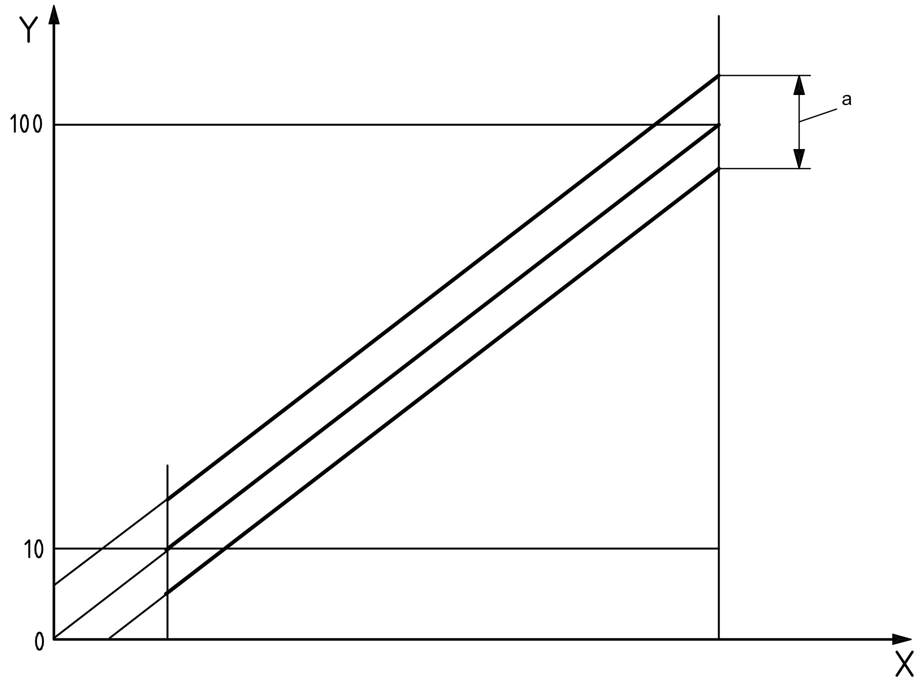
4.2 Test joints

4.2.1 The torque rate of threaded joints varies widely from application to application and can vary appreciably on a specific assembly. Any test of torque performance shall be conducted on two test joints having controlled torque rates; one having a high torque rate and one having a low torque rate, as specified in 4.2.2. These torque rates straddle the practical range of fastening joints for which hydraulic impulse tools are typically used.

4.2.2 To satisfy the conditions specified in 4.2.1, each tool shall be tested on test joints designated 60°and 360° for which the following requirements are applicable.

a) In a diagram where the torque is plotted as a function of angular displacement of the input drive of the test joint, the resulting curve shall be a straight line, within the limits set forth below. The slope of this straight line is used to determine the torque rate of each test joint by regression analysis of the torque/angle measurement points from 10 % to 100 % of the test torque.

b) Between 10 % and 100 % of the test torque, the torque/angle values shall not deviate from their theoretical straight line by more than ± 5 % of the test torque (see Figure 3).



Key

X angle

Y test torque level, expressed in percent

a ± 5 % of test torque.

Figure 3 — Diagram showing torque rate linearity requirements of the test joints

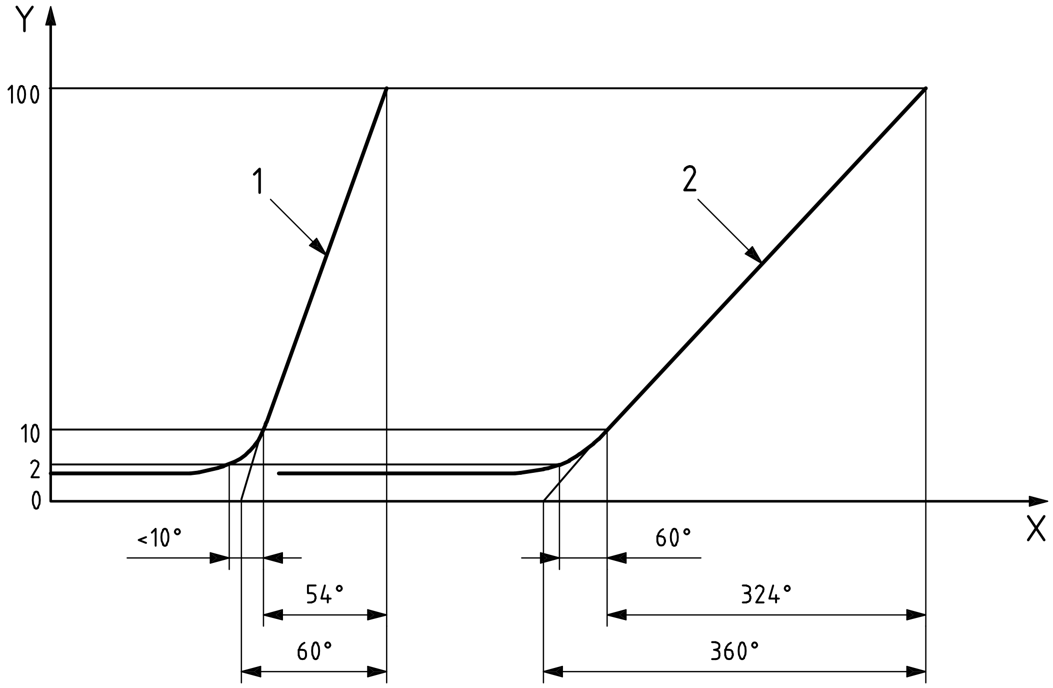
c) The test joints shall be such that the resistance to rotation during the free run-down shall not exceed 2 % of the test torque.

d) The 60° test joint shall be such that the torque increase from 10 % to 100 % of the test torque corresponds to an angular displacement of 54° (see Figure 4).

NOTE An angular displacement of 54° corresponds to a total angle of 60° at a test torque between 0 % and 100 %. The transition angle from 2 % to 10 % of the test torque level shall not exceed 10°.

e) The 360° test joint shall be such that the torque increase from 10 % to 100 % of the target torque corresponds to an angular displacement of 324° (see Figure 4).

NOTE An angular displacement of 324° corresponds to a total angle of 360° at a target torque between 0 % and 100 %. The transition angle from 2 % to 10 % of the test torque level shall not exceed 60°.



Key

X angle

Y test torque level, expressed in percent

1 60° joint

2 360° joint

Figure 4 — Diagram showing torque vs. angle curves for 60° and 360° test joints

4.2.3 The physical size of a joint assembly (mass, inertia, and stiffness) affects the transfer of energy output from the tool to the test joint. Therefore, a test joint shall be consistently and correctly sized. The test bolt should be as short as possible to obtain the deflection in the joint and to minimize the elongation of the bolt and should preferably have the same dimensions for the two test joints. Table 1 specifies maximum fastener sizes for the test joints.

4.2.4 The mass, inertia and stiffness of hardware used to connect the hydraulic impulse tool to the joint also affect the output of the hydraulic impulse tool. Therefore, drive sockets shall be used that fit the test joint fastener and match the hydraulic impulse tool's square drive, without adapters. Hex-drive hydraulic impulse tools may use a hex-to-square adapter, if required. Length extensions shall not be used between the hydraulic impulse tool and the drive socket. Table 1 specifies the maximum sizes for the bits and sockets.

Table 1 — Maximum sizes for the test bits, sockets and fasteners

Characteristic	Fastener size										
	M4	M5	M6	M8	M10	M12	M14	M16	M18	M20	M24
Torque range (N·m)	1 to 3	3 to 5	5 to 15	15 to 30	30 to 55	55 to 90	90 to 150	150 to 200	200 to 300	300 to 450	450 to 700
Max. bolt length (mm)	50	50	50	60	80	80	100	100	120	120	140
Max. socket diameter (mm)	16	16	22	22	30	30	36	40	46	50	60
Max. socket length (mm)	30	30	40	40	40	50	60	60	60	70	70
Max. bit length (mm)	50	50	50	50	—	—	—	—	—	—	—

4.2.5 Torque performance measurements made with this Technical Specification shall be based on the measurement of clamp force within the test joints. Each test joint shall be equipped with means to measure the clamp force during the tightening process. The torque coefficient relating clamp force to dynamic torque shall be measured for each test joint and shall be consistent throughout a performance test. Examples of suitable test joints are shown in Annex B.

4.2.6 To satisfy the requirements of 4.2.5, each test joint shall be calibrated to determine its mean torque coefficient ($\overline{K}$) at a torque level that is within ± 10 % of the test torque as specified below. The preferred method is with a continuous drive spindle as described in 3.7.1.

a) A mean torque coefficient ($\overline{K}$) shall be calculated from 25 peak dynamic torque readings (T_{DP}) and corresponding peak clamp force readings (F_{CP}) according to Equation (3): $K = T_{DP} / \left(F_{CP} \times D \right)$. The 6-sigma scatter of these 25 torque coefficient values shall not exceed 5 % of the mean value.

b) The mean torque coefficient ($\overline{K}$) shall be determined by calculating the mean value in this manner for each test joint before and after the tool test. The mean value measured after the tool test shall be within ± 5 % of the mean value before the tool test. A difference greater than 5 % invalidates the test results for that tool test.

4.2.7 When the calibration measurements are made on a test joint, the joint shall be rotated continuously at a speed not higher than 10 rev/min through a torque/angle transducer and with the joint equipped with a clamp force measuring device.

4.2.7.1 All measuring devices shall be of the correct capacity for the test level to be measured.

4.2.7.2 The angle transducer shall have an angle resolution of at least 1°. There shall be no rotational movement of the transducer housing during the measurement.

4.2.7.3 The accuracy and frequency response of the torque measuring equipment shall comply with the specifications stated in ISO 5393.

4.2.7.4 Clamp force measurements shall be taken by means of a measuring device and an amplifier with peak hold circuit and visual display or printout capability. The frequency response of the measuring device and amplifier shall be − 3 dB at 500 Hz, with a roll-off of at least 50 dB/decade. The repeatability of the clamp force measuring device shall be within ± 1 % of the test clamp force level.

4.3 Test method

4.3.1 All torque performance calculations made with this Technical Specification shall be based on clamp force measurements taken during the fastening process on specified test joints.

4.3.2 The target clamp force for the 60° test joint shall be calculated based on the test torque and the mean torque coefficient ($\overline{K}$) for the 60° test joint as determined in 4.2.6. The tool shall be adjusted to achieve this target clamp force value on the 60° test joint.

4.3.3 A performance test shall consist of 25 clamp force readings on each of the two test joints without further manual adjustment after initial setup. Prior to a performance test, the tool might have to be cycled to stabilize performance.

4.3.3.1 For each test cycle, the tool shall be allowed at least three full revolutions before reaching 10 % of the test target torque.

4.3.3.2 A performance test may be made at any test torque level. To determine a tool's correlated torque scatter capability over a defined torque adjustment range, a test shall be carried out on the 60° and the 360° test joints at the upper test torque and another test shall be carried out on the 60° and the 360° test joints at the lower test torque. Each test joint shall be calibrated for each test torque level according to this Technical Specification.

4.3.3.3 Normally, the tool should be used for loosening the joint. If the tool is not used for loosening the test joint, this shall be so stated in the test report.

4.3.3.4 The 25 test cycles and the loosening operations on each test joint should be performed at a consistent pace without significant delay between cycles.

4.3.4 The correlated torque (T_C) shall be calculated for each of the 25 test cycles using each peak clamp force reading (F_{CP}) and the mean torque coefficient ($\overline{K}$) for the test joint as determined in 4.2.6.

4.3.5 The tightening time and pulse count shall be measured at least once for each test joint at each test torque level.

4.3.5.1 The tightening time and pulse count for an automatic shutoff tool shall be measured from the initial pulse to the point at which the tool shuts off.

4.3.5.2 The tightening time and pulse count for a non-shutoff tool shall be measured from the initial pulse to the point at which the socket stops rotating. To eliminate operator influence, this measurement can be made by electronically determining when the clamp force values for three consecutive impulses satisfy the relationship: $\frac{\Delta F_C}{F_{CT}} < 3\%$. When the clamp force of three consecutive impulses meets this relationship the cycle shall be considered complete.

5 Evaluation of test results

5.1 For evaluating tool performance on each of the joints, the following shall be calculated from the test results:

— mean correlated torque ($\overline{T_C}$) from the 25 calculated correlated torque values;

— standard deviation (s) of the 25 calculated correlated torque values;

— $6s$ correlated torque scatter (S_{6s}) of the 25 calculated correlated torque values;

— $6s$ correlated torque scatter ($S_{6s,p}$) as a percentage of the correlated torque.

The $6s$ correlated torque scatter as a percentage of the correlated torque is calculated as given in Equation (4):

$$S_{6s,p} = \frac{6s}{\overline{T_C}} \times 100 \qquad (4)$$

5.2 For evaluating the tool performance over the range of practical torque rates as defined in 4.2, the following shall be calculated from the test results:

— combined mean correlated torque ($\overline{T_C}_{comb}$). It is calculated as described below;

— mean shift;

— combined correlated torque scatter ($\Delta T_{C comb}$);

— combined correlated torque scatter as a percentage of the combined mean torque.

The values for a to d are defined for use in the calculations which follow:

— $a = \overline{T}_{C\,60} + 3s_{60}$

— $b = \overline{T}_{C\,360} + 3s_{360}$

— $c = \overline{T}_{C\,60} - 3s_{60}$

— $d = \overline{T}_{C\,360} - 3s_{360}$

The combined mean correlated torque ($\overline{T}_{C\,comb}$) is calculated as the higher of a or b plus the lower of c or d, divided by 2.

The mean shift is calculated as $\overline{T}_{C\,60} - \overline{T}_{C\,360}$.

The combined correlated torque scatter ($\Delta T_{C\,comb}$) is calculated as the higher of a or b minus the lower of c or d.

The combined correlated torque scatter as a percentage of the combined mean correlated torque is given by Equation (5):

$$S_{6s,p} = \frac{\Delta T_{C\,comb}}{T_{C\,comb}} \times 100 \tag{5}$$

5.3 Hydraulic impulse tool correlated torque scatter capability may be identified over all or part of a tool's adjustment range. To find a tool's correlated torque scatter capability over a defined range, two tool performance tests shall be carried out on the 60° and 360° test joints. One test at the target torque equal to the upper limit of the defined torque range, and the other test at the target torque equal to the lower limit of the defined torque range.

If a single tool correlated torque scatter capability value (combined correlated torque scatter as a percentage of the combined mean correlated torque) is to be presented for a defined range of correlated torques, the larger scatter capability value at either target torque shall be chosen.

6 Presentation of data

The performance test data shall be presented as shown in the example form in Annex D.

Annex A
(informative)

Explanation and justification of the method

A performance test method for power tools serves the purpose to make tool users able to compare the performance of different tools under defined conditions.

The demand upon a standardized test method for measuring tool performance is that a test of a certain tool carried out in accordance with the standard shall give the same result regardless of the test location or equipment used (as long as the specification is followed). The test results shall be reproducible.

The performance of continuous tightening power tools (nut runners, screwdrivers, etc.) is made by measuring the delivered torque via an inline add-on torque transducer. The standardized test method for doing that is ISO 5393.

Measuring the dynamic torque of a hydraulic impulse tool using ISO 5393 presents several problems. The nature of the impulse tool itself is to deliver multiple torque pulses that accumulate clamp force in the joint. These pulses are difficult to measure. Adding an in-line transducer during testing can affect the transfer of energy.

For impulse tools that are run without an inline add-on torque transducer, the change in tool characteristics with and without the torque measuring device can be different.

For these reasons, the ISO working group ISO/TC 118/SC 3/WG 4 (the working group responsible for the this performance test standard for hydraulic impulse tools) has proposed a test method where the clamp force produced in the test joint is measured. **By measuring the clamp force instead of the torque delivered by the tool the adverse effects of adding an in-line torque transducer, as described above, are eliminated.**

Torque is the common measurable when characterizing a tool's performance. By measuring the test joint's clamp force-to-torque characteristics, the measured clamp force can be “translated” into torque. A torque coefficient (or K-factor) is defined in 3.9 as $K = T_{\mathrm{DP}} / \left(F_{\mathrm{CP}} \times D\right)$.

However, the clamp force obtained in a screw joint is related to friction. **This fact has the consequence that the frictional conditions have to be constant throughout the tests as described in this Technical Specification.** This has been a large concern for the ISO working group. Several types of test joints have been tried. Examples of test joints that have been found to fulfil the requirements of this Technical Specification are described in Annex B. Note, however, that this Technical Specification does not prescribe the use of any particular test joint design. Any test joint can be used as long as the requirements of the Technical Specification are fulfilled.

It shall be stressed that it is very important to carefully monitor the condition of the test joint during the tests. Therefore the K-factor shall be measured before and after each test series. It shall not have changed more than 5 % throughout a test series. Furthermore, the 6-sigma calculation of the K-factor shall not exceed 5 % of the mean K-factor.

According to this Technical Specification, the clamp force-to-torque characteristics are measured quasi-statically by applying torque slowly and continuously while simultaneously recording torque and clamp force. The K-factor is likely to depend on the speed at which torque is applied. Tests made by members of the working group have shown that the K-factor seems to be fairly independent of speed up to 50 rev/min. This means that, under controlled circumstances, the torque coefficient (K) can be determined by applying the torque manually with a wrench, although the application of the torque with a controlled spindle is highly recommended.

It can be discussed whether the calibration of the test joint's clamp force-to-torque characteristics by applying torque at a low speed has any resemblance with the actual situation when an impulse tool is working. An impulse is not quasi-static. Tests have been carried out where clamp force and torque were recorded simultaneously during an actual tightening. A comparison was then made with the results when torque had been applied at different constant speeds. These results are found in Annex C of this Technical Specification. The conclusion is that applying torque continuously seems to resemble the clamp-force buildup during actual tightening with an impulse tool.

Even though there are many question marks when measuring the performance of impulse tools, the working group has decided to publish this Technical Specification. It provides a means to test impulse tools under controlled conditions. The tests carried out have proven that the test method, provided that the test joint's conditions are kept within the limits prescribed in this Technical Specification, gives repeatability and reproducibility.

Finally, it should be noted that torque scatter data obtained in this test are not directly comparable with torque scatter data obtained when testing continuous tightening assembly tools according to the ISO 5393 standard. This can lead to some confusion when comparing the performance between impulse tools and continuously operating assembly tools like screwdrivers and nutrunners.

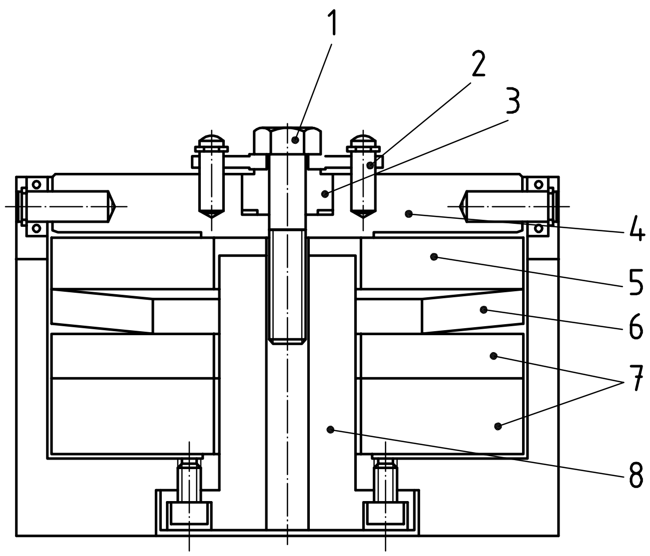
Annex B
(informative)

Clamp force tester

B.1 Mechanical clamp force tester and impulse tool holding device

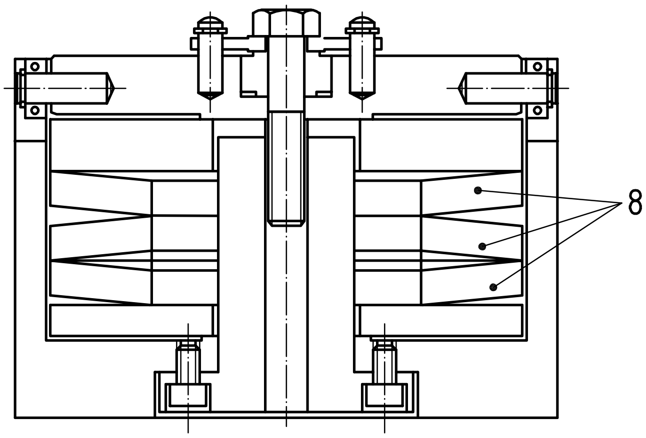
In order to fulfil the requirements of this Technical Specification, a mechanical clamp force tester and a holding device for impulse tools shall have a special design to obtain the best constant friction rate, linearity, repeatability and reproducibility of the K-value and performance data of the impulse tools.

Figure B.1 shows an example of a 40 N·m mechanical clamp force tester for impulse tools with an angle range of 60° and 360° joints.



a) 60° joint

Figure B.1 — Mechanical clamp force tester (*continued*)



b) 360° joint

Key

1 test bolt
2 under-head washer
3 load cell
4 top plate
5 top spring plate
6 Belleville spring
7 spacer
8 threaded nut

Figure B.1

B.2 Description of the mechanical test joint

a) Test bolt

The test bolt has a special surface coating which minimizes any stick slip effect between screw head and under-head washer as well as between the thread itself. It is important for a good linearity that the test bolt shall have equal dimensions for both categories and should be as short as possible to obtain stiffness. It is recommended that the test bolt length should not exceed 6D to 8D. For M10 bolts, the length should not be more than 80 mm.

b) Under-head washer

As a physical fact, “friction means wear” and abrasive particles change the condition of the clamp force tester. In order to minimize wear and to maximize constancy of the clamp force tester's performance, all parts that take up torque shall be hardened and the surfaces of the under-head washer shall be super-finished down to 0,5 µ. It shall also be properly centred, radially and tangentially fixed by two pins and with minimum play in order to prevent any torque displacement versus clamp force during the tightening process (e.g. for the linearity of the K-value).

c) Load cell

The load cell, to measure clamp force, shall be short built to allow as short a clamp length as possible. Otherwise, the angle requirement for 60° cannot be obtained. The load cell should be based on a jolt sleeve principle for the same reason.

d) Top plate

The top plate takes up the load cell and the under-head washer and shall also be properly centred, radially and tangentially fixed with little play in order to prevent any torque displacement versus clamp force during the tightening process. Two ball bearings at the circumference minimize additional friction when the top plate is moving downwards relative to the housing during the tightening process.

e) Top-spring plate and spacer

The top-spring plate and the spacer are the same part, only used differently. As a top-spring plate, it is used to fine-adjust the torque/angle requirements. As a spacer, it is used to fill up the space below the Belleville springs, so that the distance between top plate and threaded nut remains between 2 mm and 5 mm. There is a set of spacers with widths starting with 8 mm and ending with 24 mm spaced 2 mm apart.

f) Distance ring

The distance ring provides a space between the spring plate and the spacer and allows the necessary deflection for the spring plate to achieve 60° for the joint.

g) Belleville washer

To keep a constant torque/angle rate of a mechanical tester, it is necessary to use as few Belleville springs and spacer layers as possible. The 360° M10 joint, for example, with a pitch of 1,5 mm deflects the Belleville spring 1,5 mm. This transformation to a multi-layer Belleville spring system does not provide the essential constancy and performance accuracy of the tester. Therefore, a 360° joint uses only three Belleville washers, each mounted against the other in the opposite way. There is a wide range of standard Belleville washers with equal outside diameter but with different widths and different inside diameters, so that a range of test bolt sizes and different torque/angle rates can be used with one size of housing.

h) Threaded nut

The internal thread should be at least about 2 D long and hardened. It is important that the test bolt always uses the total length of the nut. The top of the nut should be right angle, so that the top plate also can be rested on it. This application provides the smallest possible angle for a 60° clamp force tester.

To maintain the condition of this clamp force tester, it is necessary to handle all the parts with care when changing the set-up of a category. There are no significant differences between the K-values for lubricated and non-lubricated conditions. However, it is recommended to lubricate the thread and the under-head washer once in a while because of the longer expected life. Only if the K-value drops, rises or shifts beyond the specified limits during the K-value determination should the clamp force tester be checked and serviced.

B.3 Impulse tool holding device

In order to prevent most of the negative influences by the test person when testing an impulse tool, a holding device shall be used and should have the following considerations. Figure 2 shows an example of a test rig on which impulse tools have been successfully tested according to this Technical Specification.

The following are important considerations.

a) The impulse tool shall not be clamped tight in the test device.

b) The impulse tool shall be centre-aligned with the clamp force tester.

c) The design of the test device shall be stable. The impulse tool should be preferably mounted vertical on three guiding bars.

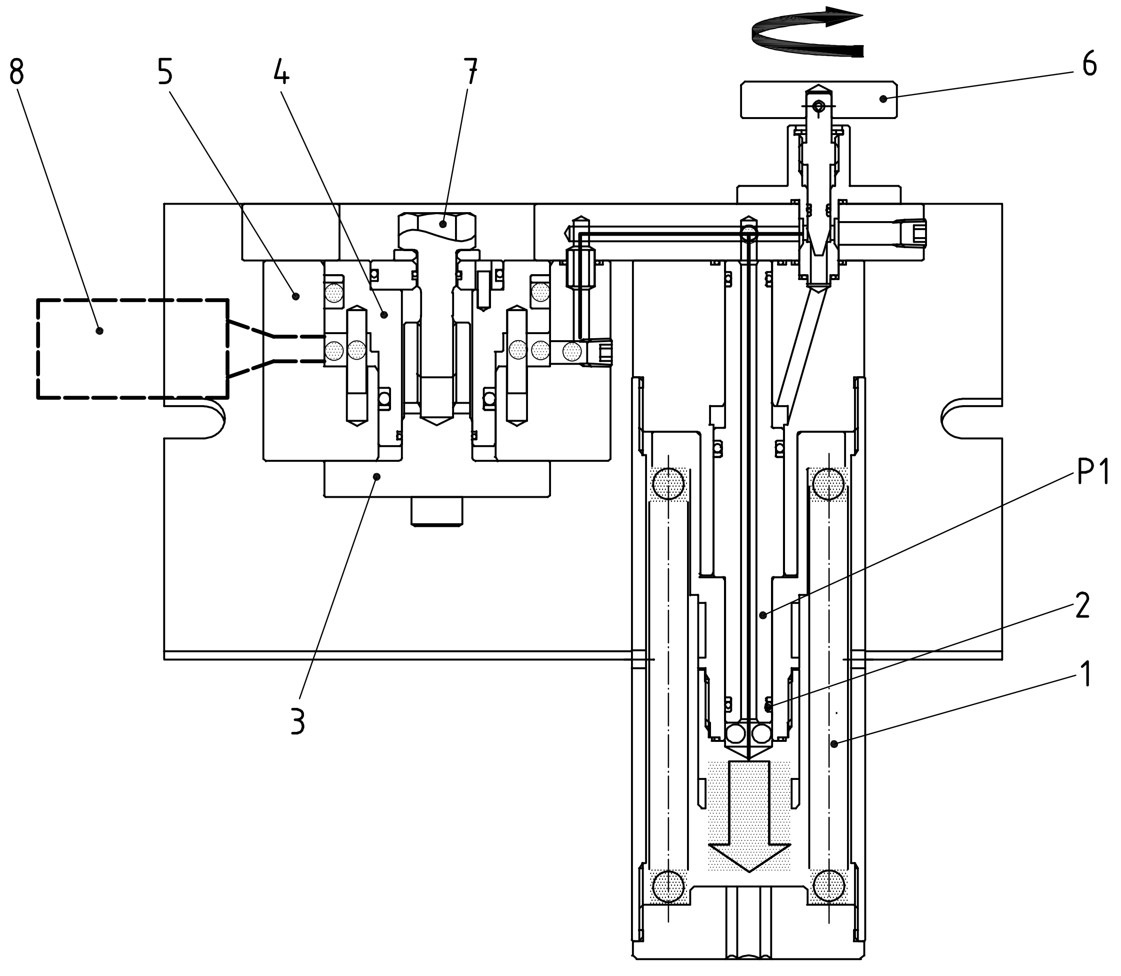
d) Two supports, one at the back and one at the front, shall centre the impulse tool to prevent any radial force to both joints while the impulse tool is being operated by the test person.

e) The mass of the top support rests freely onto the tool. The axial force should not be more than twice the weight of the impulse tool.

f) The bottom support of the tool can be clamped to the rig bar in order to adjust the impulse tool vertically relative to the test joints.

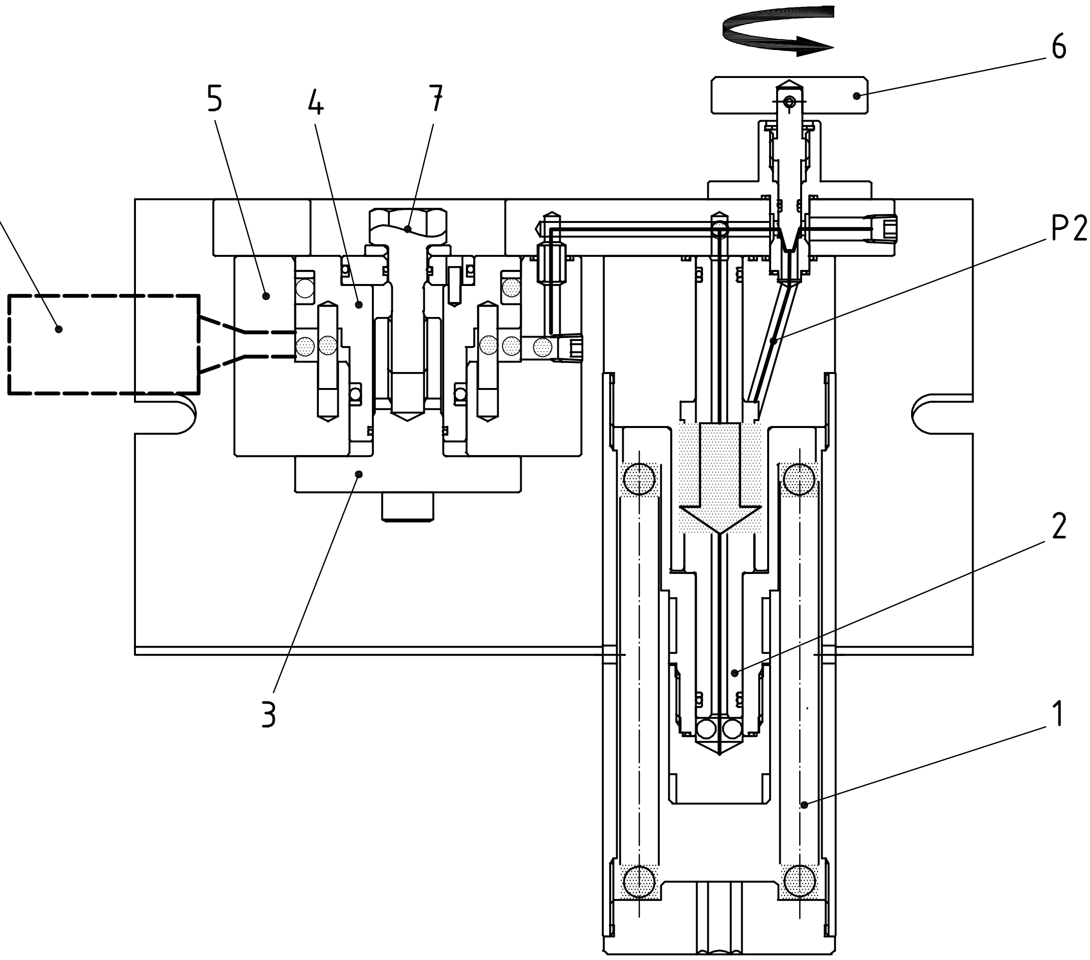
B.4 Hydraulic clamp force tester

The device described herein has been demonstrated to comply with the requirements of this Technical Specification for the specified test joints. The spring used to control the torque rate is hydraulically coupled to the bolted joint. A manually controlled valve allows either the 60° or the 360° joint to be selected while using the same bolted joint.



a) 60° joint

Figure B.2 — Hydraulic clamp force tester (*continued*)



b) 360° joint

Key

1 spring
2 piston
3 spindle nut
4 plunger
5 housing
6 joint selector
7 test bolt
8 pressure gauge
P1 oil passage for the 60° joint and the 360° joint
P2 oil passage for the 360° joint

Figure B.2

B.4.1 Operating principle

The hydraulic clamp force tester operates on the following principle.

a) The hydraulic chamber, consisting of the housing (Figure B.2, item 5) and the plunger (Figure B.2, item 4), is fastened by the spindle nut (Figure B.2, item 3) and the test bolt (Figure B.2, item 7).

b) The fastening force is transferred to the piston (Figure B.2, item 2) through hydraulic fluid.

c) The movement of the piston (Figure B.2, item 2) is restricted by the tension spring (Figure B.2, item 1).

d) The joint rate is determined with the spring (Figure B.2, item 1) adjusted to the required test torque level.

e) The clamp force can be output to the pressure gauge.

B.4.2 Features

Either a 60° or a 360° joint can be selected to test using the joint selector. The shape of piston (Figure B.2, item 2) has two areas to receive hydraulic pressure. By turning the joint selector, the oil passage is switched to either P1 or P2 in Figure B.2 for the desired joint rate.

The piston (Figure B.2, item 2) has been designed so as to have a 1:6 oil passage ratio (area of P1 to P2). This means that the 60° joint and the 360° joint can be simply selected by the joint selector without changing the springs. This helps to avoid preparation of numerous test fixtures required for different torque levels.

Annex C
(informative)

Torque coefficient (K) dependence on speed

According to this Technical Specification, the torque coefficient (K) of the test joint is measured by applying torque slowly and continuously while recording the torque and the clamp force values. The joint shall be rotated continuously at a speed less than 10 rev/min.

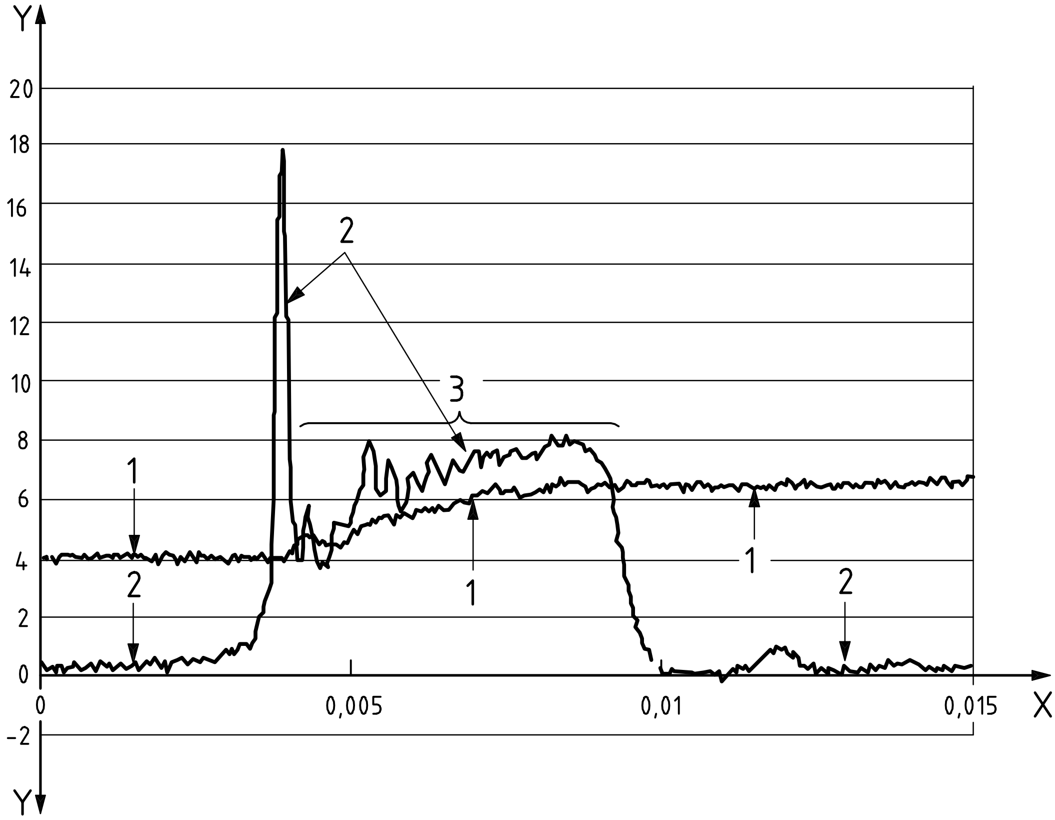
It can be discussed whether the measurement of a test joint's clamp force-to-torque relationship by applying torque at a low speed has any resemblance to the actual situation when an impulse tool is working.

Experiments were carried out to address this issue. Clamp force and torque have been recorded simultaneously during actual tightening and the results were compared with the results when torque was applied slowly at different speeds, as shown in Figures C.1 to C.3.

— Figure C.1 shows how the clamp force is built up during a single pulse from the tool. It can be seen that the initial spike does not contribute to any clamp force creation.

— Figures C.2 and C.3 show the torque/clamp force relation for an impulse tool run on the 60° and 360° test joints, together with the torque/clamp force relation recorded when applying torque continuously at different speeds (5 rev/min to 100 rev/min). The envelope of the part of the clamp force/torque curves that create clamp force overlap with the clamp force/torque lines recorded at the speed ranges from 5 rev/min to 100 rev/min, except for the 100 rev/min curve recorded on 360° joint.

The conclusion from the above then becomes that applying torque continuously at speeds lower than 50 rev/min resembles the clamp-force buildup during actual tightening with an impulse tool. This justifies the method chosen in this Technical Specification for calibrating the torque coefficient (K-factor) by applying torque continuously at less than 10 rev/min.



Key

X time, expressed in seconds

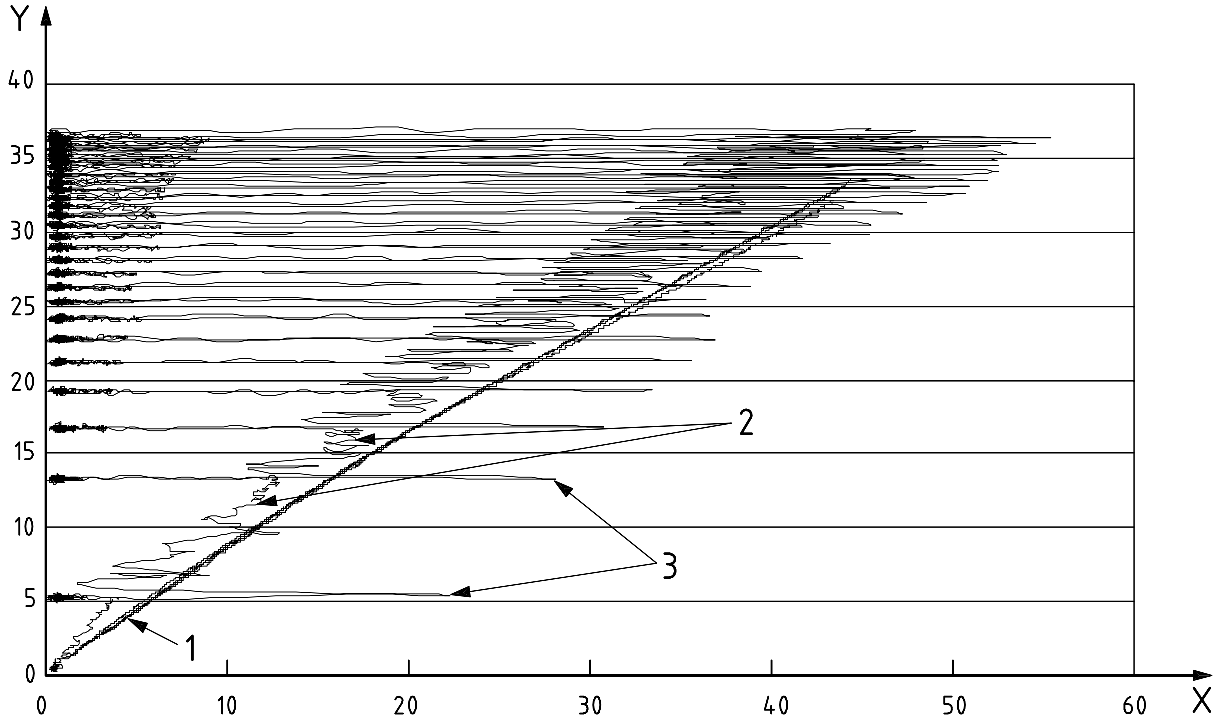
Y torque, expressed in newton-metres, or clamp force, expressed in kilonewtons

1 clamp force

2 torque

3 part of the torque pulse creating clamp force

Figure C.1 — Torque and clamp force build-up with an impulse tool during a single pulse



Key

X torque, expressed in newton-metres

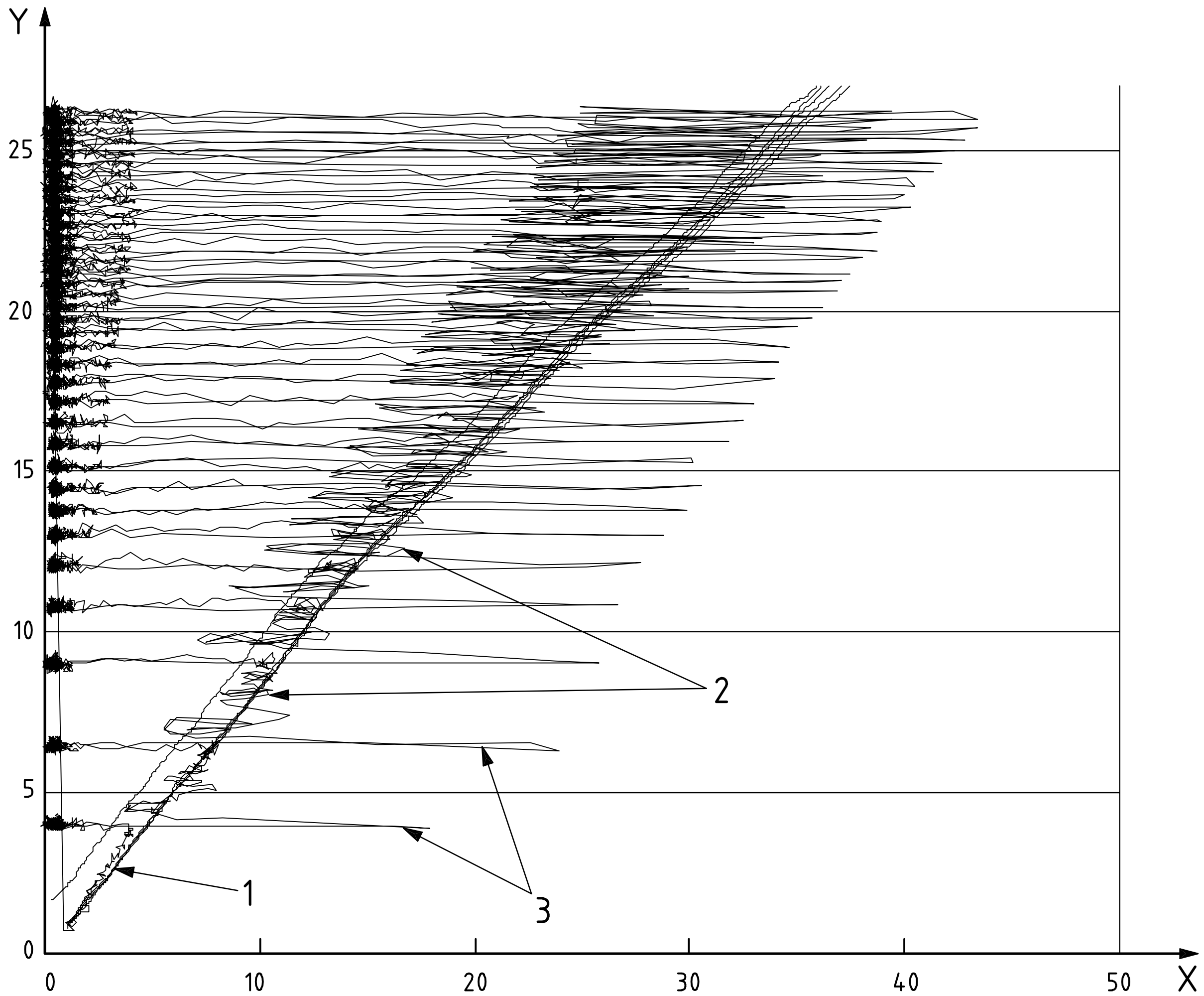
Y clamp force, expressed in kilonewtons

1 envelope of curves representing tool responses recorded at different continuous speeds (5 rev/min, 10 rev/min, 20 rev/min, 50 rev/min and 100 rev/min

2 response of the impulse tool

3 torque spikes not creating clamp force

Figure C.2 — Torque/clamp force relation for an impulse tool run on a 60° joint compared with the torque/clamp force relation when applying torque continuously at different speeds



Key

X torque, expressed in newton-metres

Y clamp force, expressed in kilonewtons

1 envelope of curves representing tool responses recorded at different continuous speeds (5 rev/min, 10 rev/min, 20 rev/min, 50 rev/min and 100 rev/min)

2 response of the impulse tool

3 torque spikes not creating clamp force

Figure C.3 — Torque/clamp force relation for an impulse tool run on a 360º joint compared with the torque/clamp force relation when applying torque continuously at different speeds

Annex D
(informative)

Example of form for hydraulic impulse tool performance test

Type of tool ______________________________

Manufacturer ______________________________

Model Number ______________________________

Free speed: __________________________ rev/min

Serial Number ________________________________

State loosening method (see 4.3.3.3)

____

I. Upper Test Torque (adjusted on the 60º test joint) ______________ N·m

Dynamic air pressure (measured during pulsing at tool inlet) ______________ MPa (Bar)

Performance data on 60° joint and 360° joint:

	60° joint	360° joint
Pulse count		
Tightening time, in seconds		
Mean correlated torque, in newton-metres		
Standard deviation s of mean correlated torque		
6s correlated torque scatter		
6s correlated torque scatter, in percent		

Combined performance data 60° joint and 360° joint:

Combined mean correlated torque	
Mean shift	
Combined correlated torque scatter	
Combined correlated torque scatter, in percent	

II. Lower Test Torque (adjusted on the 60º test) ________________ N·m

Dynamic air pressure (measured during pulsing at tool inlet) ______________ MPa (Bar)

Performance data on 60° joint and 360° joint:

	60º joint	360º joint
Pulse count		
Tightening time, in seconds		
Mean correlated torque, in newton-metres		
Standard deviation s of mean correlated torque		
6s correlated torque scatter		
6s correlated torque scatter, in percent		

Combined performance data 60° joint and 360° joint:

Combined mean correlated torque	
Mean shift	
Combined correlated torque scatter	
Combined correlated torque scatter, in percent	

III. Capability Summary:

Combined correlated torque scatter, in percent	

Tested in accordance with ISO/TS 17104 Tested by: ___________ Date: _______

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