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Forestry machinery — Portable chain-saws — Kickback test

Matériel forestier — Scies à chaîne portatives — Essai de rebond

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 23, *Tractors and machinery for agriculture and forestry*, Subcommittee SC 17, *Manually portable forest machinery*.

This third edition cancels and replaces the second edition (ISO 9518:1998), which has been technically revised

Besides editorial corrections the following changes have been made to the previous edition of this document:

— Scope: inclusion of electric-powered chain-saws;

— 3 Terms and definitions: reference to ISO 6531 added and definitions updated;

— 4.3.6 Test specimens: hardness requirement for MDF test specimens added;

— 4.4.5 Kickback machine preparation: weight of standard and lightweight carriage defined;

— 4.4.8 Horizontal friction measurements: Horizontal friction test methods added;

— 4.4.9 Rotary friction measurements: Rotary friction test methods added;

— 4.4.10 Horizontal and rotary restraining systems alignment: Restraining systems adjustments specified more precisely;

— Annex B [Procedure for hardness testing of Medium Density Fibreboard (MDF)] has been added;

— Annex D (Chain-saw centre of gravity and inertia measurement) revised.

Forestry machinery — Portable chain-saws — Kickback test

1 Scope

This document specifies the methodology for determining the kickback potential of gasoline-powered and electric-powered (including battery powered) chain-saws, complete with guide bar and saw-chain.

This document has been demonstrated to be an accurate method of measurement for evaluating computed kickback angles and energy associated with chain-saw kickback for electric-powered chain-saws (including battery powered) and gasoline-powered chain-saws with engine capacity up to 80 cm^3. It is not intended to evaluate chain-saws with an engine capacity of above 80 cm^3. Furthermore, because of physical size limitations of the kickback machine, it is not intended for testing of units with guide bar cutting length in excess of 63 cm.

Modifications to the methodology for determining the kickback potential introduced in this edition are aimed to have a better reproducibility of the results; test results obtained according to the previous methodology still maintain their validity.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 6531, *Machinery for forestry — Portable chain-saws — Vocabulary*

ISO 6535, *Portable chain-saws — Chain brake performance*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 6531 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
bar nose radius
continuous radius formed on the top portion of the bar from the centreline of the bar to an angle 35° above the centreline

Note 1 to entry: See Figure 1.

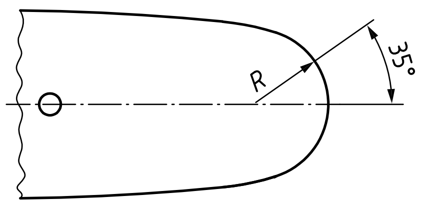


Figure 1 — Bar nose radius

3.2
manually activated chain brake
chain brake which is intended to be actuated by the hand of the operator

3.3
contact angle
angle between the surface of the test specimen and a perpendicular to the guide bar centre line

3.4
data set
group of data points, all taken at the same test conditions

3.5
horizontal system
portion of the kickback machine used to measure the horizontal (linear) energy of the kickback reaction

3.6
impact
test sequence involving releasing the test specimen at a specified speed into contact with the moving saw-chain at the guide bar tip to create a simulated kickback reaction

3.7
rotary system
portion of the kickback machine used to measure the rotary energy of the kickback reaction

3.8
specimen
test specimen
block of medium density fibreboard used as an object for the saw-chain to engage in a simulated kickback

4 Test method

4.1 Principles

The flat surface of the test specimen (MDF) is thrust into contact with the moving saw-chain at the tip of a chain-saw guide bar at a specified speed in order to produce a simulated kickback reaction. This takes place under controlled conditions in the kickback machine, which is designed to measure the magnitude of rotary and horizontal energies generated during the resulting kickback reaction.

A step-by-step search, covering a range of critical test conditions, determines the peak energy values to be used in calculating the computed kickback angle(s) CKA using the analytical model. This peak value is intended to simulate the most severe conditions reasonably expected to be encountered by typical users.

Since there may be some variability, several impacts are made under each set of conditions and the results averaged.

NOTE Test parameters such as approach speed, engine speed, shape and type of test materials have been established to permit consistent evaluation of a wide range of cutting attachment and type of power heads and to simulate kickback situations found in actual practice.

4.2 Chain-saw configuration

4.2.1 General

The worst-case configuration (e.g., saw-chain with the highest kickback magnitude) can be demonstrated on a chain-saw with cutting attachments of the same class and pitch.

4.2.2 Chain-saw families

For the purposes of chain-saw qualification, saws that have an engine displacement within 20 % and similar mass distribution (having centre of gravity coordinates within ±5 mm, a mass tolerance of ±0,2 kg, and a polar moment of inertia [PMI] tolerance of ±10 %) shall be regarded as being equivalent to one another. However, if a saw family within this range is to be qualified, at least the largest displacement saw shall be tested.

4.2.3 Requirements for testing bars and saw-chains

A guide bar with the largest bar nose radius and/or the greatest number of sprocket teeth represents the highest energy configuration and covers all other bars of the same length with a smaller radius. Tests need not be repeated for saw-chains that have been documented to have lower kickback potential than the highest kickback energy saw-chain on equivalent types of chain-saws.

At a minimum, testing shall be performed with the largest bar nose radius of the manufacturer's designated standard guide bars recommended for sale to the end-user. If multiple bar lengths are listed in the operator's manual, the longest, shortest, and one other length shall be tested. If the kickback test results for each of these lengths are less than 35° CKA, all other lengths shall be accepted. If any guide bar exceeds 35° CKA, all bar lengths shall be tested.

4.3 Equipment and materials to determine CKA

4.3.1 Computer program, as specified in Annex A, to compute the kickback angle using measured inputs.

4.3.2 Chain-saw kickback test machine for energy level measurements.

4.3.3 Engine speed indicator with an accuracy of ±1,5 % of the measured value.

4.3.4 Carriage-velocity timing device, including probes with an accuracy of ±1 ms.

4.3.5 Timer control switch box.

4.3.6 Test specimens, consisting of medium-density fibreboard (MDF) samples, 38 mm × 38 mm × 250 mm or 38 mm × 76 mm × 250 mm. The samples shall be oriented with the rough side (end grain) facing the bar tip. The density range shall be 737 kg/m^3 ± 32 kg/m^3. The samples shall have a hardness of 2 892 N ± 667 N (the method for determining fibreboard hardness is specified in Annex B).

4.3.7 Chain-brake actuating apparatus (for complete chain-saw tests only).

NOTE The bill of materials and engineering drawings describing a kickback test machine, the kickback calculation program, and a manual entitled "Chain-saw Kickback Test Machine - Principles of Operation" are available on request from the Outdoor Power Equipment Institute, 341 S Patrick St, Alexandria, VA 22314, USA.

4.4 Preparation

4.4.1 General

Record all measurements on the kickback test record (see Figures C.1 and C.2).

4.4.2 Physical measurements of chain-saw

4.4.2.1 Prior to taking measurements prepare the chain-saw and saw-chain in accordance with 4.4.4. The physical measurements listed in 4.4.2.2 to 4.4.2.4 shall be made with the guide bar and saw-chain attached in proper working position and with oil and fuel tanks full.

4.4.2.2 Measure the chain-saw mass in kilograms. An accuracy of ±50 g is acceptable for this measurement.

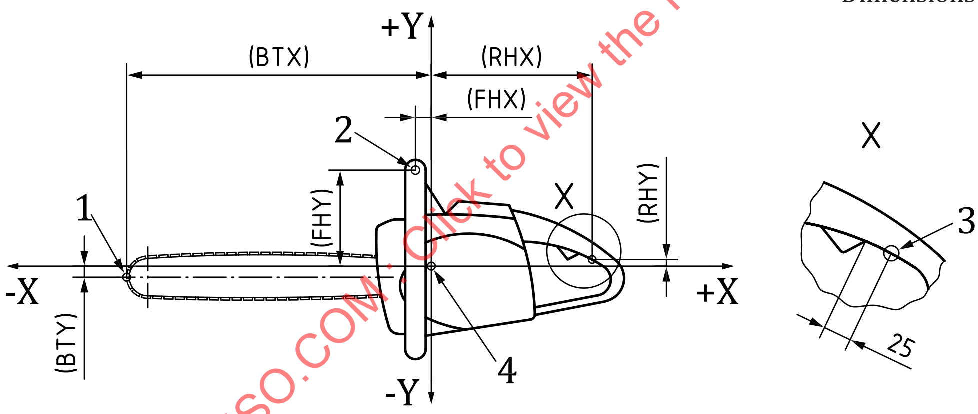
4.4.2.3 Determine the location of axis of rotation, through the centre of gravity, perpendicular to the plane of the guide bar. It is to be marked on the saw body. An accuracy of ±6 mm is acceptable for this measurement.

4.4.2.4 Determine the chain-saw polar moment of inertia (PMI) about an axis through the centre of gravity and perpendicular to the plane of the guide bar, in kilograms metre squared. A procedure for determining the polar moment of inertia is presented in Annex D.

4.4.3 Dimensional measurements

4.4.3.1 The bar tip and handle coordinates shall be measured in millimetres to an accuracy of ±3 mm as follows: (see Figure 2).

Dimensions in millimetres



Key

1 bar tip coordinates

2 front handle coordinates

3 rear handle coordinates

4 centre of gravity

Bar tip coordinates (BTX, BTY) are with the chain adjusted so that maximum X dimension is obtained. Measure to the tip of the chain on the guide bar located along the projected centreline of the guide bar. For asymmetrical bars, it is located along a line through the centre of the upper quadrant nose radius and parallel to the guide bar centreline.

Front handle coordinates (FHX, FHY) are measured to the centre of the front handle bar. If the handle is angled in any plane or direction, use the midpoint of the grip area.

Rear handle coordinates (RHY, RHY) are measured 25 mm behind the rear edge of the throttle trigger on the underside of the handle surface.

Observe the sign convention carefully.

The Centreline of guide bar shall be horizontal.

Measure the chain-saw bar tip and handle locations from the centre of gravity.

Figure 2 — Coordinate measurements

4.4.3.2 The chain-saw shall be positioned on a level surface so that the centreline of the guide bar is level. The guide bar tip, Point B, shall be located at the intersection of a horizontal line through the nose radius with the outermost element of the saw-chain. This measurement shall be made with the chain adjusted such that the maximum X dimension is obtained to the tip of the chain on the guide bar. Measure and record BTX, the horizontal displacement from the centre of gravity to Point B. Measure and record BTY, the vertical displacement from the centre of gravity to Point B.

For non-symmetrical bars, Point B will not lie on the centreline of the guide bar. The saw-chain shall be rotated to the greatest horizontal displacement.

4.4.3.3 On the front handle, Point F shall be located at the centre of the front handle, at the midpoint of the hand-grip segment. Measure and record FHX, the horizontal displacement from the centre of gravity to Point F. Measure and record FHY, the vertical displacement from the centre of gravity to Point F.

If the handle is angled in any plane or direction, use the midpoint of the grip area.

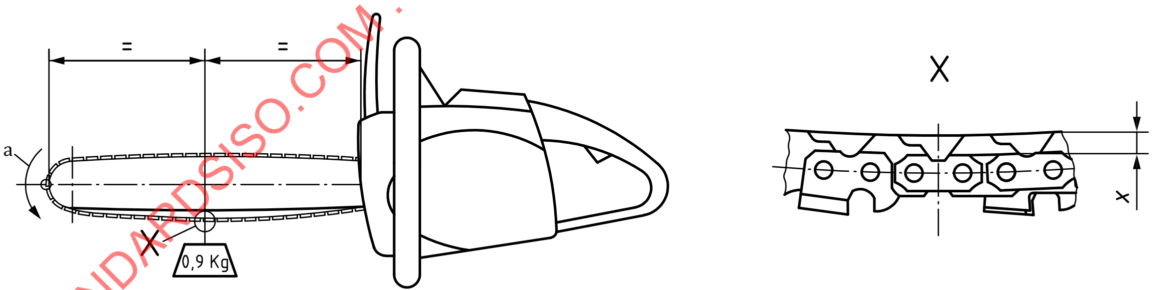
4.4.3.4 On the rear handle, Point R shall be located by determining the intersection of a 25 mm radius arc with the lower portion of the rear handle. (The arc shall originate at the lowest point where the throttle control trigger of the chain-saw intersects the saw casing.) Measure and record RHX, the horizontal displacement from the centre of gravity to Point R. Measure and record RHY, the vertical displacement from the centre of gravity to Point R.

4.4.4 Chain-saw and saw-chain preparation

4.4.4.1 The chain-saw and saw-chain shall be prepared for testing using the following procedure.

4.4.4.2 The saw-chain shall be new.

4.4.4.3 Saw-chain tension shall be set to provide a maximum clearance between the chain and the bar of 0,017 mm per mm of the bar length, in accordance with Figure 3. The chain should move freely on the bar with moderate hand pressure.



Key

x maximum 0,017 x rated bar cutting capacity

a Rotate chain to the tightest condition.

Figure 3 — Saw-chain tension adjustment

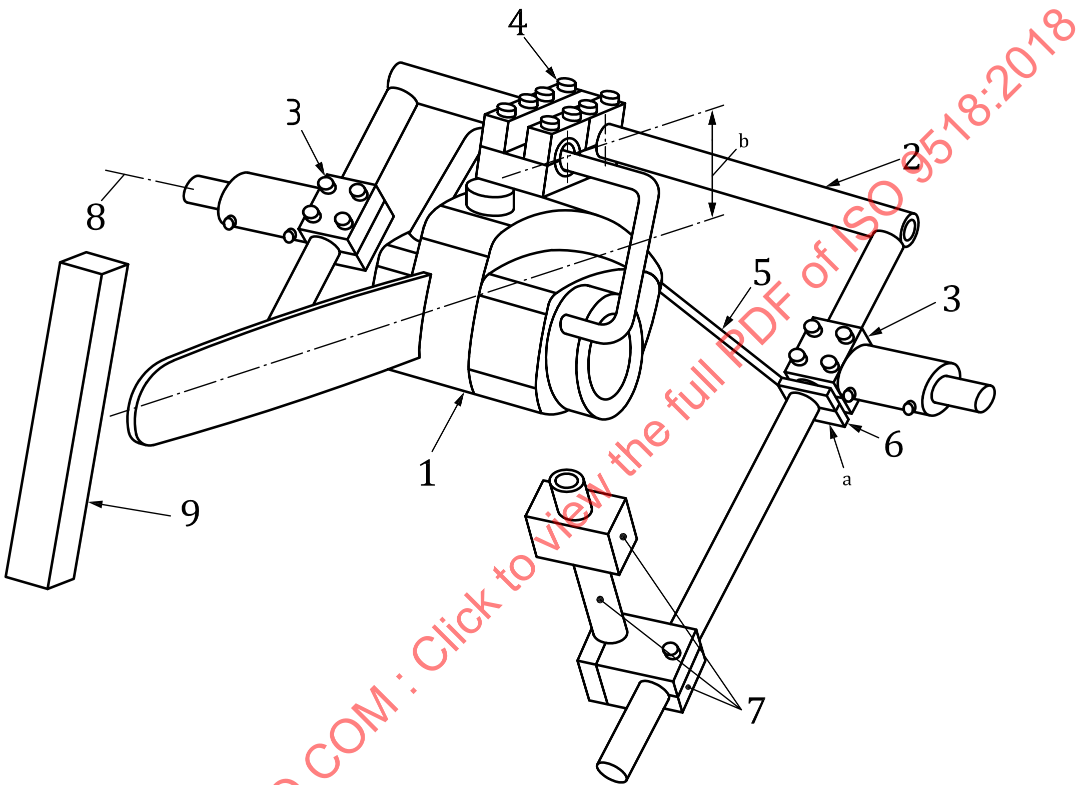
4.4.4.4 The chain-saw shall be in functionally new condition.

4.4.4.5 The chain-saw shall be run-in according to the manufacturer’s recommendations.

4.4.4.6 If the saw is equipped with a removable bar tip guard, remove the bar tip guard for testing.

4.4.4.7 If the saw is equipped with a chain brake, disable the mechanism if necessary to prevent activation. The chain brake may be rendered inoperative by physically blocking the brake mechanism against operation or by tying the chain brake lever to the front handle.

4.4.4.8 Remove the front handle grip cover (if any) in the area where the saw handle clamp will be attached and construct a clamp insert to fit the saw handle. Attach the saw handle clamp to the front handle and the cradle so that the longitudinal axis of the guide bar is level and parallel to the longitudinal axis of the kickback machine as nearly as possible and the guide bar plane is in a vertical position (see Figure 4). Tighten securely.



Key

1 chain-saw
2 cradle
3 support block
4 clamp
5 brace assembly
6 brace
7 balancing weights
8 kickback machine rotary axis
9 MDF specimen
[a] One brace preferred, second brace optional; brace to be attached as close to support blocks as possible.
[b] Clamp centreline parallel to guide bar centreline.

Figure 4 — Installation of saw/clamp/cradle assembly

Under some test conditions, the front handle may become distorted, making testing difficult and subject to error. Substitution of a stronger, fabricated handle is permitted, so long as location of the centre of the mounting clamp is substantially unchanged from the original handle. Weight increase is to be minimized, and in no instance is total added weight to exceed 5 % of the empty saw weight. Adjust the chain-saw CG location, balance and mass of carriage matching weight accordingly, but unmodified chain-saw mass and PMI shall be used for computer calculations of CKA.

For electric chain-saws, the mass, centre of gravity, and polar moment of inertia measurements shall be made with no extension cord plugged into the saw. The length of power cord protruding from the saw shall be positioned over the rear handle and taped or tied in position. For purposes of this test, the maximum length of power cord supplied with the electric saw should be 300 mm.

4.4.4.9 Attach the cradle to the saw clamp assembly. Do not tighten bolts to the cradle assembly.

4.4.5 Kickback machine preparation

4.4.5.1 Before installing the chain-saw and cradle into the kickback machine, prepare the kickback test machine as follows.

4.4.5.2 If the chain-saw mass (see 4.4.2.2) is less than the standard carriage (3,8 kg), the standard carriage may be replaced with the lightweight carriage (2,2 kg).

4.4.5.3 Insert a fibreboard test specimen in the carriage clamp. The specimen shall be oriented with the rough side (end grain) facing the guide bar tip.

4.4.5.4 If necessary, add mass to the carriage until the carriage mass (including fibreboard test specimen and any clamps, if used) equals the mass of the saw ±100 g.

4.4.6 Chain-saw installation and alignment

4.4.6.1 The chain-saw and cradle assembly shall be installed and aligned into the kickback test machine with the following procedure.

4.4.6.2 Install the saw/clamp/cradle assembly in the kickback machine in accordance with Figure 4, and align the guide bar with the centreline of the fibreboard specimen.

4.4.6.3 Adjust the chain-saw, clamp and cradle in the kickback machine so that the centre of gravity of the saw is aligned to within ±3 mm of the rotary axis. Make this adjustment by rotating the saw/clamp/assembly where it attaches to the cradle and by sliding the cradle in the support blocks.

Do not rotate the clamp where it attaches to the saw handle, this was adjusted in 4.4.4.8.

4.4.6.4 Attach a brace assembly between the chain-saw rear handle and either leg of the cradle as nearly as possible to the rotary axis, and with mass of brace centred as nearly as possible about the rotary axis. A second brace may be installed if needed to maintain saw position during testing.

4.4.6.5 Securely tighten all assembly fasteners.

The mass and position of brace assembly can affect test results. The mass of the brace assembly shall not exceed 0,4 kg.

For electric saws, the cord shall be secured and routed from the front handle so as to closely follow the axis of rotation in such a manner that the cord shall not impede the free rotation of the chain-saw.

4.4.7 Balance saw/clamp/cradle assembly

4.4.7.1 The system shall be balanced using the minimum amount of mass located as close to the rotary axis as possible (see Figure 4).

4.4.7.2 Fuel and oil tanks shall be full.

NOTE External fuel and oil supplies to maintain full tanks are acceptable.

4.4.7.3 Acceptable initial balance is achieved when the saw/clamp/cradle assembly will not rotate at the “horizontal” or “vertical” positions or when a 60 g mass hung from the rotary pulley will counter any observed rotation. If the centre of gravity of the saw shifts due to soft vibration isolators, a compromise between the horizontal and vertical positions is permissible.

For convenience, a record of the position of balancing weights and external braces may be kept on a form such as that shown in Figure C.2.

4.4.8 Horizontal friction measurements

4.4.8.1 General

Horizontal friction shall be measured prior to and after kickback energy tests. Measurements shall be made with the ratchet pawl in its activated position. Pulleys for restraining the weight system shall spin freely. The average of the horizontal friction measurements in the direction of travel away from the powerhead shall not exceed 2,2 N.

4.4.8.2 Carriage bearing alignment

If necessary to meet the maximum tolerance for horizontal friction, the carriage bearings may be aligned using the following procedure.

a) One bearing shall be adjusted with the other one loose. After adjustment, the position of the adjusting screw shall be noted when the first bearing is aligned.

b) The first bearing shall be loosened and then the second bearing shall be adjusted. When loose, each bearing shall be tightened until it begins to grip the shaft. The tightening shall be stopped just before an increase in the force required to move the bearing is felt.

c) The first bearing shall be returned to its proper setting.

4.4.8.3 Horizontal friction test

4.4.8.3.1 General

To determine the horizontal friction one of the following test methods A or B shall be used.

4.4.8.3.2 Horizontal friction test method A

a) Weights shall be attached to the carriage, with the MDF specimen installed, to equal, within 100 g of the mass of the chain-saw.

b) The friction measurement weight cup shall be connected to the carriage.

c) Sufficient mass shall be added to the cup assembly to cause the carriage to move at least 0,3 m (with the ratchet in place). Record the weight of the cup and the amount of added mass needed.

d) When the mass required to move the carriage exceeds 0,23 kg, the bearings shall be cleaned and the machine shall be adjusted as required.

e) Horizontal friction, f_h, shall then be computed as follows:

$$f_h = m_1 + m_2$$

where

m_1 is the mass of cup assembly, expressed in kilograms;

m_2 is the added mass, expressed in kilograms.

4.4.8.3.3 Horizontal friction test method B

a) A 0,23 kg mass and cable assembly shall be attached to the carriage.

b) When the mass causes the carriage to travel at least 0,3 m, with ratchets in place, the friction level shall be within tolerance.

c) The horizontal system shall be cleaned and adjusted to reduce the friction level if necessary.

d) Horizontal kickback energies shall be computed with a frictional level of 2,2 N.

4.4.9 Rotary friction measurements

4.4.9.1 General

Rotary friction shall be measured prior to and after kickback energy tests. Measurements shall be made with the ratchet pawl in its activated position. Pulleys for restraining the weight system shall spin freely. The average of the rotary friction measurements shall not exceed 2,2 N.

In saws with soft isolator systems, the centre of gravity shifts as the saw and cradle rotate. If shifting of the centre of gravity of the saw prevents accurate friction measurements, a substitute saw of about the same mass may be used for friction measurements.

4.4.9.2 Rotary bearing alignment

If necessary to meet the maximum tolerance for rotary friction, the rotary bearings may be aligned and adjusted using the following procedure.

a) The rotary machine parts shall be removed and an alignment shaft placed through the rotary bearings.

b) The alignment shaft shall be levelled.

c) The pillow blocks and bearing plates shall be adjusted so that the shaft passes easily through the bearings and rotates freely.

4.4.9.3 Rotary friction test

4.4.9.3.1 General

To determine the rotary friction one of the following test methods A or B shall be used.

4.4.9.3.2 Rotary friction test method A

a) The friction-measurement weight cup shall be attached to the rotary pulley with the cradle legs horizontal.

b) Sufficient mass shall be added to the weight cup to cause a saw rotation of at least 180°, with ratchet pawls in place.

c) When the mass required to move the rotary system exceeds 0,23 kg, the bearings shall be cleaned and adjusted to bring the friction level within tolerance.

d) Rotary axis friction, f_r, shall then be computed as follows:

$f_r = m_1 + m_2$

where

m_1 is the mass of cup assembly, expressed in kilograms;

m_2 is the added mass, expressed in kilograms.

4.4.9.3.3 Rotary friction test method B

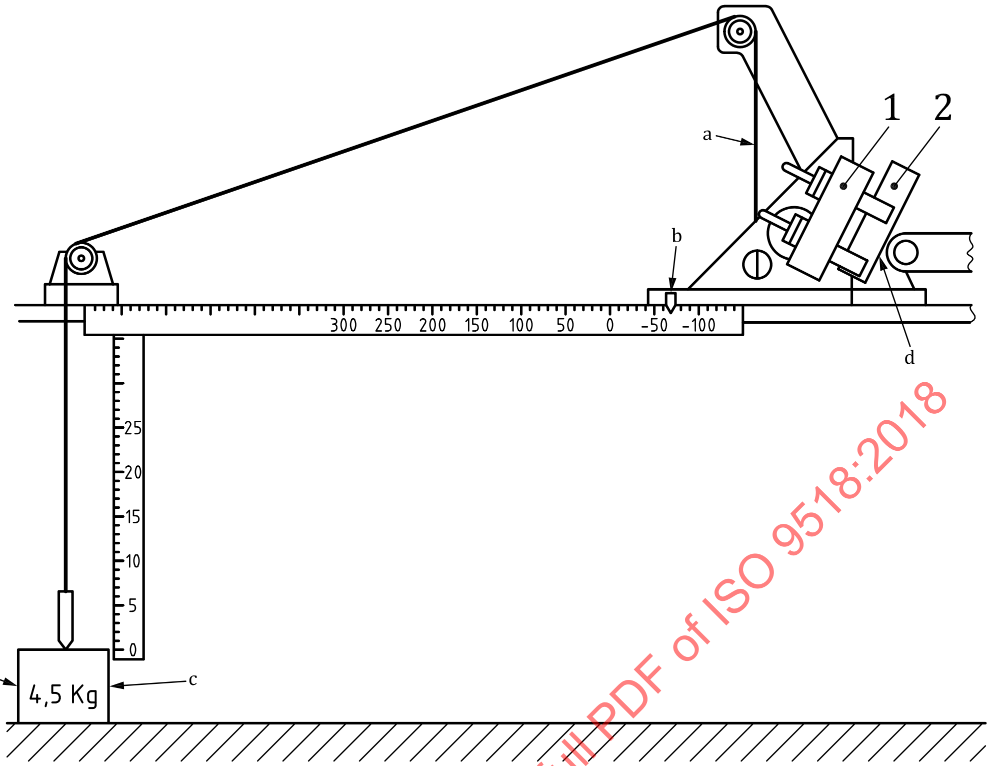
a) A 0,23 kg mass and cable assembly shall be attached to the rotary pulley, with the ratchet pawls in place.

b) When the 0,23 kg mass causes the saw cradle assembly to rotate from the horizontal (0°) through at least 180°, the friction level shall be within tolerance.

c) In rotary kickback energy computations, a 2,2 N rotary friction shall be used.

4.4.10 Horizontal & rotary restraining systems alignment

4.4.10.1 The specimen contact angle shall be set to 30°. Position the carriage so that the test specimen contacts the saw-chain. Adjust the position of the rack/horizontal restraining assembly so that the cable from the carriage to the pulley is vertical with the carriage positioned from 25 mm to 75 mm to the right of the point at which the weight will lift (see Figure 5). (The horizontal restraining weight will just swing free with the carriage pointer at "0".)



Key

1 MDF carriage

2 MDF specimen

3 restraining weight

a This section of cable is vertical.

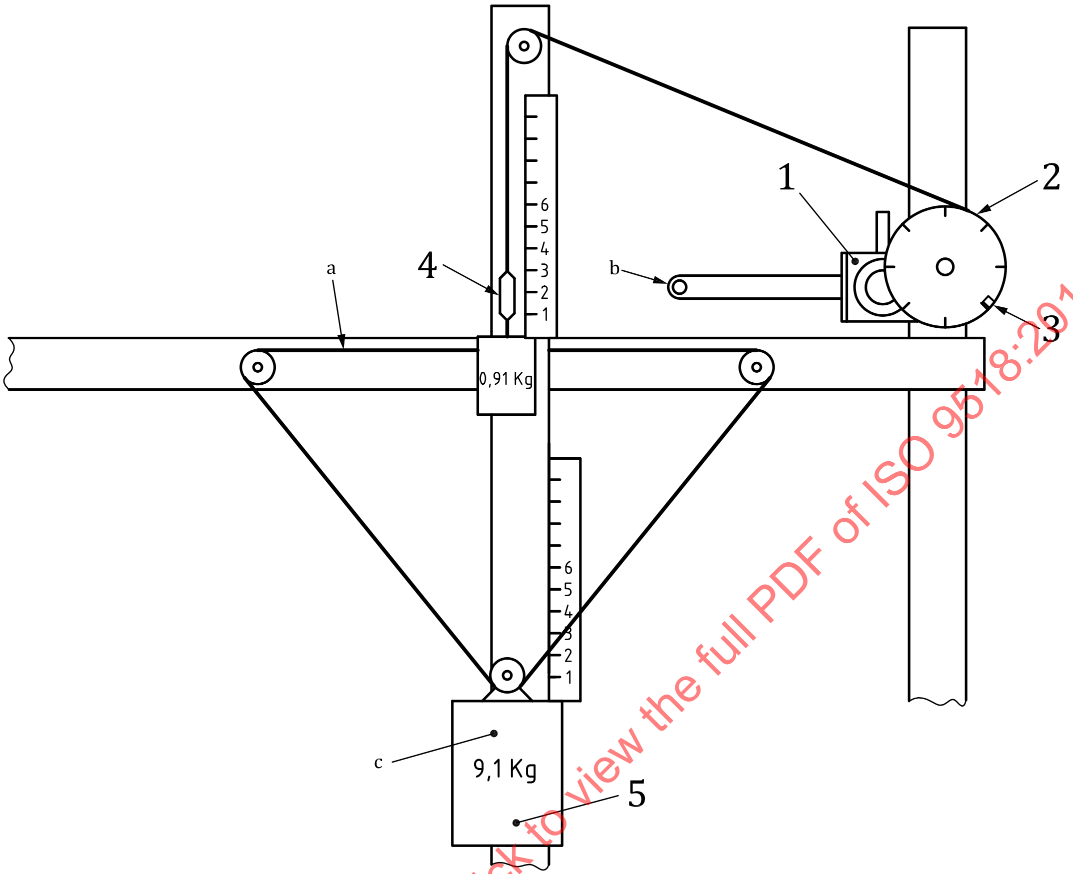
b The MDF carriage is 25 mm to 75 mm to the right of the point at which the weight will lift.

c The restraining weight will just swing free with the carriage pointer at "0". (A larger weight shall be used only if necessary.).

d The specimen contact angle is 30°.

Figure 5 — Adjustment of rack/horizontal restraining system

4.4.10.2 With the guide bar centreline horizontal, install the cable attachment pin on the rotary pulley and adjust the turnbuckle to bring the 0,91 kg weight on the rotary restraining system to the zero position (see Figure 6).



Key

1 chain-saw

2 rotary pulley

3 cable attachment pin

4 turnbuckle

5 restraining weight

a Adjust the location of the cable attachment pin in the rotary pulley and adjust the turnbuckle so that this section of cable is horizontal. (This is the "0" position of the 0,91 kg weight.)

b The guide bar centreline is horizontal.

c A larger weight shall be used only if necessary.

Figure 6 — Adjustment of rotary restraining system

4.4.11 Impact velocity adjustment

Adjust the carriage release point to achieve a velocity (just prior to contact of the specimen with the bar tip) of 0,76 m/s ± 0,013 m/s.

4.5 Test requirements and procedures

4.5.1 Test requirements

4.5.1.1 Following are general requirements to be followed over the course of conducting a kickback test.

Record data on the kickback test record, see Figure C.1.

4.5.1.2 Adjust the specimen contact angle to the initial value shown for data set 1A in Table 1 or 2. For subsequent data sets, readjust the angle as specified.

Table 1 — Test sequence

Data set no.	Contact angle °	Impact velocity m/s	Engine speed (±200 min^{-1}) min^{-1}
1A	0	0,76	11,000 (maximum or highest attainable)
1B			9,000 (or maximum minus 2,000)
2A	5		11,000 (maximum or highest attainable)
2B			9,000 (or maximum minus 2,000)
3A	10		11,000 (maximum or highest attainable)
3B			9,000 (or maximum minus 2,000)
4A	15		11,000 (maximum or highest attainable)
4B			9,000 (or maximum minus 2,000)
5A	20		11,000 (maximum or highest attainable)
5B			9,000 (or maximum minus 2,000
6A	25		11,000 (maximum or highest attainable)
6B			9,000 (or maximum minus 2,000)
7A	30		11,000 (maximum or highest attainable)
7B			9,000 (or maximum minus 2,000)

Table 2 — Optional test sequence

Data set no.	Contact angle °	Impact velocity m/s	Engine speed (±200 min^{-1}) min^{-1}
1A	0	0,76	11,000 (maximum or highest attainable)
2A	5		
3A	10		
4A	15		
5A	20		
6A	25		
7A	30		
1B	0		9,000 (or maximum minus 2,000)
2B	5		
3B	10		
4B	15		
5B	20		
6B	25		
7B	30		

4.5.1.3 After each impact the chain-saw should be inspected for unusual conditions and reset for the next impact. Do not operate a damaged saw.

4.5.1.4 For saws equipped with a centrifugal clutch, the clutch shall be burned at the start of the test and after each 12 impacts. To burn the clutch, clamp the saw-chain to the guide bar and run the saw for 5 s with full throttle. Measure and record the slip speed in min^{-1}. If the slip speed varies by more than 500 min^{-1} during the test, replace the clutch.

4.5.1.5 Saw-chain tension shall be set initially and adjusted during the test in accordance with 4.4.4.3.

4.5.1.6 On occasion, the balance of the saw/clamp/cradle may change. Check and reset balance if imbalance exceeds 60 g as specified in 4.4.7.3. If imbalance of more than 60 g occurs, data from the previous impact is invalid.

4.5.1.7 The test specimen is to be clamped in the carriage with a rough face (end grain) presented to the saw-chain.

4.5.1.8 Make only two impacts on each specimen (one on each rough face).

4.5.1.9 The specimen should be examined and changed after each impact.

The orientation of the test specimen shall be adjusted so that the kerf from the chain will not intersect the upper edge of the specimen face. All saw-chain cuts shall start within the middle 25 mm on the face of the specimen. If any kerf runs off the specimen, or if the specimen splits, do not use the energy readings in the computations. Repeat the impact on another specimen. Tendency for specimen splitting can be reduced by adding side supports, for example a C-clamp. If such a device is so used the clamping forces must be minimum and the carriage mass shall be compensated.

4.5.1.10 Upon completion of the test, measure the horizontal and rotary friction levels as described in 4.4.8 and 4.4.9. The greater measured level is to be used for energy computations. If friction at the end of the test program exceeds the specifications of 4.4.8 or 4.4.9, the test shall be repeated.

4.5.2 Kickback testing procedure

4.5.2.1 Using the following procedure, perform impacts at the test conditions specified in the test sequence of Table 1. If it is more convenient, the test sequence in Table 2 may be used instead.

For electric powered saws, the supply voltage and frequency shall be adjusted to the rated voltage and frequency of the chain-saw. The contact angle sequence shall be followed with the unit operating at the resulting output speed.

4.5.2.2 With the barrier bar in position, start the chain-saw. Adjust the engine speed to the value specified for data set 1A in the test sequence.

4.5.2.3 Raise the barrier bar and stand clear of the kickback machine.

4.5.2.4 Release the carriage, observing the engine speed just as the specimen contacts the moving chain at the bar tip.

4.5.2.5 Turn off the chain-saw after all motion has stopped.

4.5.2.6 Record the vertical displacement, in millimetres, of the horizontal restraining weight and the horizontal displacement, in millimetres, of the carriage (see Figure 5).

4.5.2.7 Record the vertical displacement, in millimetres, of the upper and lower rotary restraining weights (see Figure 6).

The horizontal and rotary restraining systems may have separate calibrations to permit direct readings.

4.5.2.8 Complete data set 1A by repeating the steps in 4.5.2.2 to 4.5.2.7. Each repetition is considered one "impact". Each data set consists of either three or six impacts depending on the outcome of calculations specified in 4.5.3.4 or 4.5.3.5.

4.5.2.9 Repeat the steps in 4.5.2.2 to 4.5.2.7 for the remaining data sets as specified in the test sequence of Table 1 or 2.

4.5.3 Kickback energy determination

4.5.3.1 Compute the horizontal energy, W_h, for each impact:

$$W_h = (9{,}8\, m_h\, D_h + F_h\, D_c)\, 10^{-3}$$

where

W_h is the horizontal energy, expressed in Joules;

m_h is the mass of the horizontal restraining weight, expressed in kilograms;

F_h is the horizontal axis friction, expressed in Newtons;

D_h is the displacement of the horizontal restraining weight, expressed in millimetres;

D_c is the displacement of the carriage, expressed in millimetres.

4.5.3.2 Compute the rotary energy, W_r, for each impact:

$$W_r = [(9{,}8\ m_u + F_r)D_u + 9{,}8\ m_l D_l]\ 10^{-3}$$

where

W_r is the rotary energy, in Joules;

m_u is the mass of the upper rotary weight, expressed in kilograms;

m_l is the mass of the lower rotary weight, expressed in kilograms;

D_u is the displacement of the upper rotary weight, expressed in millimetres;

D_l is the displacement of the lower rotary weight, expressed in millimetres;

F_r is the rotary friction force, expressed in Newtons.

4.5.3.3 After performing three impacts at the conditions specified for a data set, compute the average of the three rotary energy values and the average of the three horizontal energy values.

4.5.3.4 If the rotary energy values of the data set are each within 10 % of the average rotary value, use the average of the three values.

4.5.3.5 If any of the rotary energy values of the data set is not within 10 % of the average, perform three additional impacts and use the average of all six rotary energy values. Similarly, use the average of the six horizontal energy values.

4.5.3.6 The peak rotary energy without a chain brake, W_r, is taken as the highest of the average rotary energies found in the test sequence.

4.5.4 Termination of test sequence

The test sequence may be discontinued if, at both engine speeds, there is:

a) a 50 % reduction in the average rotary energy between measurements at two consecutive contact angles, or

b) a cumulative decrease in the average rotary energy for two consecutive contact angles.

4.5.5 Chain brake energy determination

4.5.5.1 This subclause establishes the additional test procedures necessary for evaluation of complete chain-saw units when the computed kickback angle without brake (CKA_{wob}) exceeds the acceptable limit of the relevant product standard.

For units, that generate very low kickback energies, testing with the chain brake may not be possible. It is recommended that testing be discontinued at this point for saws with (CKA_{wob}) equal to 20° or less at the peak rotary energy condition identified in 4.5.3.6.

To account for the action of the chain brake, it shall be necessary to determine

a) the rotary kickback energy with the chain brake actuated,

b) the actuation angle as specified in 4.5.6, and

c) the chain brake stopping time, as specified in 4.5.7.

At the discretion of the manufacturer, 4.5.5.2 and 4.5.5.3 may be omitted.

4.5.5.2 At the conclusion of the test sequence specified in 4.5.2, remove the means used to prevent the chain brake from actuating and perform three additional impacts at peak rotary energy conditions. If the rotary energy values are not within 10 % of the average, perform three additional impacts and compute the average of all six impacts.

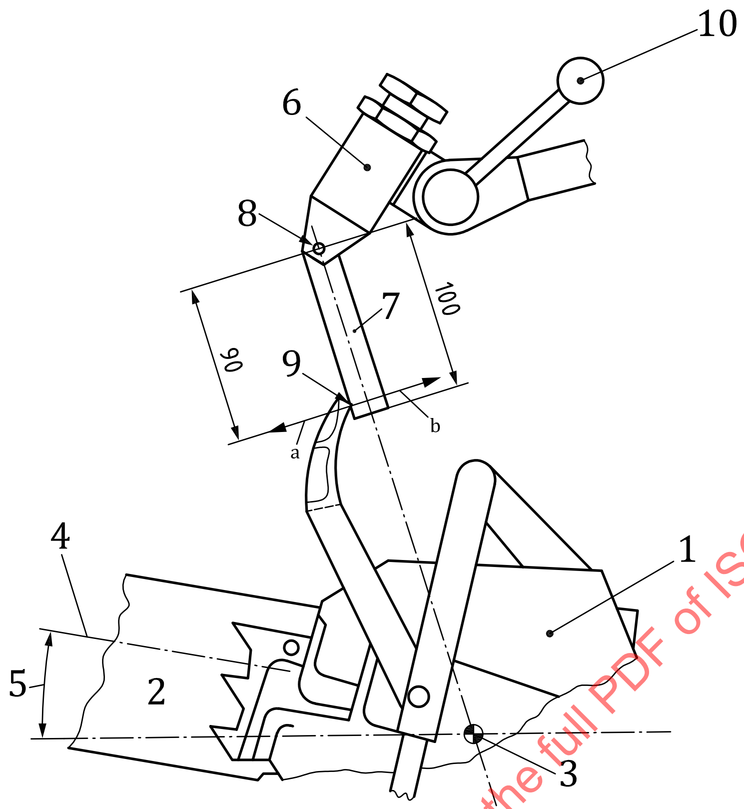
4.5.5.3 If the chain brake actuates each time, the energy value that is put into the computer model as rotary energy with the chain brake operating, R_4, is taken as the average of the rotary energy values. If the chain brake does not actuate each time, proceed to 4.5.5.4.

When the chain brake does not operate each time, and it can be demonstrated through the test described in ISO 13772 that the brake will release in actual operation, an additional mass (not to exceed 200 g) may be added to the centre of the front hand guard. Balance of the saw cradle unit should be compensated accordingly, if required to maintain balance requirements of 4.4.7. Other parameters may not be changed.

4.5.5.4 Mount the brake actuator on the left side of the mainframe column of the kickback machine.

4.5.5.5 Set the spring-loaded lever so that the lever and the hand guard contact each other at or immediately past the point where the saw exits from the test specimen (see Figures 7 and 8).

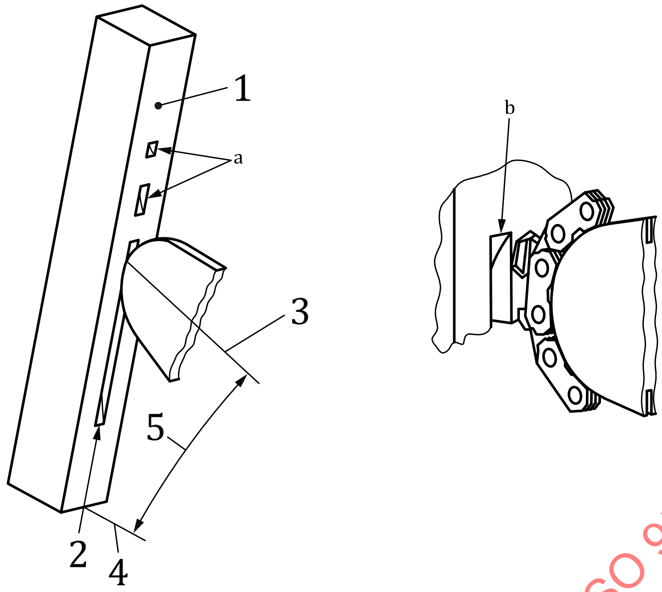
Dimensions in millimetres



Key

1 chain-saw powerhead
2 guide bar
3 centre of gravity
4 guide bar centreline
5 specimen exit angle
6 lever-setting mechanism
7 spring-loaded lever
8 pivot point
9 contact point
10 position-locking lever
a Measure brake release force in this direction.
b Measure lever release force in this direction.

Figure 7 — Adjustment of chain brake actuator



Key

1 MDF specimen

2 kerf

3 guide bar centre line

4 horizontal

5 specimen exit angle

a Ignore tracks.

b Measure exit angle with chain in contact at highest point in cut area tracks where cutters have hit.

Figure 8 — Specimen exit angle measurement

4.5.5.6 Set the spring-loaded lever of the chain brake actuator in the set position so that its centreline intersects the chain-saw centre of gravity as shown in Figure 7.

4.5.5.7 Adjust the position of the spring-loaded lever (in its set position) so that the contact point of the chain brake lever (hand guard) with the spring-loaded lever is 90 mm from the pivot of the spring-loaded lever (see Figure 7).

4.5.5.8 Recheck steps 4.5.5.5, 4.5.5.6 and 4.5.5.7. Readjust if necessary.

4.5.5.9 Measure the chain brake release force in Newtons, with the engine not running. The brake release force shall be measured with a spring scale accurate to ±1 N. The force shall be applied at a uniform rate at the centre of the top part of the brake lever. The force shall be measured in a direction which is normal to the centreline of the spring-loaded lever when the saw is in the contact position and the spring-loaded lever is set as shown in Figure 7.

4.5.5.10 Adjust the release force of the spring-loaded lever to a value equal to the chain brake release force plus 10 N. Measure the release force of the spring-loaded lever by placing a spring scale at a point 90 mm from the pivot point of the spring-loaded lever and pulling normal to the centreline of the lever. Record the release force.

4.5.5.11 Position the chain-saw so that the guide bar is horizontal, and set the contact angle and engine speed at the settings determined to give the highest average rotary energy in 4.5.3.

4.5.5.12 All tests performed in accordance with 4.5.5.13 and 4.5.5.14 shall be conducted at the contact angle and engine speed determined to give the highest average rotary energy.

4.5.5.13 Conduct the chain brake actuation test to determine the rotary energy with both the chain brake and the chain brake actuator operating, W_{ca}. Using the procedures detailed in 4.5.2, conduct the kickback test with both the actuator and chain brake operating. Repeat for a total of three impacts. If the rotary energy values are not within 10 % of the average, perform three additional impacts and use the average of the six values. If the chain brake activates on each impact, W_{ca} is taken as the average of the rotary values. If the brake does not activate on each impact, compute the kickback angle using values calculated in accordance with 4.5.3.

If the brake activates but does not trip the spring-loaded lever, record that the lever did not trip and continue calculations and test as though the lever did trip.

4.5.5.14 Conduct the kickback test to determine the rotary energy with the chain brake actuator operating, W_a, but without the chain brake operating.

By a suitable means, such as taping or wiring the chain brake handle to the saw handle, disable the chain brake so that it will not activate. Using the procedures detailed in 4.5.2, conduct the kickback test with the chain brake actuator operating and the chain brake disabled.

Repeat for a total of three impacts. If the rotary energy values are not within 10 % of the average, perform three additional impacts and use the average of the six values. W_a is taken as the average of the rotary energy values.

4.5.5.15 Calculate R_4, the rotary energy, with the chain brake operating. This is the energy value which is input to the computer model:

$$R_4 = W_r - W_a + W_{ca}$$

where

- W_r is the peak rotary energy without a chain brake as determined in 4.5.3, expressed in Joules;
- W_a is the rotary energy with the chain brake actuator operating, but without the chain brake operating, as determined in 4.5.5.14, expressed in Joules;
- W_{ca} is the rotary energy with both the chain brake and the chain brake actuator operating, as determined in 4.5.5.13, expressed in Joules.

4.5.6 Chain brake actuation angle measurement

4.5.6.1 General

This measurement approximates the moment at which the brake actuates and is an input to the kickback calculation program for determining CKA with brake actuated.

4.5.6.2 Measure the angles where the guide bar tip exits from the test specimens at peak rotary energy conditions as determined in 4.5.3 and compute the average. This is the specimen exit angle (see Figure 8).

4.5.6.3 If the rotary energy, R_4, was determined in accordance with 4.5.5.3, then the actuation angle A2 is one-half of the specimen exit angle.

4.5.6.4 If the rotary energy, R_4, was determined in accordance with 4.5.5.15, the chain brake actuation angle A2 is taken as the specimen exit angle.

4.5.7 Chain brake stopping time measurement

4.5.7.1 The chain brake stopping time test shall be conducted at the engine speed setting of the peak rotary energy condition determined in 4.5.3. Use the pendulum test technique specified in ISO 6535.

4.5.7.2 The chain-saw shall be adjusted for best cutting performance in accordance with the chain-saw manufacturer's recommendations.

4.5.7.3 The chain-saw shall be solidly mounted during the test.

4.5.7.4 No adjustment of the brakes is permitted during the test.

4.5.7.5 Initially, the brake shall be in a dry and unlubricated condition.

4.5.7.6 The chain brake shall be activated 10 times without recording data. Then activate the brake three times and record the average stopping time. Refer to ISO 6535 for test apparatus details and test technique.

4.6 Kickback angle computation

4.6.1 General

The computed kickback angle, which is used as a measure of the reaction of a hand-held chain-saw when subjected to a rotational kickback under simulated conditions (see Figure 9), is determined with the computer program described by the flow chart in Annex A.

4.6.2 Input data

4.6.2.1 The variables listed below, as have been determined by this testing process, are the inputs to the kickback calculation program.

4.6.2.2 Chain-saw mass, expressed in kilograms, in accordance with 4.4.2.2.

4.6.2.3 Chain-saw moment of inertia, expressed in kilograms metre squared, in accordance with 4.4.2.4.

4.6.2.4 Bar tip and handle locations, expressed in millimetres, in accordance with 4.4.3.

4.6.2.5 Energy levels without brake actuation established at the peak rotary conditions in accordance with 4.5.3 as follows:

a) horizontal energy, W_h, expressed in Joules;

b) rotary energy, W_r, expressed in Joules.

If the average rotary energies measured at other sets of conditions are within 10 % of the peak rotary value, calculate the computed kickback angle for each of these sets of conditions and use the highest computed kickback angle.

4.6.2.6 Chain brake rotary energy, R_4, expressed in Joules, in accordance with 4.5.5.

4.6.2.7 Chain brake actuation angle, A2, expressed in degrees, in accordance with 4.5.6.

4.6.2.8 Saw-chain stopping time, expressed in milliseconds, in accordance with 4.5.7.

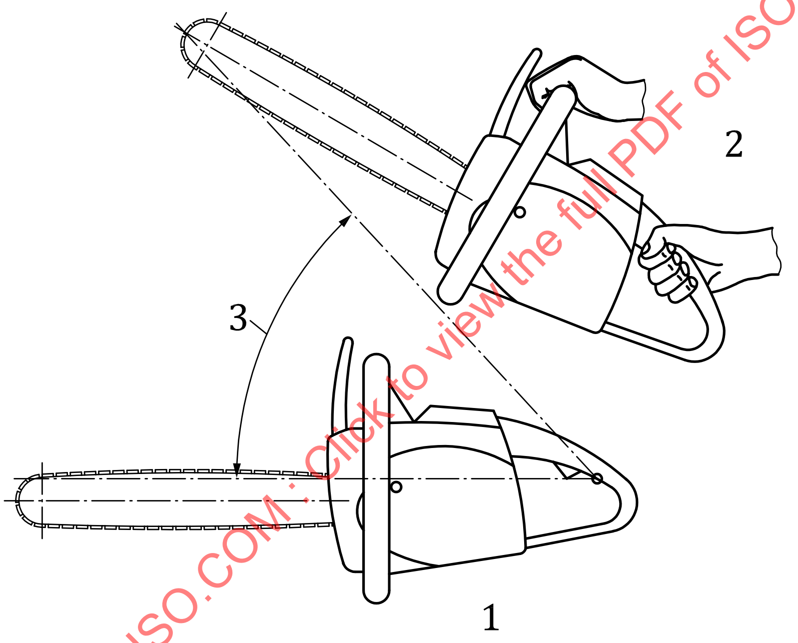
4.6.3 Computation and results

The CKA_{wob}, CKA_{wb}, and CKA_{cs}, as applicable, shall be determined in accordance with the analytical model provided. The computer kickback program uses standard engineering force-motion equations to predict the path of the saw based on the kickback energy and saw characteristics input data and the simulated operator reaction forces, as illustrated in Figure 9. The CKA values are calculated from this predicted path. The computer program flowchart is specified in Annex A, along with some examples of computer printouts in Annex E, which demonstrate the results of various chain-saw kickback tests. The values calculated by the analytical program are defined as:

— CKA_{wob}: The computed kickback angle determined without brake actuation.

— CKA_{wb}: The computed kickback angle with brake actuation, also referred to as the peak bar stop angle. Should it be determined by the program that the chain is still moving at the moment when the bar motion has stopped, the computer program will print the comment “Chain Stopped After Bar Peak”.

— CKA_{cs}: The computed kickback angle at the moment when the motion of the saw-chain has stopped, also called the chain stop angle.



Key

1 initial chain-saw position

2 peak chain-saw position as determined by mathematical simulation

3 computed kickback angle

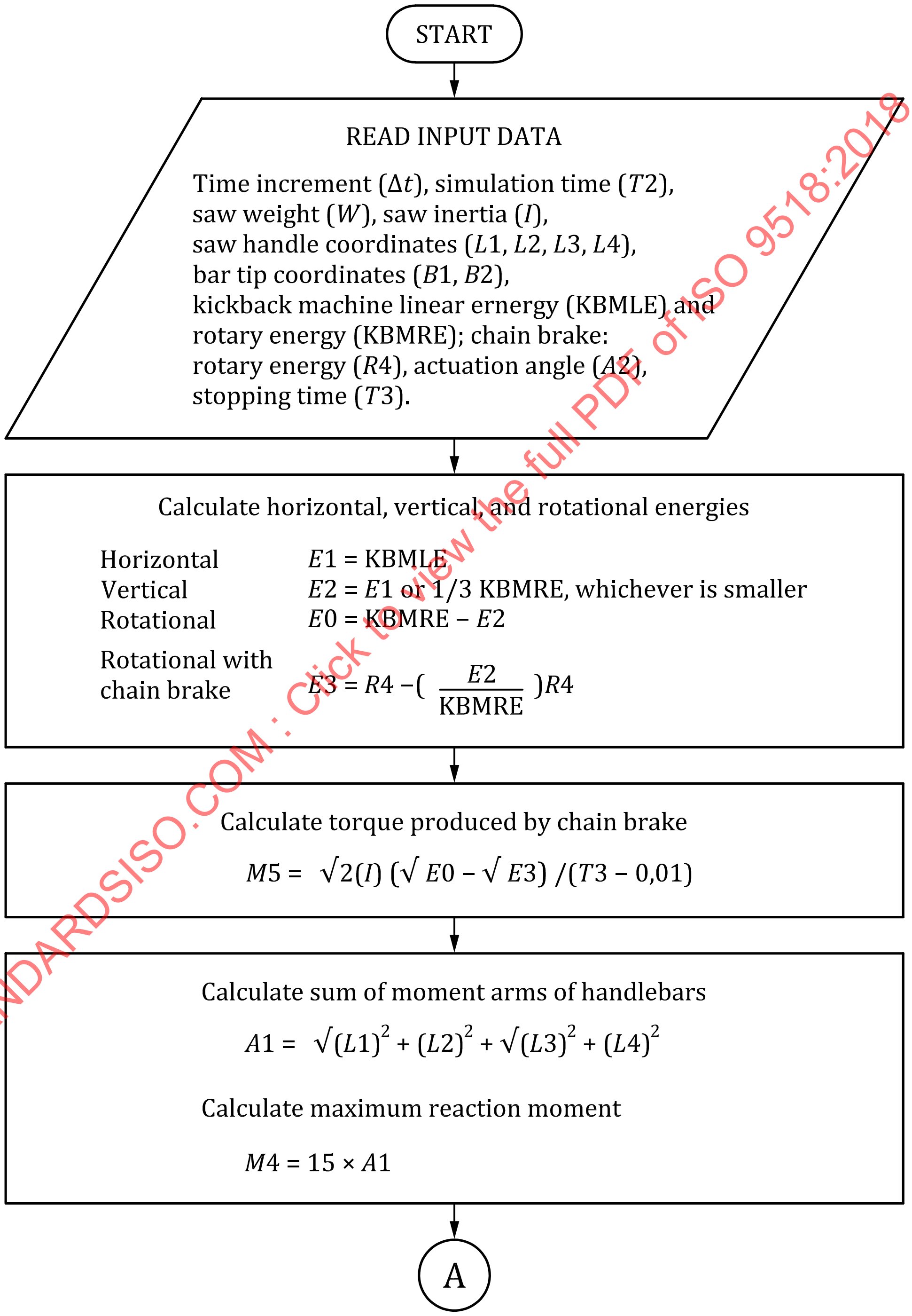
Figure 9 — Computed kickback angle

5 Test report

The test report shall include the kickback test record (see example in Figure C.1) and the chain-saw installation and balancing test record (see example in Figure C.2).

Annex A
(normative)

Computer program flowchart



A

Calculate initial velocities

$$\omega = -\sqrt{\frac{2(E0)}{I}}$$ Rotational

$$V_x = -\sqrt{\frac{2(E1)}{W}}$$ Horizontal

$$V_y = -\sqrt{\frac{2(E2)}{W}}$$ Vertical

$V_{1,1} = \omega$
$V_{2,1} = V_x$
$V_{3,1} = V_y$

Calculate intercepts of hand force equations

Force intercepts:

$$J1 = 1{,}3(E0)^{0{,}25}\left(\sqrt{(L1)^2+(L2)^2}+\sqrt{(L3)^2+(L4)^2}\right)^{1/2}\sqrt{(386{,}4)(I)}$$

$$J2 = -3{,}614\ [(W)(E1)]^{0{,}25} + 6{,}012$$

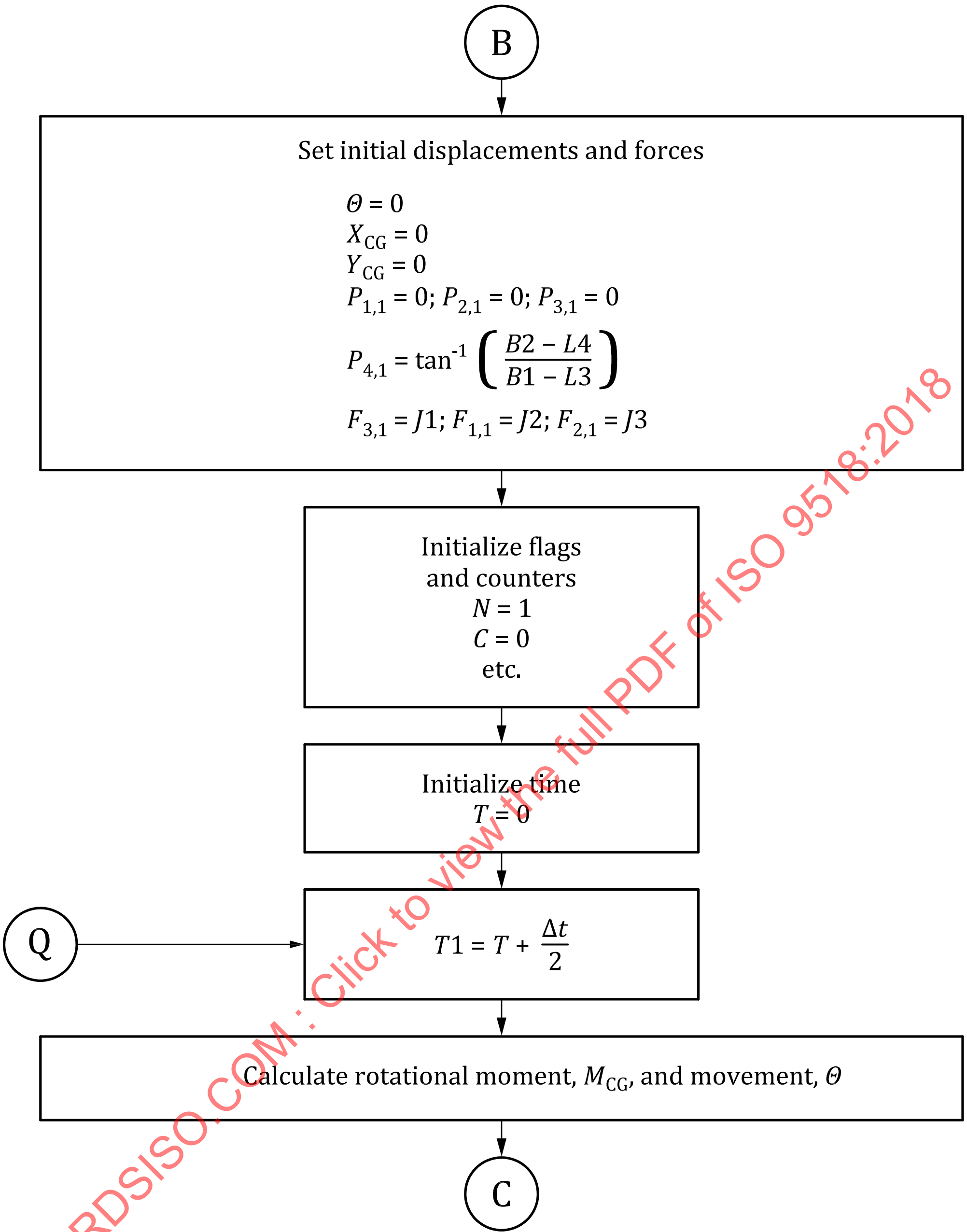
$$J3 = 0{,}0713(J1) + 3{,}047W - 5{,}215\sqrt{E2} + 2{,}989$$

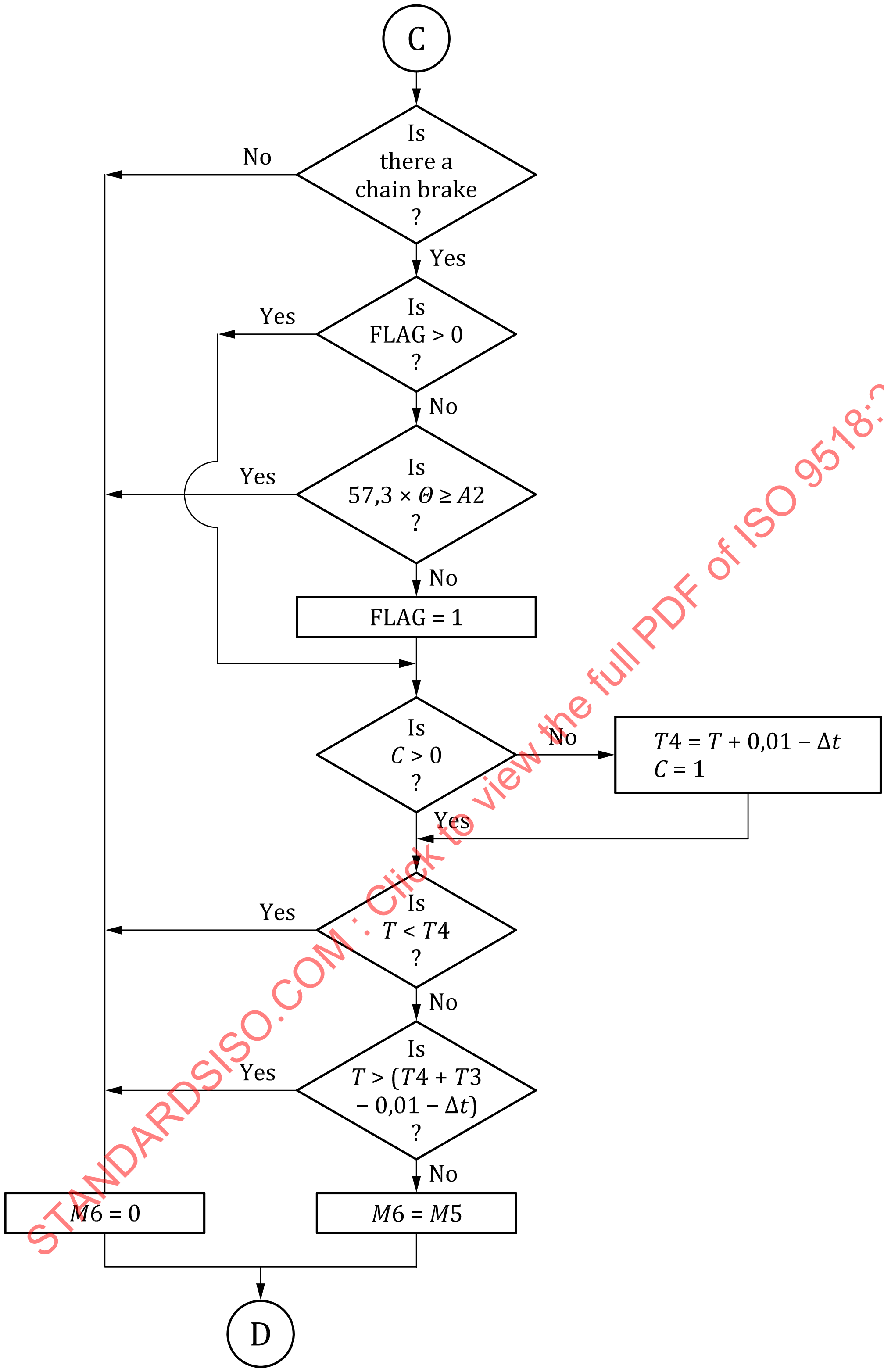
Time intercepts:
$K1 = 0{,}107$
$K3 = 0{,}112\,8$

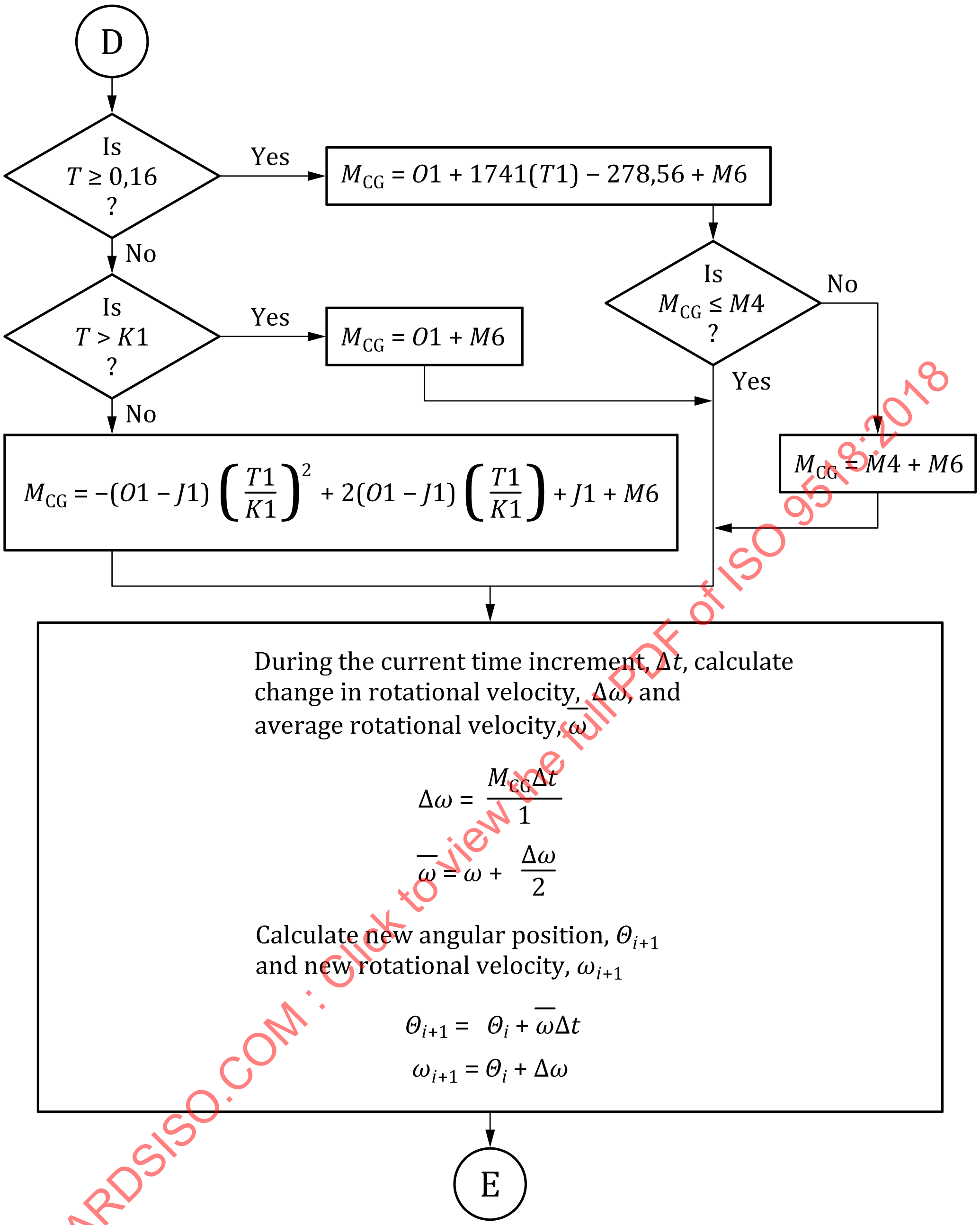
Offset:
$O1 = 0$
$O3 = 0{,}327\,64W + 2{,}063$

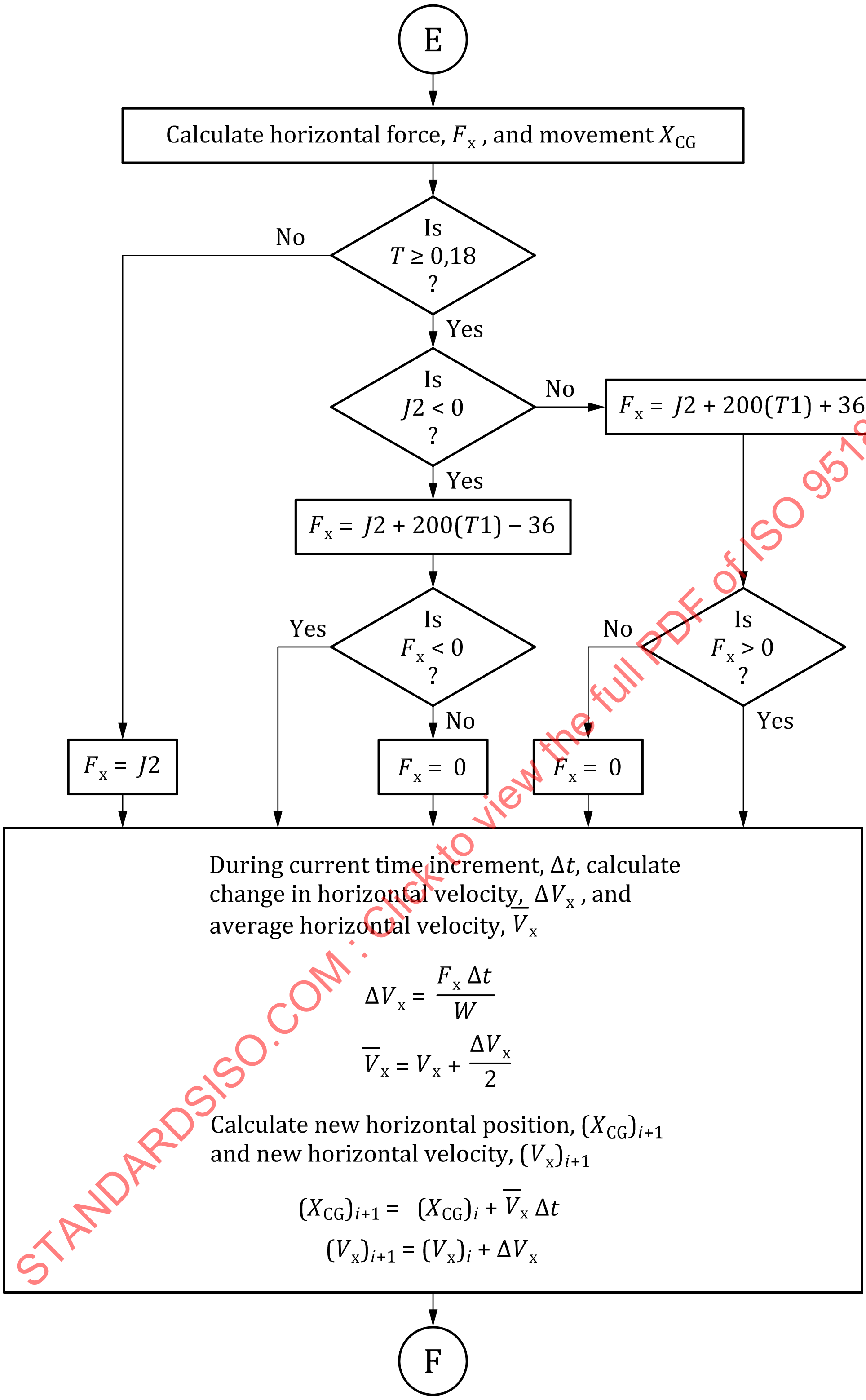
Print out
Input data

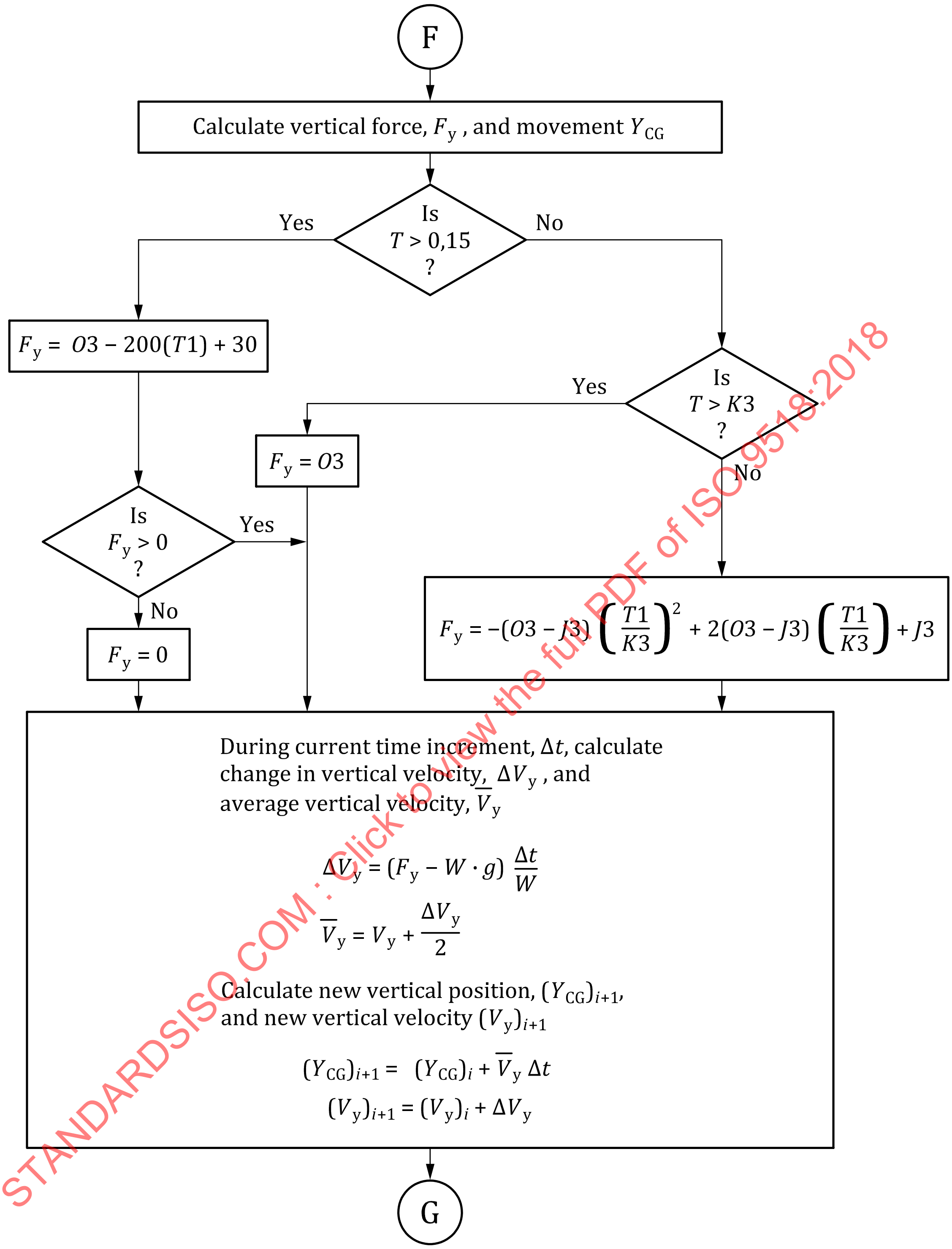
B

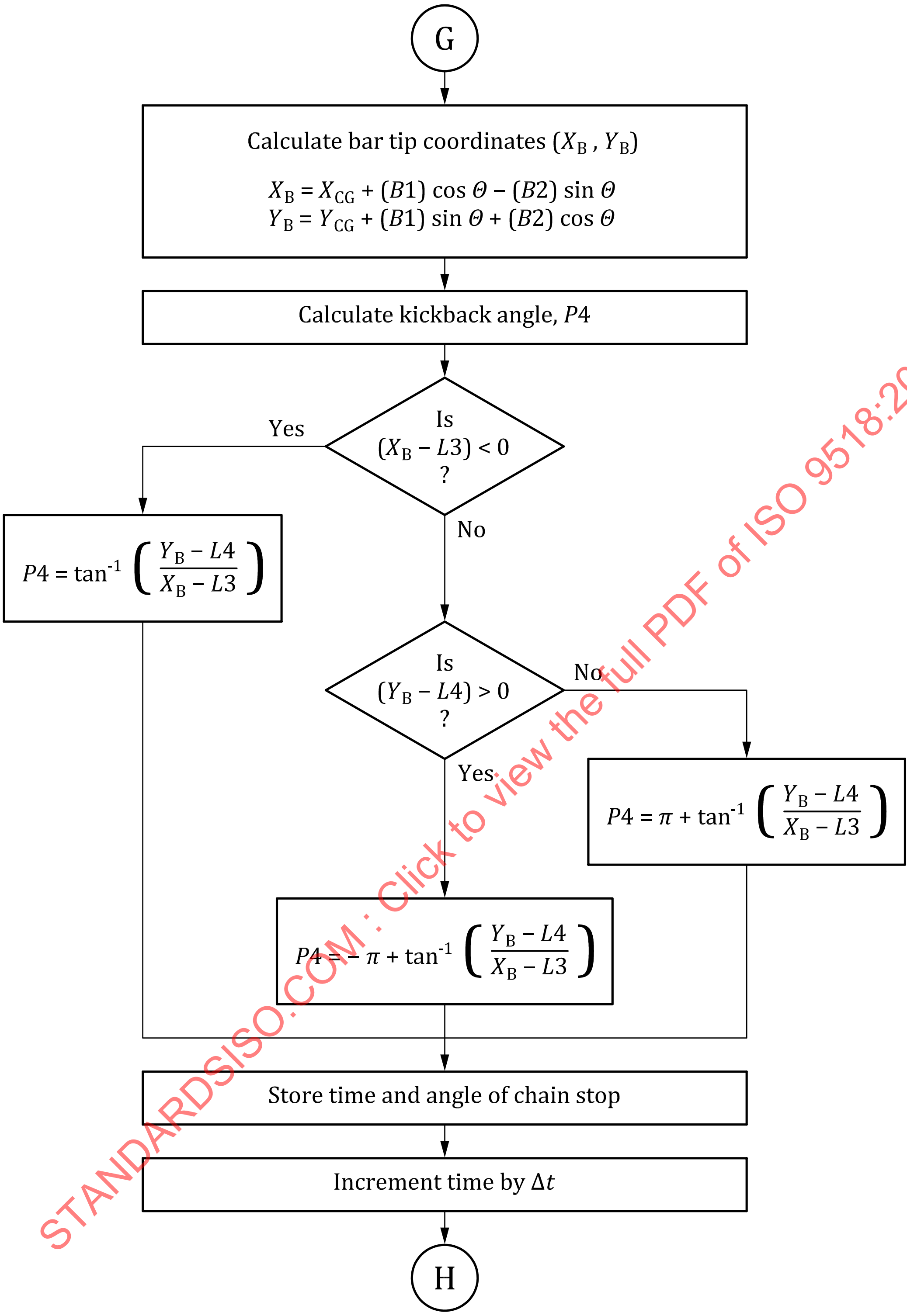

B
Set initial displacements and forces
$\Theta = 0$
$X_{CG} = 0$
$Y_{CG} = 0$
$P_{1,1} = 0$; $P_{2,1} = 0$; $P_{3,1} = 0$
$P_{4,1} = \tan^{-1}\left(\frac{B2 - L4}{B1 - L3}\right)$
$F_{3,1} = J1$; $F_{1,1} = J2$; $F_{2,1} = J3$
Initialize flags
and counters
$N = 1$
$C = 0$
etc.
Initialize time
$T = 0$
Q
$T1 = T + \frac{\Delta t}{2}$
Calculate rotational moment, M_{CG}, and movement, Θ
C

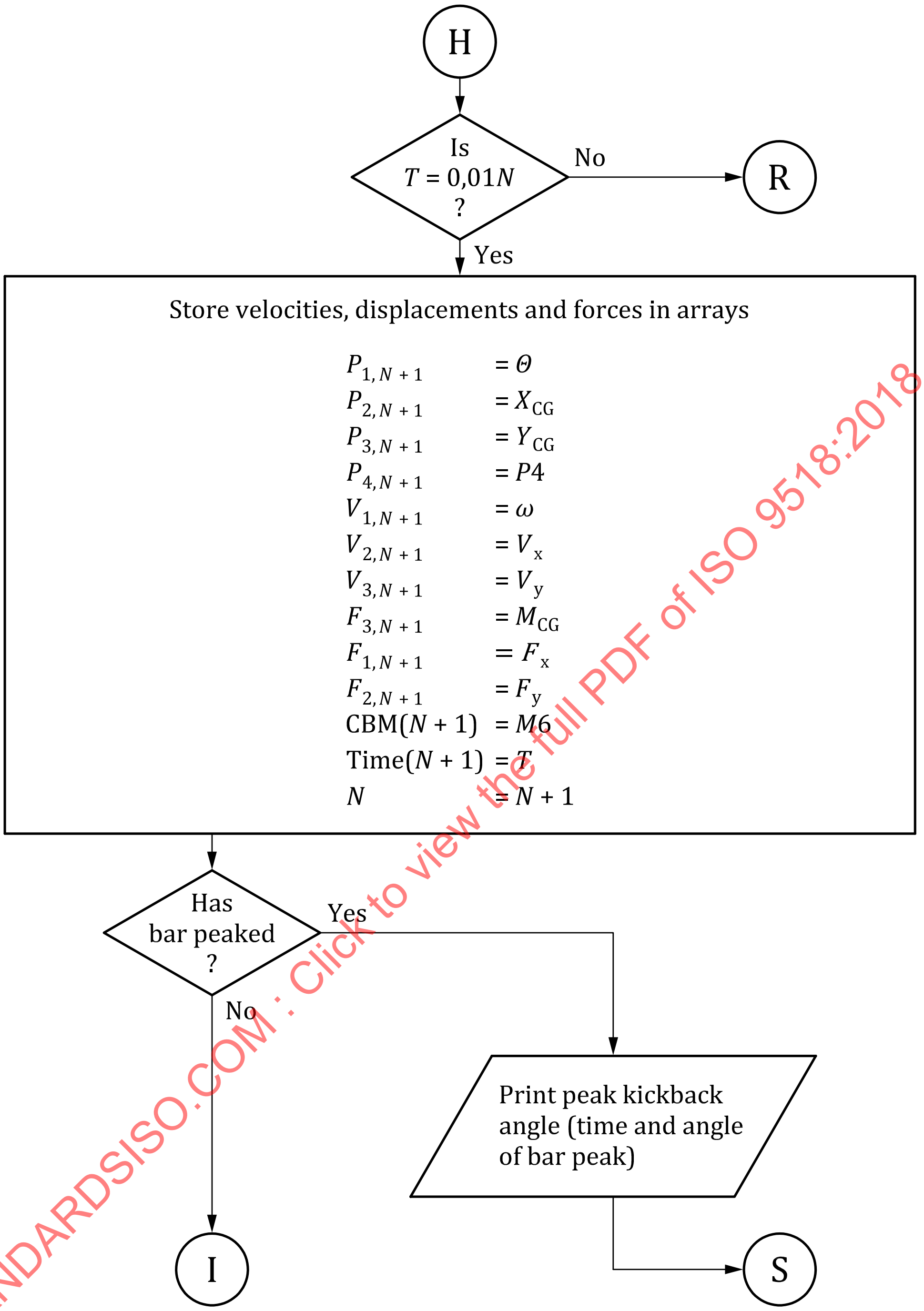

C
Is there a chain brake ?
No
Yes
Is FLAG > 0 ?
Yes
No
Is 57,3 × Θ ≥ A2 ?
Yes
No
FLAG = 1
Is C > 0 ?
No
T4 = T + 0,01 − Δt
C = 1
Yes
Is T < T4 ?
Yes
No
Is T > (T4 + T3 − 0,01 − Δt) ?
Yes
No
M6 = 0
M6 = M5
D

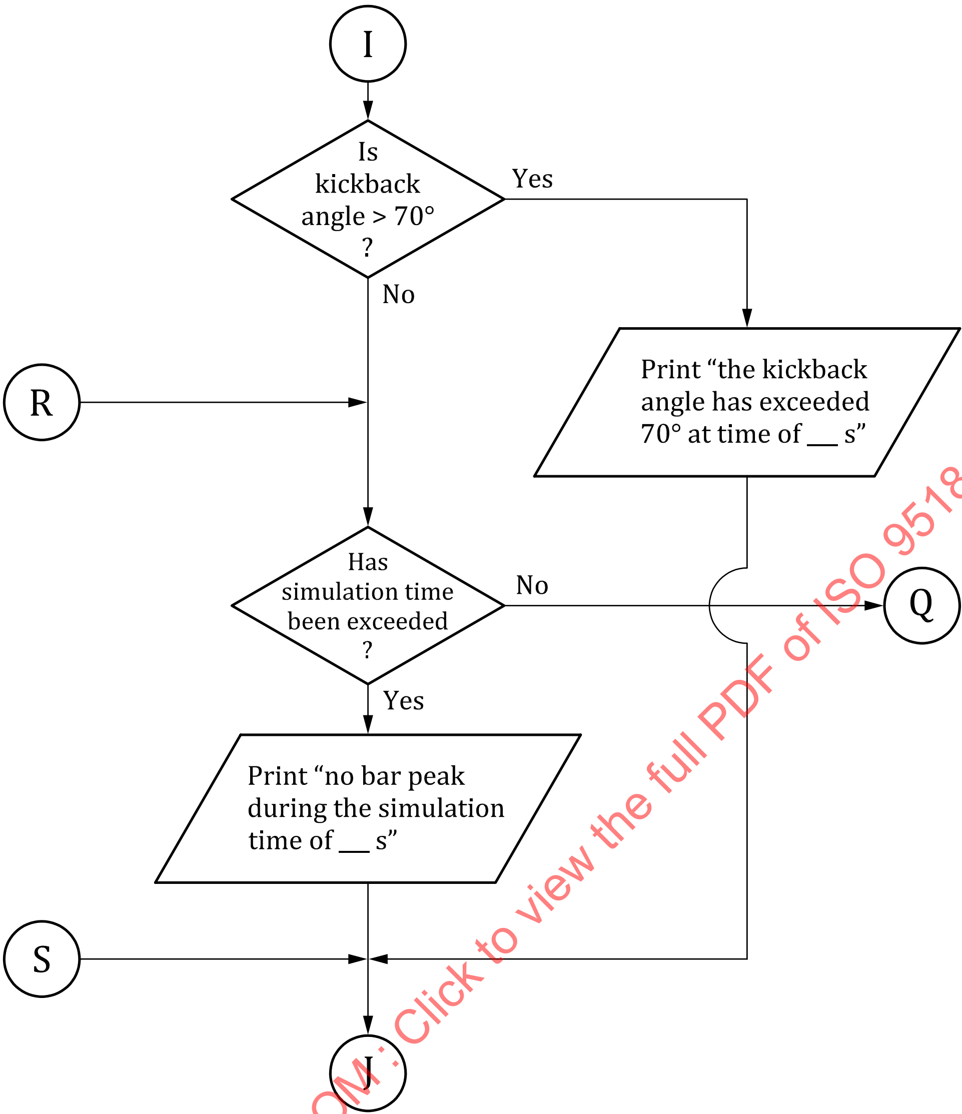

D
Is
T ≥ 0,16
?
Yes
$M_{CG} = O1 + 1741(T1) - 278,56 + M6$
No
Is
T > K1
?
Yes
$M_{CG} = O1 + M6$
No
$M_{CG} = -(O1 - J1)\left(\frac{T1}{K1}\right)^2 + 2(O1 - J1)\left(\frac{T1}{K1}\right) + J1 + M6$
Is
$M_{CG} \leq M4$
?
No
Yes
$M_{CG} = M4 + M6$
During the current time increment, Δt, calculate
change in rotational velocity, $\Delta\omega$, and
average rotational velocity, $\overline{\omega}$
$\Delta\omega = \frac{M_{CG}\Delta t}{1}$
$\overline{\omega} = \omega + \frac{\Delta\omega}{2}$
Calculate new angular position, Θ_{i+1}
and new rotational velocity, ω_{i+1}
$\Theta_{i+1} = \Theta_i + \overline{\omega}\Delta t$
$\omega_{i+1} = \Theta_i + \Delta\omega$
E

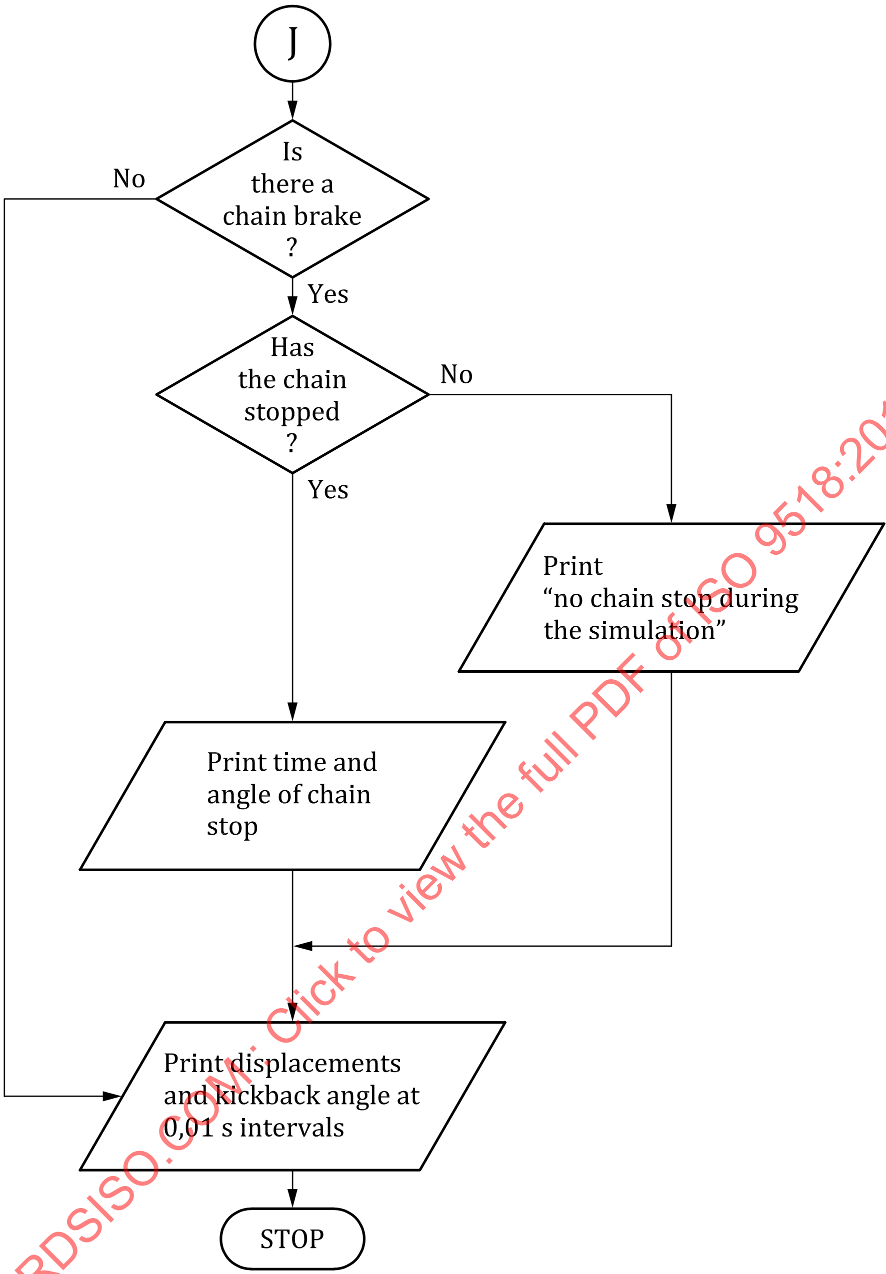

E
Calculate horizontal force, F_x, and movement X_{CG}
Is $T \geq 0,18$?
No
Yes
Is $J2 < 0$?
No
$F_x = J2 + 200(T1) + 36$
Yes
$F_x = J2 + 200(T1) - 36$
Is $F_x < 0$?
Yes
No
Is $F_x > 0$?
No
Yes
$F_x = J2$
$F_x = 0$
$F_x = 0$
During current time increment, Δt, calculate change in horizontal velocity, ΔV_x, and average horizontal velocity, $\overline{V}_x$
$\Delta V_x = \frac{F_x \Delta t}{W}$
$\overline{V}_x = V_x + \frac{\Delta V_x}{2}$
Calculate new horizontal position, $(X_{CG})_{i+1}$ and new horizontal velocity, $(V_x)_{i+1}$
$(X_{CG})_{i+1} = (X_{CG})_i + \overline{V}_x \Delta t$
$(V_x)_{i+1} = (V_x)_i + \Delta V_x$
F


F
Calculate vertical force, F_y, and movement Y_{CG}
Is $T > 0{,}15$?
Yes
No
$F_y = O3 - 200(T1) + 30$
Is $T > K3$?
Yes
No
$F_y = O3$
Is $F_y > 0$?
Yes
No
$F_y = 0$
$F_y = -(O3 - J3)\left(\frac{T1}{K3}\right)^2 + 2(O3 - J3)\left(\frac{T1}{K3}\right) + J3$
During current time increment, Δt, calculate change in vertical velocity, ΔV_y, and average vertical velocity, $\overline{V}_y$
$\Delta V_y = (F_y - W \cdot g)\frac{\Delta t}{W}$
$\overline{V}_y = V_y + \frac{\Delta V_y}{2}$
Calculate new vertical position, $(Y_{CG})_{i+1}$, and new vertical velocity $(V_y)_{i+1}$
$(Y_{CG})_{i+1} = (Y_{CG})_i + \overline{V}_y \Delta t$
$(V_y)_{i+1} = (V_y)_i + \Delta V_y$
G


G
Calculate bar tip coordinates (X_B , Y_B)
$X_B = X_{CG} + (B1) \cos \Theta - (B2) \sin \Theta$
$Y_B = Y_{CG} + (B1) \sin \Theta + (B2) \cos \Theta$
Calculate kickback angle, $P4$
Is ($X_B - L3$) < 0 ?
Yes
No
$P4 = \tan^{-1}\left(\frac{Y_B - L4}{X_B - L3}\right)$
Is ($Y_B - L4$) > 0 ?
No
Yes
$P4 = \pi + \tan^{-1}\left(\frac{Y_B - L4}{X_B - L3}\right)$
$P4 = -\pi + \tan^{-1}\left(\frac{Y_B - L4}{X_B - L3}\right)$
Store time and angle of chain stop
Increment time by Δt
H


H
Is
$T = 0{,}01N$
?
No
R
Yes
Store velocities, displacements and forces in arrays
$P_{1,N+1} = \Theta$
$P_{2,N+1} = X_{CG}$
$P_{3,N+1} = Y_{CG}$
$P_{4,N+1} = P4$
$V_{1,N+1} = \omega$
$V_{2,N+1} = V_x$
$V_{3,N+1} = V_y$
$F_{3,N+1} = M_{CG}$
$F_{1,N+1} = F_x$
$F_{2,N+1} = F_y$
CBM(N + 1) = $M6$
Time(N + 1) = T
$N = N + 1$
Has
bar peaked
?
Yes
No
Print peak kickback angle (time and angle of bar peak)
I
S


I
Is kickback angle > 70° ?
Yes
No
Print "the kickback angle has exceeded 70° at time of __ s"
R
Has simulation time been exceeded ?
No
Q
Yes
Print "no bar peak during the simulation time of __ s"
S
J


J
Is there a chain brake ?
No
Yes
Has the chain stopped ?
No
Yes
Print "no chain stop during the simulation"
Print time and angle of chain stop
Print displacements and kickback angle at 0,01 s intervals
STOP

Annex B
(normative)

Procedure for hardness testing of Medium Density Fibreboard (MDF)

It has been demonstrated that both the density and hardness of MDF test coupons have an effect on the energy response during kickback testing. 4.3 of this standard requires a minimum MDF hardness of 2 892 N ± 667 N. The hardness of MDF shall be determined as follows:

a) Prepare samples meeting the density and dimensional criteria specified in 4.3 d).

b) Conduct a modified Janka Ball Hardness test (ASTM D1037) using a suitable tension/compression tester by conducting the following steps:

   i) Select a spherical penetrator measuring 12,7 mm diameter.

   ii) Supporting the MDF coupon on a flat planar surface, impress the penetrator into the cut face of the coupon surface at a speed of 15,24 mm/min to a depth of 2,54 mm. Make five impressions at the centreline of the coupons, spaced at least 38,1 mm apart and away from the ends of the coupon.

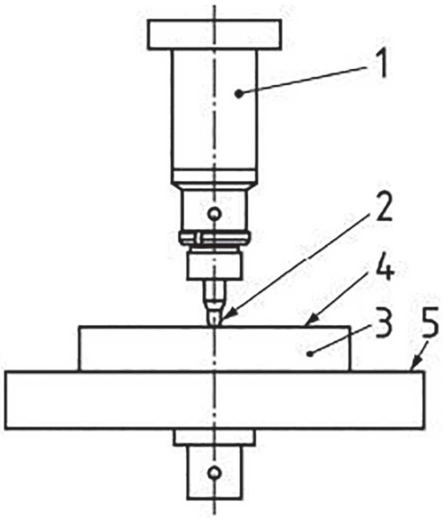
   iii) Measure and record the peak load obtained during the test interval.

   iv) Average the results of all five tests on each coupon to provide a single value.

c) Inspect the area around the impressions made in step b) ii). Any evidence of cracking or splitting down the centreline of the coupon is cause for rejection.

d) Coupons are acceptable when the average peak load measures 2 892 N ± 667 N.

A typical test setup is shown in Figure B.1.



Key

1 load cell
2 6,35 mm radius penetrator
3 MDF test coupon
4 cut face
5 flat planar surface

Figure B.1 — MDF hardness testing — Typical test setup

CAUTION — Do not use coupons that have been hardness tested for subsequent kickback testing.

Annex C
(informative)

Test record

KICKBACK TEST RECORD

Test Number: Date:

Laboratory: Technician:

Saw Manufacturer:	Model:	Chain Manufacturer:	Type:	D.L. count:
Serial No.		Cutter Type:		
Displacement	cm^3	Sequence:		
Saw Mass	kg	Condition:	D.G.Setting: mm	
Carriage mass kg	Matching mass: kg	Pitch:	Gauge: mm	
Inertia:	kgm^2	Guide bar manufacturer:		
Rotary Friction:	N	Bar part No.:	Nose type:	
Horizontal Friction:	N	Bar nose radius: mm	Bar gauge: mm	
Clutch Slip Speed:	min^{-1}	Drive Sprocket type:	Tooth count:	
MDF hardness:	N			

Chain-saw handle and bar tip coordinates (mm)

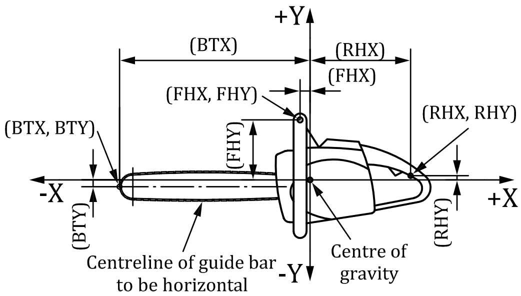
RHX		FHX		BTX	
RHY		FHY		BTY	

Chain brake summary

Release force:	N	W_r	
Release force + 10 N:	N	W_{ca}	
∠of actuation A2:	°	W_c	
Chain stop time T3:	s	R_4	

Chain brake actuation

	Automatic	
	Automatic with added weight of :	g
	Manual (with activator)	



Data summary

Data set No.	Con-tact angle °	Engine speed s^{-1}	Avg. linear energy J	Avg. Rotary energy J	CKA °
1A	0	183			
2A	5	183			
3A	10	183			
4A	15	183			
5A	20	183			
6A	25	183			
7A	30	183			
8A	35	183			
Peak average rotary energy					J

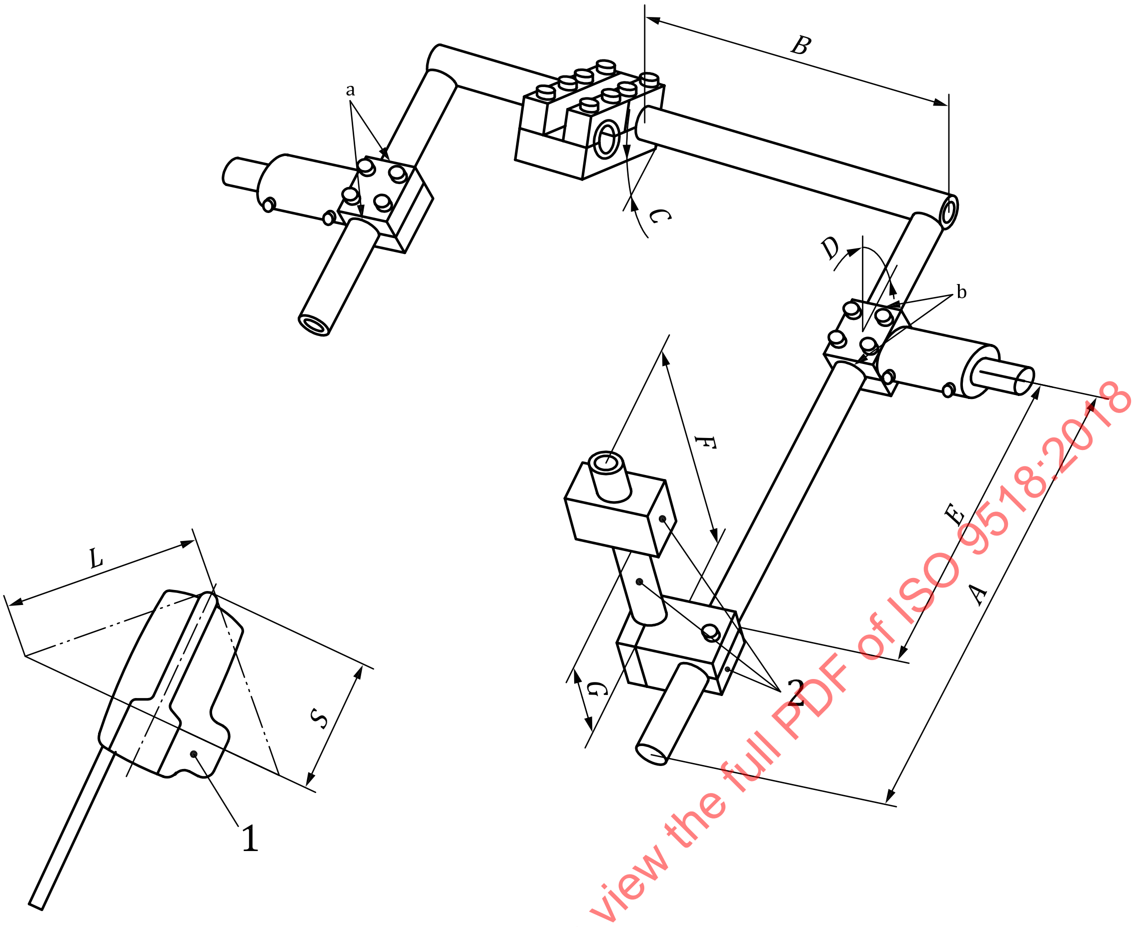
Data set No.	Contact angle °	Engine speed s^{-1}	Aver-age linear energy J	Aver-age rotary energy J	CKA °
1B	0	150			
2B	5	150			
3B	10	150			
4B	15	150			
5B	20	150			
6B	25	150			
7B	30	150			
8B	35	150			
Average rotary energy at Peak CKA:					J

Computed kickback angle

CKA without brake_(CKAwob)		°	CKA with brake (CKA_{wb})		°
			Chain stop angle (CKA_{cs})		°
Energy split			Energy split		
Horizontal:	Vertical:	Rotational:	Horizontal:	Vertical:	Rotational:
Comments					

Laboratory:		Powerhead:	
Technician:		Guide bar:	
Date:		Chain:	
Project:			
Issue:			

Figure C.1 — Kickback test record



Key

1 chain-saw

2 balancing weights

a Record brace location.

b Record brace location.

	Right brace	Left brace
L		
S		

Cradle measurements		Counterbalance measurements	
A:	mm	E:	mm
B:	mm	F:	mm
C:	°	G:	
D:	°		

Figure C.2 — Chain-saw installation and balancing test record

Annex D
(informative)

Chain-saw centre of gravity and inertia measurement

D.1 Introduction

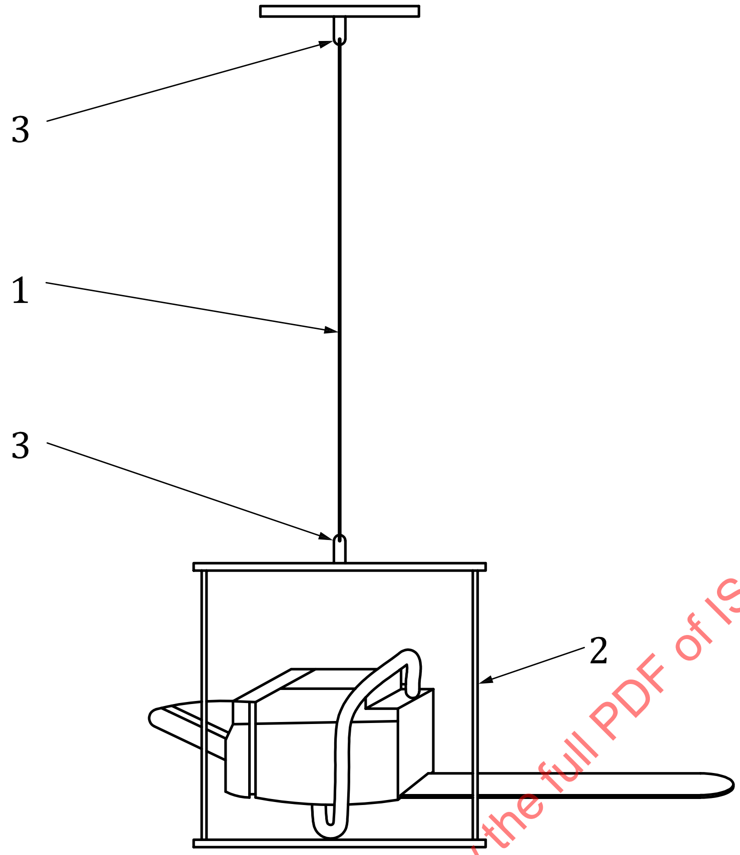
The centre of gravity of the chain-saw and the inertia of the chain-saw about an axis passing through its centre of gravity and perpendicular to the guide bar may be measured using the procedures in this Annex, or equivalent. Measurements are to be taken with fuel tanks and oil tanks full.

NOTE The following is an example only. Other technically adequate methods of making these measurements are acceptable.

D.2 Inertia measurement with a torsion pendulum

D.2.1 Inertia computation

The inertia of a chain-saw can be determined with a torsion pendulum (as shown in Figure D.1), by a calculation based on the measured oscillation period of the pendulum with the chain-saw placed on the pendulum platform. The centre of gravity of the chain-saw should be aligned with the platform centre as illustrated in Figure D.2.



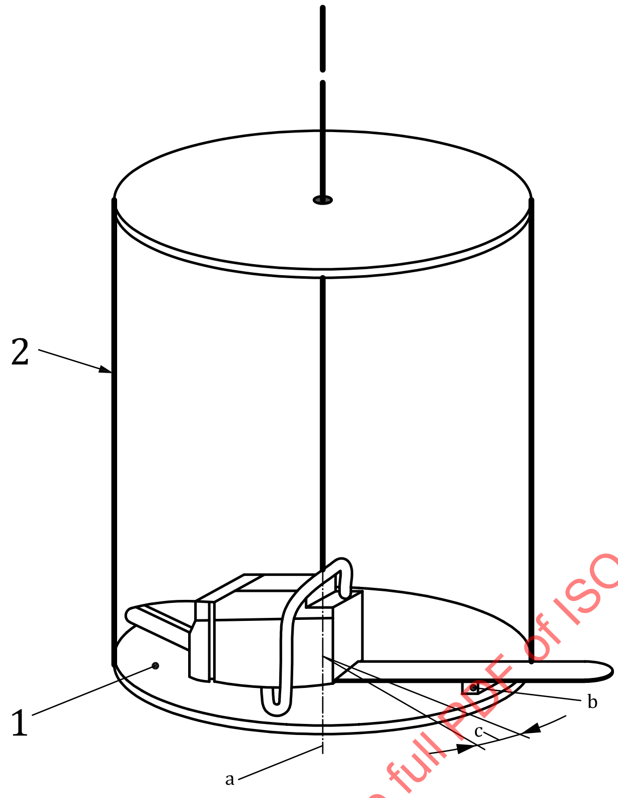
Key

1 torsion wire

2 pendulum platform assembly

3 wire clamps

Figure D.1 — Torsion pendulum



Key

1 pendulum platform

2 pendulum platform assembly

a Centre of gravity of chain-saw aligned with platform centre.

b Polyurethane foam blocks to be used such that guide bar is level and parallel to platform.

c Rotate the platform through a 10° arc.

Figure D.2 — Chain-saw positioning on the torsion pendulum

The inertia of the chain-saw can be calculated as:

$$I_{cs} = I_{tot} - I_{pen}$$

where

I_{cs} is the inertia of the chain-saw, expressed in kilogram metre squared (kgm^2);

I_{pen} is the inertia of the pendulum expressed in kilogram metre squared (kgm^2);

I_{tot} is the total inertia of the pendulum with chain-saw expressed in kilogram metre squared (kgm^2).

The inertia is defined as

$$I = c \times T^2$$

where

c is the calibration constant of the pendulum, expressed in kilogram square metres per second squared (kgm^2/s^2);

T is the oscillation period, expressed in seconds (s).

The formula $I_{cs} = I_{tot} - I_{pen}$ can thus be written as:

$$I_{cs} = c \times (T_{tot}^2 - T_{pen}^2)$$

where

T_{tot} is the oscillation period of the pendulum with chain-saw, expressed in seconds (s);

T_{pen} is the oscillation period of the pendulum without chain-saw, expressed in seconds (s).

D.2.2 Determination of the pendulum calibration constant *c*

The calibration constant, c, of the pendulum can be calculated as:

$$c = I_{cs}/(T_{tot}^2 - T_{pen}^2)$$

By replacing the chain-saw with a calibration disc of known inertia I_{cal}, c can be determined:

$$c = I_{cal}/(T_{tot}^2 - T_{pen}^2)$$

The inertia of the calibration disc can be calculated as:

$$I = (m \times r^2)/2$$

where

r is the radius of the disc, expressed in metres (m);

m is the mass of the disc, expressed in kilograms (kg).

Discs are suitable for calibration as they are easy to manufacture, their inertia is easy to calculate and the centre of gravity of the discs can be easily aligned with the centreline of the pendulum platform. Different calibration discs should be chosen to cover the mass range of the chain-saws (e.g. 3 kg – 15 kg).

To determine the calibration constant, measure the oscillation period of the empty pendulum T_{pen} as well as of the pendulum with the different calibration discs T_{tot}. Rotate the platform through a 20° arc and measure three time intervals of 20 cycles each. The oscillation period is the average seconds per cycle for the 60-cycle sample.

D.2.3 Determination of the inertia of the pendulum, I_{pen}

The inertia of the pendulum can be calculated as:

$$I_{pen} = c \times T_{pen}^2$$

D.2.4 Example for the determination of *c* and I_{pen}

D.2.4.1 General

D.2.4.2 through D.2.4.4 show an example for the determination of the pendulum calibration constant c and the inertia I_{pen} of a pendulum, as described in D.2.1 to D.2.3.