INTERNATIONAL STANDARD

**ISO 9518**

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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

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.

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.

International Standard ISO 9518 was prepared by Technical Committee ISO/TC 23, *Tractors and machinery for agriculture and forestry,* Subcommittee SC 17, *Manually portable forest machinery*.

This second edition cancels and replaces the first edition (ISO 9518:1992), which has been technically revised, mainly to extend it to include chain-saws with an engine capacity of 80 $cm^3$.

Annex A forms an integral part of this International Standard. Annex B is for information only.

## Introduction

The movement of a chain-saw during kickback can be simulated by a mathematical model. Through application of engineering principles, vertical, horizontal and rotational components of the chain-saw's movement are predicted. The model is presented in this International Standard in the form of a computer program which predicts the peak position of the chain-saw, upward and backward towards the user. This is called the "computed kickback angle" and is illustrated in figure 1.

The computer program uses standard engineering force-motion equations to predict the path of the saw based on kickback energy, physical characteristics of the chain-saw and simulated operator reaction forces. User reaction forces were determined through analysis of high-speed motion pictures of actual hand-held kickbacks.[1)]

Input data for the computer program is obtained from physical measurements and from kickback energy tests performed on a completely assembled chain-saw including powerhead, guide bar and saw chain.

Kickback energy of a chain-saw is measured on a apparatus (called the kickback machine) developed specifically for this purpose. Kickbacks are generated by delivering the flat surface of a fibreboard test specimen into contact with the bar tip under controlled conditions. This apparatus and standardized specimen have been found to yield a realistic measurement of kickback energy of any specific saw/bar/chain combination.

The test procedure requires testing over a range of conditions to ensure that peak kickback energy for the particular saw/bar/chain combination on test is determined.



When the rotating parts of a chain-saw are stopped by a chain brake, a moment is generated that tends to reduce the kickback angle. The procedure accounts for this effect.



Annex A is a flow diagram of the computer program used to determine the computed kickback angle. Annex B contains a BASIC language program (complete with examples) to make these computations

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[1)] For additional details see *Overview of the KICKBACK Computer Program — Contents and Development*, available from the Portable Power Equipment Manufacturer´s Association, 4720 Montgomery Lane, Suite 514, Bethesda, MD 20814, USA.

# Forestry machinery — Portable chain-saws — Kickback test

## 1 Scope

This International Standard specifies the methodology for determining the kickback potential of a gasoline-powered chain-saw, complete with guide bar and saw chain.

This International Standard has been demonstrated to be an accurate method of measurement for evaluating computed kickback angles and energy associated with chain-saw kickback for 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, testing of units with guide bar cutting length in excess of 63 cm is not recommended.

NOTE — Although this International Standard is applicable to gasoline-powered chain-saws, the kickback machine and test procedure ought to be also suitable for testing of electric powered chain-saws. To aid in application of this test method to electric powered units, some instructions are included in this document that relate specifically to electric chain-saws.



## 2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.



ISO 6535:1991, *Portable chain-saws — Chain brake performance*.

BOM-0100, *Kickback machine — Bill of materials.*2)

## 3 Definitions

For the purposes of this International Standard, the following definitions apply.

**3.1**
**bar tip guard**
shield that prevents contact with the chain at the tip of the guide bar and which may be removable and replaceable

**3.2**
**chain brake lever**
device, usually the front hand guard, used to activate the chain brake

2) The bill of materials and engineering drawings describing the kickback machine are available from the Portable Power Equipment Manufacturer´s Association, 4340 East-West Highway, Suite 912, MD 20814, USA.

**3.3**
**computed kickback angle**
angle used as a measure of the reaction of a hand-held chain-saw, backward and upward toward the user, when subjected to a rotational kickback under simulated conditions

See figure 1.

**3.4**
**contact angle**
angle between the surface of the test specimen and a perpendicular to the guide bar centreline

**3.5**
**data set**
group of data points, all taken at the same test conditions

**3.6**
**horizontal system**
portion of the kickback machine used to measure the horizontal energy of the kickback reaction

**3.7**
**impact**
test sequence involving releasing the specimen into contact with the moving saw chain at the guide bar tip to create a simulated kickback reaction

**3.8**
**kickback**
**rotational kickback**
rapid upward and backward motion of the saw which can occur when the moving saw chain near the upper portion of the tip of the guide bar contacts an object such as a log or branch



**3.9**
**kickback machine**
apparatus used to measure the energy generated by a chain-saw kickback under controlled conditions

**3.10**
**power head**
chain-saw without the guide bar and chain

**3.11**
**rotary system**
portion of the kickback machine used to measure the rotary energy of the kickback reaction

**3.12**
**specimen**
**test specimen**
block of medium density fibreboard used as an object for the saw chain to engage in a simulate kickback

# 4 Test method

## 4.1 Principle

The flat surface of a wood-like specimen is thrust into contact with the moving saw chain at the tip of a chain-saw guide bar, in order to produce a simulated kickback reaction. This takes place under controlled conditions in apparatus 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 computing kickback angle. 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 head and to simulate kickback situations found in actual practice. Other test parameters will lead to different computed kickback angles.

## 4.2 Materials

**Test samples**, consisting of medium-density fibreboard (density range 732 kg/m$^3$ ± 32 kg/m$^3$). Samples shall be oriented with the rough side (end grain) facing the bar tip. Standard test samples are 38 mm × 38 mm × 250 mm. At the discretion of the test laboratory, specimens with depth (measured perpendicular to the test face) up to 76 mm may be used.

NOTE — Because kickback energy measurements are sensitive to the consistency of the fibreboard, careful control of these specimens is essential. In order for test results to be reproducible over time and for comparisons with results from other laboratories, the test specimens need to be calibrated against "known" specimens. Calibration requires kickback testing with samples from batch lots using a "standard" saw/chain/bar combination for which the kickback energies have been established. A calibration factor can then be applied to the energy values before they are used in the computer model.

## 4.3 Apparatus

**4.3.1 Chain-saw kickback machine BOM-0100** for energy level measurements. (See clause 2.)

**4.3.2 Engine speed indicator** with a rotational frequency reading accuracy of ± 1,5 % of the measured value.

**4.3.3 Carriage velocity timing device,** including probes with an accuracy of ± 1 ms and a holding circuit to prevent unwanted re-triggering.

**4.3.4 Chain brake timing device,** including probes having an accuracy of ± 3 ms.



**4.3.5 Chain brake testing apparatus** in accordance with ISO 6535.

**4.3.6 Computer and kickback program** to compute the kickback angle.



## 4.4 Preparation

NOTE — Record all measurements on the kickback test record (see figures 9 and 10).

### 4.4.1 Physical measurements

**4.4.1.1** The following physical measurements are to be made with the guide bar and saw chain attached in proper working position and with oil and fuel tanks full. The saw chain shall be prepared in accordance with 4.4.2 prior to taking measurements.

**4.4.1.2** Chain-saw mass in kilograms. An accuracy of ± 50 g is acceptable for this measurement.

**4.4.1.3** 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.

**4.4.1.4** Chain-saw moment of inertia about an axis through the centre of gravity and perpendicular to the plane of the guide bar, in kilograms metre squared.

**4.4.1.5** Chain-saw tab tip, front handle and rear handle locations relative to the centre of gravity expressed as x, y coordinates, in millimetres. An accuracy of ± 3 mm is acceptable for these measurements (see figure 2).

### 4.4.2 Saw chain preparation

**4.4.2.1** The saw chain shall be new.

**4.4.2.2** Saw chain tension shall be set in accordance with figure 3. The chain should move freely on the bar.

### 4.4.3 Chain-saw preparation

**4.4.3.1** The chain-saw shall be in functionally new condition.

**4.4.3.2** The saw shall be run-in according to the manufacturer's recommendations.

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

**4.4.3.4** If the saw is equipped with a chain brake, disable the mechanism if necessary to prevent activation.

**4.4.3.5** Remove the front handle grip cover 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 so that it is as nearly parallel top the guide bar centreline as possible (see figure 4). Tighten securely.

NOTES

1 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. Chain-saw CG location, balance and mass of carriage matching weight must be adjusted accordingly, but unmodified chain-saw mass and PMI should be used for computer calculations of CKA.

2 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.

**4.4.3.6** Attach the cradle to the saw clamp assembly. Do not tighten.



### 4.4.4 Kickback machine preparation

**4.4.4.1** If the chain-saw mass (see 4.4.1.2) is less than the standard carriage (4 kg), the standard carriage may be replaced with the lightweight carriage.



**4.4.4.2** 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.

**4.4.4.3** If necessary, add weight to the carriage until the carriage mass (including fibreboard specimen) equals the mass of the saw ± 100 g.

### 4.4.5 Chain-saw installation and alignment

**4.4.5.1** 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.

**4.4.5.2** 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.

NOTE — Do not rotate the clamp where it attaches to the saw handle, this was adjusted in 4.4.3.5.

**4.4.5.3** 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.

NOTES

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

2 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.

### 4.4.6 Saw/clamp/cradle assembly balance

**4.4.6.1** Fuel and oil tanks shall be filled.

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

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

**4.4.6.3** 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 isolators, a compromise between the horizontal and vertical positions is permissible.

### 4.4.7 Friction measurements

**4.4.7.1** Horizontal friction shall be measured prior to and after kickback energy tests. Measurements shall be made with the ratchet pawl in its activated position: they shall be made over a distance of at least 300 mm. If the horizontal friction the direction of travel away from the power head exceeds 2,2 N the source(s) of friction shall be located and corrected.

**4.4.7.2** Rotary friction shall be measured prior to and after kickback energy tests. Measurements shall be made with the ratchet pawl in its activated position: they shall be made through and angle from 0° to 180°. If the rotary friction exceeds a force of 2,2 N applied to the rotary pulley, the source(s) of friction shall be located and reduced.

NOTE — 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.



### 4.4.8 Restraining systems alignment



**4.4.8.1** The specimen contact angle shall be set to 30°. Position the carriage so that the specimen contact so that the 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 (see figure 5).

**4.4.8.2** With the guide bar centreline horizontal, install the cable attachment pin on the rotary pulley and adjust the turnbuckle to bring the 0,9 kg weight on the rotary restraining system to the zero position (see figure 6).

### 4.4.9 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.

## 4.5 Test requirements and procedures

NOTE — Record data on the kickback test record, figure 9.

### 4.5.1 Test requirements

**4.5.1.1** Adjust the specimen contact angle to the value shown for data set 1A in table 1. For subsequent data sets, readjust the angle as specified.

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

**4.5.1.3** 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 reciprocal seconds ($s^{-1}$).

If the slip speed varies by more than 8 $s^{-1}$ during the test, replace the clutch.

**4.5.1.4** Saw chain tension shall be set initially and adjusted during the test in accordance with 4.4.2.2.

**4.5.1.5** On occasion, the balance of the saw/clamp/cradle may change. Check and reset balance if imbalance exceeds 60 g as specified in 4.4.6.3. If imbalance of more than 60 g occurs, data from the previous impact is invalid.

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

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

**4.5.1.8** The specimen should be examined and changed after each impact.

The orientation of the 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.

**4.5.1.9** Upon completion of the test, horizontal and rotary friction levels are to be measured as described in 4.4.7. The greater measured level is to be used for energy computations. If friction at the end of the test program exceeds the specifications of 4.4.7, the test shall be repeated.



### 4.5.2 Kickback testing

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.



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

**4.5.2.1** 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.

**4.5.2.2** Raise the barrier bar and stand clear of the kickback machine.

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

**4.5.2.4** Turn off the chain-saw.

**4.5.2.5** Record the vertical displacement, in millimetres, of the horizontal restraining weight and the horizontal displacement, in millimetres, of the carriage (see figure 5).

**4.5.2.6** Record the vertical displacement, in millimetres, of the upper and lower rotary restraining weights (see figure 6).

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

**4.5.2.7** Complete data set 1A by repeating the steps in 4.5.2.1 to 4.5.2.6. 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.

**4.5.2.8** Repeat the steps in 4.5.2.1 to 4.5.2.7 for the remaining data sets as specified in the test sequence of table 1 or 2.

**4.5.2.9** 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 decrease in the average rotary energy for two consecutive contact angles.

**Table 1 — Test sequence**

| **Data set** | **Contact angle** degrees | **Impact velocity** m/s | **Engine speed**[1)] $s^{-1}$ ± 3 $s^{-1}$ |
|---|---|---|---|
| 1A | 0 | | 183 |
| 1B | 0 | | 150 |
| 2A | 5 | | 183 |
| 2B | 5 | | 150 |
| 3A | 10 | | 183 |
| 3B | 10 | | 150 |
| 4A | 15 | 0,76 | 183 |
| 4B | 15 | | 150 |
| 5A | 20 | | 183 |
| 5B | 20 | | 150 |
| 6A | 25 | | 183 |
| 6B | 25 | | 150 |
| 7A | 30 | | 183 |
| 7B | 30 | | 150 |

1) If a speed of 183 $s^{-1}$ cannot be reached, the A-series tests shall be carried out at the highest possible speed and the B-series tests at the highest possible speed less 33 $s^{-1}$.



**Table 2 — Optional test sequence**

| **Data set** | **Contact angle** degrees | **Impact velocity** m/s | **Engine speed**[1)] $s^{-1}$ ± 3 $s^{-1}$ |
|---|---|---|---|
| 1A | 0 | | 183 |
| 2A | 5 | | 183 |
| 3A | 10 | | 183 |
| 4A | 15 | | 183 |
| 5A | 20 | | 183 |
| 6A | 25 | | 183 |
| 7A | 30 | 0,76 | 183 |
| 1B | 0 | | 150 |
| 2B | 5 | | 150 |
| 3B | 10 | | 150 |
| 4B | 15 | | 150 |
| 5B | 20 | | 150 |
| 6B | 25 | | 150 |
| 7B | 30 | | 150 |

1) If a speed of 183 $s^{-1}$ cannot be reached, the A-series tests shall be carried out at the highest possible speed and the B-series tests at the highest possible speed less 33 $^{-1}$.