American National Standard

for Power Tools –

Gasoline-Powered Chain Saws – Safety Requirements

ANSI B175.1-1991

ANSI American National Standards Institute
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American National Standard
for Power Tools–

Gasoline-Powered Chain Saws–
Safety Requirements

Secretariat

Portable Power Equipment Manufacturers Association

Approved January 10, 1991

American National Standards Institute, Inc.

Abstract

This standard was developed to establish acceptable minimum safety requirements for the manufacture of chain saws. The safety precautions included have been developed from experience and testing by manufacturers, users, and regulatory agencies.

American National Standard

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Annexes

Foreword (This foreword is not part of American National Standard B175.1-1991.)

This standard sets forth the minimum safety requirements for gasoline-powered chain saws. These requirements have resulted from several years of standards development effort by the American National Standard Committee B175, which became an Accredited Standards Committee in 1984. The original standard was approved in 1979.

Working from the 1979 version of the requirements, which had been developed in accordance with the ANSI canvass method of standards development, the B175 Committee was established in 1980 to consider several modifications to the requirements. In September 1982, the B175 Committee submitted suggested modifications to several requirements: handle strength, handle size, and handle clearance; chain brake and hand guard; balancing test procedures; accelerometer and accelerometer mounting location; and on/off controls. These modifications were approved by the ANSI Board of Standards Review in 1983.

In January 1982, the B175 Committee began their consideration of the proposed kickback requirements. At that time, the 1979 version of the ANSI B175.1 standard required that chain saws be equipped with a device intended to reduce the hazard associated with kickback, and stated that a performance standard was being developed to replace this requirement. The 1985 revisions to the requirements were the result of the B175 Committee's effort to develop a set of performance requirements to address the phenomenon of rotational chain saw kickback for gasoline-powered chain saws below 3.8 cubic inch displacement.

It had been estimated that rotational chain saw kickback accounts for approximately one-fifth of all chain saw injuries, including some of the most severe injuries. The kickback phenomenon, in which the chain saw can be propelled upward and rearward toward the operator at rapid speeds, results from the complex interplay of many variables. Accordingly, the performance requirements of the 1985 supplement reflected a level of sophistication corresponding to the complexity of the kickback phenomenon itself. For example, the testing requirements mandated the use of a specially instrumented kickback machine designed specifically to measure kickback energy. Compliance with the 1985 requirements, which is expressed in terms of the computed kickback angle at which either the chain saw guide bar or the moving saw chain stops, was determined through an analytical model.

In addition to the complexity of the test equipment and test procedures, the revised requirements were unique in that they addressed the safety of chain saws produced prior to the 1985 supplement through the provisions governing replacement cutting attachments. The requirements for testing saw chain were developed in recognition of the importance of saw chain in the kickback reaction, and were intended to provide a means to enhance the safety of chain saws already in use.

In the 1985 supplement, the B175 Committee also devised new requirements for communicating with the user. New labels for chain saw powerheads and for new and replacement saw chain were devised. In addition, the warnings and instructions in the owner's manual were supplemented, revised, and reorganized.

The B175 Committee submitted the proposed rotational kickback provisions to the ANSI Board of Standards Review on May 20, 1985. Final approval by the Board of Standards Review was received on June 26, 1985. The B175 Committee established the effective date for these revised requirements at 90 days after the date the requirements were published by ANSI. (The date of publication was December 2, 1985.).

The Consumer Product Safety Commission, an independent agency of the Federal government, was a nonvoting member and active participant on the B175 Committee. In May of 1982, CPSC published an Advance Notice of Proposed Rulemaking announcing the agency's intention to develop a mandatory consumer product safety rule concerning chain saws and their component and replacement parts. On August 7, 1985, CPSC voted to withdraw the Advance Notice of Proposed Rulemaking in light of the anticipated effectiveness of these revisions in reducing kickback injuries.

Electric chain saws are not covered by the kickback requirements in this standard. However, Underwriters Laboratories, which was a voting member and active participant on the B175 Committee, developed requirements for electric chain saws. (Their standard was later approved as an American National Standard and designated as ANSI/UL 1662-1989.)

The B175 Accredited Standard Committee began a general review of the standard in 1985, and submitted a number of revisions to the Board of Standards Review on November 30, 1990. These proposed changes were approved on January 10, 1991. The provisions that are amended by these changes include: bow guides, guide bar effective length, on/off or stop control, throttle control linkage, handle strength, handle clearance, spark-arresting mufflers, sprocket and clutch guards, chain guards, replacement chain, front hand guard, chain brake, rear handle, chip discharge, kickback test procedure, replacement guide bar, labels for replacement saw chain, balance, guide bar length, vibration, vibration level test procedure, sound level test procedure, and one-handed operation.

This standard contains 12 annexes, all of which are informative and are not considered part of this standard.

Suggestions for improvement of this standard will be welcome. They should be sent to the Office of the Secretariat, ASC B175 Committee, 7315 Wisconsin Avenue, Suite 702E, Bethesda, MD 20814-3202.

This standard was processed and approved for submittal to ANSI by the Accredited Standards Committee on Safety of Gasoline-Powered Chain Saws and Leaf Blowers, B175. Committee approval of this standard does not necessarily imply that all committee members voted for its approval. At the time it approved this standard, the B175 Committee had the following members:

Bela Csonka, Chairman

Organization Represented	*Name of Representative*
American Society of Plastic Surgeons	James Ferraro
Andreas Stihl	Manfred Bortfeld
Carolton Company	Ren Atkinson

Organization Represented	*Name of Representative*
Electrolux Motor AB	Dan Ericsson
Homelite/Textron	Jack Campbell
McCulloch Corporation	Don Woodward
National Equipment Servicing Dealers Association	Norman Beck
Oregon Cutting Systems/Blount	Arvin Hille
Poulan/Weed Eater	Bela Csonka
Power Tools Institute	James Bates
Underwriters Laboratories	William Hoper
U.S. Consumer Products Safety Commission (nonvoting	Jim McNamara
U.S. Department of Health/Occupational Safety and Health Administration (nonvoting)	Frank Smith

Individual Members

Jack Ehlen
Ronald Loyd
Vindent Morabit

American National Standard for Power Tools –

Gasoline-Powered Chain Saws – Safety Requirements

1 Scope and purpose

1.1 Scope

The requirements of this standard apply to portable, hand-held, gasoline-powered chain saws for use primarily in cutting wood.

NOTE – Metric units are included for information only.

1.2 Purpose

The purpose of this standard is to establish minimum safety requirements with respect to the manufacture of portable, hand-held, gasoline-powered chain saws.

2 Normative references

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

ANSI S1.4-1983 and its supplement ANSI S1.4A-1985, *Specification for sound level meters*

ANSI S2.11-1969 (R1986), *Methods for specifying the characteristics of auxiliary equipment for shock and vibration measurement*

ANSI/SAE J184-FEB87, *Qualifying a sound data acquisition system*

IEC 184(1965), *Methods for specifying the characteristics of electromechanical transducers for shock and vibration measurements* [1)]

IEC 222(1966), *Methods for specifying the characteristics of auxiliary equipment for shock and vibration measurements* [1)]

IEC 651(1979), *Sound level meters* [1)]

ISO 5349:1986, *Mechanical Vibration – Guidelines for the measurement and assessment of human exposure to hand-transmitted vibration* [1)]

SAE J335-SEPT90, *Recommended Practice – Multiposition small engine exhaust system fire ignition suppression* [2)]

3 Definitions [3)]

3.1 bar tip guard: A shield that prevents contact with the chain at the tip of the guide bar and that may be removable and replaceable.

3.2 bow guide: A narrow rail structure with a large open center that supports and guides the saw chain.

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1) IEC and ISO documents are available from the American National Standards Institute, 11 West 42nd Street, New York, NY 10036.

2) Available from the Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

3) For additional nomenclature, see annex B.

3.3 bow guide cutting capacity: The maximum diameter of the log that the bow guide, with chain and guards attached, will cut through. Capacity shall be expressed in terms of the nearest whole unit of measure (in/cm).

3.4 bucking: The process of cross-cutting a felled tree, or log, into lengths.

3.5 chain brake: A device used to stop the saw chain.

3.6 chain saw powerhead: A chain saw without the saw chain and guide bar.

3.7 choke control: A control that is used to richen the carburetor fuel/air mixture.

3.8 clutch: A mechanism for connecting and disconnecting a driven member to and from a rotating source of power.

3.9 drive sprocket: The toothed part that drives the saw chain.

3.10 felling: The process of cutting down a tree.

3.11 felling back cut: The final cut in a tree-felling operation made on the opposite side of the tree from the notching undercut.

3.12 front hand guard: A structural barrier between the front handle of a chain saw and the guide bar, typically located close to the hand position on the front handle and sometimes employed as an activating lever for a chain brake.

3.13 front handle: The support handle located at or toward the front of the chain saw.

3.14 guide bar: A solid railed structure that supports and guides the saw chain.

3.15 guide bar effective length: The length of cut a guide bar and chain will make when the guide bar adjustment is at the halfway point. The chain used for measurement will be the one normally intended to be used with the bar. Measurement shall be made from (a) the bumper plate (where no spikes are provided or the spikes are removable) or (b) the root of the spikes (where the spikes are a permanent part of the saw) to the top of the chain cutters at the tip end of the bar. Capacity shall be expressed in terms of the nearest whole unit of measure (in/cm).

3.16 kickback

3.16.1 pinch kickback: The rapid pushback of the saw chain that can occur when the wood closes in and pinches the moving saw chain in the cut along the top of the guide bar.

3.16.2 rotational kickback: The rapid upward and backward motion of the saw that 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.

3.17 low-kickback saw chain: A saw chain that has been demonstrated to meet the requirements of 5.12.2.4.

3.18 may: The term that indicates a permissive requirement.

3.19 muffler: A device to reduce engine exhaust noise and direct the exhaust gases.

3.20 normal cutting positions: Those positions assumed in performing the bucking and felling cuts.

3.21 notching undercut: A notch cut in a tree to direct the tree's fall.

3.22 oiler control: A system for oiling the guide bar and saw chain.

3.23 on/off or stop control: A control that allows the engine to run or stop.

3.24 primer control: A control for supplying extra fuel for engine starting.

3.25 rear handle: The support handle located at or toward the rear of the saw.

3.26 reduced-kickback guide bar: A guide bar that has been demonstrated to reduce kickback significantly.

3.27 reduced-kickback saw chain: A saw chain that has been demonstrated to reduce kickback significantly, but that does not meet the requirements of 5.12.2.4.

3.28 saw chain: A loop of chain that has cutting teeth for cutting wood and is driven by the engine and supported by the guide bar.

3.29 shall: The term that indicates a mandatory requirement.

3.30 spiked bumper (spike): The pointed tooth or teeth used when felling or bucking to pivot the saw and maintain position while sawing.

3.31 sprocket: The toothed part that drives the saw chain.

3.32 starter: The mechanism that rotates the engine to start it.

3.33 throttle control system: The complete system including the throttle control trigger, throttle control linkage, and, in some cases, a throttle control latch or a throttle control lockout, or both.

3.33.1 throttle control latch: A device to temporarily set the throttle control valve in a partially open position to aid the operator in starting the engine.

3.33.2 throttle control linkage: The mechanism that transmits motion from the throttle control trigger to the throttle control valve.

3.33.3 throttle control lockout: A movable stop that prevents the accidental opening of the throttle control valve until manually released.

3.33.4 throttle control trigger: The part of the saw, usually a lever, activated by the operator's hand or finger, which in turn controls the throttle control valve.

3.33.5 throttle control valve: A control that adjusts the volume of fuel and air mixture delivered to the combustion chamber of an internal combustion engine.

4 Responsibility

It shall be the responsibility of the chain saw manufacturer to design and construct his chain saws in accordance with clause 5. It shall be the responsibility of the owner to maintain the chain saw in accordance with the instructions in the owner's manual.

Chain saws shall be used in accordance with the operating instructions and safety precautions listed in the owner's manual. It shall be the responsibility of the owner to see that such instructions and precautions are given to every operator who uses the saw.

5 General specifications

5.1 Throttle control system

The chain saw shall be equipped with a continuous-pressure throttle control system that will shut off the power to the saw chain after the pressure is released.

5.1.1 Throttle control trigger

There shall be a guard completely around the trigger in the plane of trigger motion. A continuous loop formed by the handle and body of the chain saw will satisfy this requirement. The trigger shall be located so that it may be actuated and released while both hands are gripping the chain saw handle(s).

5.1.2 Throttle control lockout

If a throttle control lockout is provided, it shall be constructed so that it must be actuated before the throttle control valve can be opened. When the throttle control system is locked out, the throttle control valve shall be locked in the idle position. The throttle control lockout shall not prevent the engine from returning to idle speed.

5.1.3 Throttle control latch

If a throttle control latch is provided for starting, it shall be self-releasing when the throttle control trigger is depressed. In the starting mode the saw chain may be powered.

The throttle control latch shall be constructed so that two or more independent motions are required to engage the latch. A one-motion throttle latch is acceptable, provided that it does not cause the chain to be powered.

5.1.4 Throttle control linkage

The throttle control linkage shall either be enclosed or confined in a space defined by the vertical projection of the handle containing the throttle control trigger with the saw in an upright position and with the bar centerline horizontal.

The throttle control linkage shall be constructed so that a force in the amount of three times the empty weight of the chain saw (without guide bar and saw chain), applied in any direction on the rear handle, shall not increase engine speed to a point at which the clutch engages and chain movement begins.

5.1.5 Carburetor

The throttle control valve shall return to the idle position if the throttle control linkage becomes disconnected, regardless of the attitude of the chain saw.

5.2 Handles

All chain saws shall be designed and constructed with a handle, or handles, enabling the operator to operate the chain saw with two hands.

5.2.1 Handle strength

The chain saw handles shall not break when subjected to the static test loads separately applied in each of six directions as specified in figure 1. The chain saw may be supported at the guide bar mounting pad when the test loads are applied. The load shall be applied in the normal hand grip area of not more than 3.5 in (90 mm). The grip area for the front handle is defined as that area closest to the center of balance for the saw when in the bucking or crosscutting position.

5.2.2 Handle vibration isolation system

If a handle vibration isolation system is used, the chain saw shall be constructed so that a failure of one or more of the vibration isolators shall not result in the loss of ability of the operator to control the chain saw.

5.2.3 Handle sizes

5.2.3.1 General

The handle clearances and the handle sizes shall be at least the minimum values specified in figure 2.

5.2.3.2 Handle clearance

If a fixed hand guard that meets the requirements of 5.9.4 and figure 5 is provided, then the requirements of dimension B, figure 2, shall not apply. When a saw is provided with a hand guard that can be pivoted toward the handle, the construction shall comply with dimension B, figure 2.

5.3 Pull-type starter

The chain saw, if equipped with a rope or rewind starter, shall require no more cranking effort than that specified in figure 3. The test weight specified in figure 3 shall be attached to the starter rope and allowed to drop. The drop distance shall be no more than 24 in (610 mm). The chain saw tested shall be new as shipped, shall be run for not more than 1 hour, and shall be tested for cranking effort with the room and engine temperatures between 60°F and 80°F (16°C and 27°C). If the chain saw is equipped with a device to reduce starting effort, this device should be employed. The minimum cranking speed shall be reached each time on three consecutive tries.

5.4 Controls

5.4.1 On/off or stop controls

A shutoff control shall be provided to stop the operation of the engine. The off or stop position shall be clearly and durably identified as "stop." This control shall require deliberate activation before the engine can be restarted. In addition, a shutoff function may be used that provides an automatic reset after a delay sufficient to ensure that the engine has come to a complete stop. All off or stop controls shall be located so that each control can be activated by the operator while maintaining a grip on the handles with both hands.

5.4.2 Oiler control

If the chain saw is equipped with a manual saw chain oiler control, it shall be located so that it can be operated while maintaining a grip on the handle, or handles, with both hands.

5.4.3 Choke control

If a manual choke control is provided, it shall be clearly and durably identified.

5.4.4 Primer Control

If a manual primer control is provided, it shall be clearly and durably identified.

5.5 Fuel tanks and oil tanks

5.5.1 Tank filler location and identification

The fuel tank and oil tank filler openings shall be located so that they will not be unduly obstructed by the chain saw components. Each cap or opening shall be clearly and durably identified. If only the caps are identified, they shall not be interchangeable.

5.5.2 Tank filler openings

The minimum diameter of the fuel tank filler hole shall be 0.72 in (18 mm). The minimum diameter of the oil tank filler hole shall be 0.50 in (13 mm).

5.5.3 Fuel line

The fuel line shall be routed so that it is not subject to abrasion where the line is outside the fuel tank.

5.6 Exhaust system

5.6.1 Exhaust direction

The exhaust flow shall be away from the chain saw and away from the operator when cutting in the normal cutting positions.

5.6.2 Muffler location

The muffler shall be located or guarded so that the operator will not inadvertently contact any hot muffler surface when starting or operating the chain saw in the normal cutting positions.

5.6.3 Spark-arresting mufflers

All saws shall have spark-arresting mufflers meeting the specifications and performance requirements given in SAE J335-SEPT90.

5.7 Saw chain tensioning

The chain saw shall be manufactured with provisions for adjusting the guide bar to obtain proper saw chain tension.

5.8 Bars

5.8.1 Guide bars

No opening with a dimension greater than 0.40 in (10 mm) shall be in the cutting area of the guide bar.

5.8.2 Bow guides

In accordance with 5.16, the following wording shall be placed on the bow guide:

> **WARNING:** A bow guide increases the risk of severe kickback and serious injury. Do not use the bow guide unless you have experience and/or specialized training. Do not remove guard(s) and/or spur(s) provided by the manufacturer.

This warning may be suitably paraphrased.

5.9 Guards

5.9.1 Rotating part guards

All power-driven shafts, gears, flywheels, and starter pulleys, except sprockets and clutches, shall be positioned or otherwise guarded to prevent contact by a probe having a hemispherical end and a diameter of 0.50 in (13 mm).

5.9.2 Sprocket and clutch guards

The clutch and sprocket shall be guarded on the top, sides, and rear so as to conform with the accessibility noted in 5.9.1. If the chain saw is equipped with a wraparound front handle, the sprocket guard shall fully cover the chain to the rear of the handle and extend forward of the handle a distance of 1 in (25 mm) or greater. For this protected area, the sprocket guard may be open on the bottom, but shall extend at least 0.50 in (13 mm) below the saw chain cutter teeth.

5.9.3 Bow guide guard(s) and spike(s)

5.9.3.1 Chain guards that cover the saw chain on the upper and lower portion of the bow guide, near the powerhead, shall be provided. The guards shall cover a minimum of 4 in (102 mm) of exposed chain in each area. To allow for assembly, a maximum of 0.5 in (13 mm) gap is allowed between guards and the powerhead when a new, unused chain is installed.

5.9.3.2 A bow guide shall also be equipped with spike(s), dog(s), or spur(s), as illustrated in figure 4.

5.9.3.3 The saw chain shall be replaceable without removing the chain guard(s) or spike(s).

5.9.4 Front hand guard

5.9.4.1 General

All chain saws shall be equipped with a front hand guard, meeting the requirements of 5.9.4.2 and the requirements specified in figure 5. The hand guard may be designed to also function as a chain brake actuator.

5.9.4.2 Front hand guard impact strength requirement

The guard shall not break when struck one time by the pendulum shown in figure 6 at the midpoint of the dimension B of figure 5. This test shall be conducted at the temperature of −13°F ± −4.0°F (−25°C ± 2°C). For this test, the chain saw shall not be running. If the hand guard can actuate a chain brake, this test shall be carried out with the chain brake in the actuated position.

5.9.5 Chain brakes

5.9.5.1 General

If a chain brake is provided, it shall stop the saw chain within 0.15 second, maximum, and

0.12 second, average, after actuation, when tested in accordance with 5.9.5.2.

If a chain saw is equipped with a hand-guard-actuated chain brake, the actuating lever shall meet the requirements in 5.9.4 and the requirements specified in figure 5.

When tested in accordance with 5.9.5.2, the static release force shall be not less than 4.4 lbf nor more than 15.4 lbf (20–70 N).

5.9.5.2 Hand-guard-actuated chain brake test requirements

The following requirements shall be met when testing hand-guard-actuated chain brakes:

a) During the test, the chain saw shall be rigidly mounted by the bar pad or the handles.

b) Initially, the brake's friction surface shall be in a dry and unlubricated condition.

c) The engine shall be run-in before the test, and the chain saw adjusted and operated according to the manufacturer's instructions.

d) Only new brakes shall be tested.

e) No adjustment to the brake shall be permitted during the test.

f) The test temperature shall be 68°F ± 9°F (20°C ± 5°C).

g) The chain brake shall be activated in accordance with the test sequence set forth in figure 6. The brake shall be activated by the pendulum, having a mass of 1.5 lb (0.7 kg) and a length of 27.5 in (700 mm).

h) The pendulum shall strike the midpoint of dimension B as shown in figure 5. The drop height shall be 8 in (200 mm) as shown in figure 6.

i) The throttle shall be kept in a fixed position at racing speed during the test. Racing speed is defined as the manufacturer's rated engine speed for maximum power plus 33%, or full throttle, whichever is less. When the chain has stopped after braking, the throttle shall be returned to the idle position and the brake reset. The braking time is defined as the interval from the instant the pendulum hits the chain brake actuator to the instant the saw chain stops.

j) The static force needed to release the chain brake actuator shall be measured at the top edge of the hand guard in the direction of 45° forward and downward in relation to the guide bar centerline at the midpoint of dimension B as shown in figure 5. The force shall be applied at a uniform rate with the engine not running.

5.9.6 Rear handle

The rear handle shall be designed or positioned so that the operator's hand is protected if the chain breaks or comes off the guide bar. If a rear handle is designed so that any portion of the operator's hand is in line with the guide bar centerline, then a hand guard shall be provided.

Where a handle offset from the plane of the guide bar is used, guarding shall extend from the right side of the handle a distance sufficient to intersect the plane of the bar and chain, but need not extend more than 1.2 in (30 mm). This protection shall be provided as measured from the right outer surface of the handle and shall extend over that length defined by the projection of the trigger finger and hand (dimensions F & H), shown in figure 2, in a direction perpendicular to the surface of the handle top and down to the guarding.

5.10 Chip discharge

The chain saw shall be designed so that the main stream of wood chips and sawdust shall not be directed any higher than the centerline of the guide bar when tested in the horizontal bucking position.

5.11 Sound levels

The chain saw sound level shall not exceed 108 dBA at the chain saw operator's ear and 84 dBA at a distance of 50 ft (15 m) from the chain saw location. The sound levels shall be measured in accordance with clause 6. The owner's manual shall provide instructions for the use of hearing protection.

5.12 Chain saw kickback

5.12.1 Scope

Permissible limits of computed kickback angle (see figure 7) for chain saws that are below 3.8 cubic inch displacement (c.i.d.) are established in 5.12.2. (The application of computed kickback angle limits to saws that are 3.8 c.i.d. and larger is under investigation.) In addition, in accordance with 5.12.2, all saws shall have devices to reduce the hazard of kickback. Performance requirements for replacement chain are also included in 5.12.2. There are no specific performance requirements for guide bars in the standard. However, some guidelines for selecting replacement bars are provided in 5.12.2.

In accordance with 5.12.3, kickback warning labels shall be placed on all chain saw powerheads, and warning labels shall be used on replacement saw chains.

Accredited Standards Committee (ASC) B175 recognizes that there is a limited group of users whose extraordinary needs may not be satisfied by bar-and-chain combinations that comply with the 45° acceptance criteria of the standard. In such cases, it is appropriate that other bar-and-chain combinations be available at the user's request. The original equipment recommended for sale by the manufacturer, for a chain saw below 3.8 c.i.d., shall result in the chain saw meeting the performance requirements of the standard. Any user choosing different cutting attachments shall do so knowingly in the face of clear and strong warnings.

Other clauses dealing with kickback are 5.15, which requires instructions regarding kickback to be in the owner's manual, and clause 8, which establishes the test equipment and procedures for determining the computed kickback angle.

The requirements for the kickback of electric chain saws are not included in this standard, but are described in ANSI/UL 1662. [4)]

5.12.2 Acceptance criteria

5.12.2.1 Chain saws below 3.8 c.i.d.

The following applies to chain saws below 3.8 c.i.d.:

a) When evaluated in accordance with clause 8, either the chain saw shall not exceed a 45° computed kickback angle, or the moving chain shall be stopped before the chain saw exceeds a 45° computed kickback angle;

b) The chain saw shall have at least two separate features to reduce the risk of injury from kickback, such as a bar tip guard, a chain brake, a low- or reduced-kickback saw chain, a reduced-kickback guide bar, or other feature demonstrated to reduce significantly the risk of injury from kickback. This requirement is in addition to the requirement for a front hand guard contained in 5.9.4.

5.12.2.2 Chain saws 3.8 c.i.d. and above

The following applies to chain saws 3.8 c.i.d. and above:

a) Chain saws 3.8 c.i.d. and above may meet the acceptance criteria of 5.12.2.1;

b) Chain saws 3.8 c.i.d. and above that do not meet the acceptance criteria of 5.12.2.1 shall be equipped to reduce the risk of injury from kickback through the use of a feature such as a bar tip guard, a chain brake, a reduced-kickback guide bar, a low- or reduced-kickback saw chain, or other feature demonstrated to reduce significantly the risk of injury from kickback. This requirement is in addition to the requirement for a front hand guard contained in 5.9.4.

5.12.2.3 Replacement saw chain

The following applies to replacement saw chain:

a) Saw chain sold as replacement equipment for a specific chain saw model originally certified in accordance with the criteria of 5.12.2.1(a) shall, when evaluated with that chain saw model, enable that chain saw model to meet the acceptance criteria of 5.12.2.1(a); or

b) It shall conform to the requirements for low-kickback saw chain in accordance with 5.12.2.4.

5.12.2.4 Low-kickback saw chain

Chain may be designated "low-kickback" saw chain if, when evaluated using the chain saws listed in table 1, the computed kickback angle does not exceed 45° for any saw. The chain saws listed in the table are intended to represent 85% of the current United States market for chain saws under 3.8 c.i.d. The chain shall

4) Since ANSI/UL 1662 is not needed to complete a requirement in this standard, it is listed in annex M, Bibliography.

Table 1 – Replacement saw chain test sample

Manufacturer	c.i.d.	Model	Bar Size (in)	Bar Tooth	Pitch
Poulan	2.0	2000	14	7	3/8 MINI
	2.3	2300 AV	16	7	3/8 MINI
	3.4	3400	18	9	3/8
	2.3	Sears 71-35507	16	7 Top Sharp	3/8 MINI
	3.7	Sears 71-35610	18	9 Top Sharp	3/8
Echo	1.7	280E	12	7	3/8 MINI
	2.04	302S	16	7	3/8 MINI
Homelite	1.6	XL10	10	H-Tip	3/8 MINI
	2.4	240	16	9	3/8 MINI
	3.3	330	16	11	3/8
	3.5	SXL	20	11	3/8
Husqvarna	2.7	44	18	12	325
	3.11	50	16	12	325
	3.75	61	24	11	3/8
McCulloch	2.0	MAC 130	14	9	3/8 MINI
	2.1	PM 310	14	9	3/8 MINI
	3.7	PM 610	16	11	3/8
	3.5	PM 1010	20	11	3/8
	2.0	MAC 130	14	9 Top Sharp	3/8 MINI
	2.1	PM 310	16	9 Top Sharp	3/8 MINI
	2.3	Titan 35	16	9 Top Sharp	3/8 MINI
Stihl	2.3	009 EQ	14	9	3/8 MINI
	2.5	011 AVEQ	16	9	3/8 MINI
	2.6	024 AVEQ	16	11	325
	2.9	028 WB	16	11	325
	3.75	034 AVSEQ	20	10	3/8

be tested on each model in the sample that will accommodate the chain.

NOTE – Additional models may be nccessary to provide a minimum of four models that will accommodate the chain being evaluated. For those chain saws equipped with a chain brake, the computed kickback angle shall be determined with the chain brake operative and shall not exceed 45°.

5.12.2.5 Replacement guide bars

Because of differences in replacement guide bars, the following guidelines shall be considered to determine kickback energy:

a) Sprocket nose guide bars with the same effective length, the same number of sprocket nose teeth, and the same pitch may be considered to have equivalent kickback energy;

b) A hard-nose guide bar having the same effective bar length, and the same or smaller nose radius as a sprocket-nose bar, may be considered to have equivalent or less kickback energy than the sprocket nose-bar. (See figure 8 for definition of bar nose radius.);

c) Kickback energy of all guide bar types may be considered to be less for smaller nose radius sizes.

5.12.3 Kickback labels

5.12.3.1 Labels – All chain saw powerheads

All chain saw powerheads shall be clearly and durably marked in a lasting manner with the following verbatim or suitably paraphrased statements (pictorial or graphic illustrations may be used in lieu of or in addition to written statements):

Contact of the guide bar tip with any object should be avoided.

Tip contact may cause the guide bar to move suddenly upward and backward, which may cause serious injury.

Both of the operator's hands must be used to operate the chain saw.

5.12.3.2 Labels – Chain saw powerheads below 3.8 c.i.d

Chain saw powerheads below 3.8 c.i.d. shall be clearly and durably marked in a lasting manner to identify at least one replacement bar-and-chain combination that has been evaluated with that chain saw powerhead and that will provide performance conforming to 5.12.2.1(a), and shall state that there may be other replacement components for achieving kickback protection.

5.12.3.3 Labels – Chain saw powerheads 3.8 c.i.d. and above

a) Chain saw powerheads 3.8 c.i.d. and above that have been evaluated and found to meet the acceptance criteria of 5.12.2.1 may be labeled in accordance with 5.12.3.2.

b) Chain saw powerheads 3.8 c.i.d. and above that are not labeled in accordance with 5.12.3.2 shall be clearly and durably marked in a lasting manner with the following verbatim or suitably paraphrased warning:

WARNING: This chain saw is capable of severe kickback that could result in serious injury to the user. Do not operate this chain saw unless you have extraordinary cutting needs and experience and specialized training for dealing with kickback. Chain saws with significantly reduced kickback potential are available.

5.12.3.4 Labels – Replacement saw chain

All saw chain packaging shall be clearly labeled in accordance with (a), (b), or (c) below, as appropriate. The labels may be suitably paraphrased or combined, or both, as appropriate. The label or labels must be clearly visible without opening the package.

a) *Saw chain that is sold for specific chain saw models and meets the requirements of 5.12.2.3(a):*

This saw chain met the kickback performance requirements of ANSI B175.1-1991 when tested with [list specific chain saw model(s) and guide bar combinations, or refer to manufacturer's literature]. It may not meet the ANSI B175.1-1991 performance requirements when used on other chain saws or guide bars.

b) *Saw chain that meets the requirements of 5.12.2.4:*

This saw chain met the kickback performance requirements of ANSI B175.1-1991 when tested on a representative sample of chain saws.

c) *Saw chain not meeting the requirements of 5.12.2.3 or 5.12.2.4:*

WARNING: This saw chain may be capable of severe kickback that could result in serious injury to the user. Do not use this saw chain unless you have experience and specialized training for dealing with kickback. Saw chain with reduced-kickback potential is available.

5.13 Balance

5.13.1 When tested in accordance with 5.13.2, the centerline of the guide bar shall not be at an angle greater than 15° above or 30° below the horizontal. For chain saws with an engine displacement of more than 5 in^3 (81.94 cm^3), the guide bar shall not contact the horizontal plane defined by the base of the chain saw when placed in the upright position.

5.13.2 The test procedure is as follows:

a) The chain saw fuel and chain oil tanks shall be filled to at least one-half their respective capacities.

b) The chain saw shall be fitted with the type of guide bar and chain recommended

Table 2 – Balance

Engine displacement		Guide bar test length	
cubic in	cubic cm [1]	in (± 2 in)	cm[1] (± 5 cm)
through 2.0	through 33	12	30
>2.0 to 2.5	>33 to 41	14	35
>2.5 to 4.0	>41 to 66	16	40
>4.0 to 5.0	>66 to 82	20	50
>5.0 to 6.0	>82 to 98	24	60
>6.0	>98	32	80

[1] Metric conversions are not exact. The numbers are rounded and reflect commonly used metric bar lengths.

by the manufacturer. The length of the guide bar shall be in accordance with table 2.

c) For chain saws with an engine displacement up to 5 in^3 (81.94 cm^3), the chain saw shall be suspended by the front handle gripping area with the crankshaft in the horizontal position.

d) For chain saws with an engine displacement more than 5 in^3 (81.94 cm^3), the chain saw may be supported on a horizontal plane.

5.14 Vibration

Vibration of all chain saws except those intended for the occasional user shall meet the following requirement. When tested in accordance with clause 7, the front and rear handles shall be constructed so that the root mean square (rms) value of the weighted acceleration sum (WAS) from 3 orthogonal axes for each handle shall not exceed 15 m/sec/sec.

5.15 Safety instructions

5.15.1 Chain saw

All chain saw powerheads shall be clearly and durably marked with the following verbatim or suitably paraphrased statement:

> **WARNING:** Read and follow all safety precautions in the owner's manual. Failure to follow instructions could result in serious personal injury.

5.15.2 Owner's manual

An owner's manual shall be provided with each chain saw or powerhead and shall include the following information:

a) The owner's manual shall provide the safety precautions listed in annex D, verbatim or suitably paraphrased. These shall be of a form readily legible and with a letter size of not less than 5/64 in (2.0 mm);

b) The owner's manual shall include an explanation of the kickback safety features that the chain saw incorporates as part of the original-equipment safety system or that are recommended by the manufacturer. This shall include discussion of chain saw features such as bar tip radius and type, bar length, bar tip guard, saw chain, chain brake, front hand guard, or other appropriate feature. The owner's manual shall also provide sufficient information to enable the user to maintain the safety system throughout the life of the product and shall explain the consequences of improper maintenance, use of nonconforming replacement components, or the removal of safety devices. The user shall also be informed about the possible effects of normal use and maintenance on the kickback safety performance of the equipment;

c) The owner's manual shall include instructions for starting and stopping the chain saw;

d) The owner's manual shall provide instructions for properly installing and adjusting the guide bar and saw chain;

e) The owner's manual shall explain the proper techniques for making the basic felling, limbing, and bucking cuts with the chain saw;

f) For chain saws that are labeled as meeting the kickback performance requirements of 5.12.2.1, the owner's manual shall caution the user not to use replacement saw chain unless it has been designated as meeting the ANSI B175.1-1991 kickback performance requirements on that specific powerhead, or has been designated as low-kickback saw chain in accordance with ANSI B175.1-1991;

g) For chain saws that are labeled as meeting the kickback performance requirements of 5.12.2.1, the owner's manual shall contain the following statement:

Low-kickback saw chain is chain that has met the kickback performance requirements of ANSI B175.1-1991 (American National Standard for Power Tools–Gasoline-Powered Chain Saws–Safety Requirements) when tested on the representative sample of chain saws below 3.8 c.i.d. specified in ANSI B175.1-1991.

h) For chain saws 3.8 c.i.d. and above that do not meet the kickback performance requirements of 5.12.2.1, the owner's manual shall contain the warning set forth in 5.12.3.3(b);

i) The owner's manual shall provide instructions for the use of hearing protection.

5.16 Marking and identification

The marking may be accomplished by silk screening, embossing, casting, molding, or affixing a pressure-sensitive label.

The marking used shall form a durable bond with the base material and shall show no appreciable loss of adhesion during weathering exposure. The marking shall be weather resistant and following normal cleaning procedures shall show no appreciable fading, discoloration, cracking, crazing, blistering, or dimensional change. The marking shall not be affected by spilled gasoline or oil.

6 Chain saw sound level test procedures

6.1 Scope

This test procedure establishes the instrumentation, test site, saw operation, and measurements for determining the sound level of chain saws.

6.2 Instrumentation

The following instrumentation shall be used:

- A precision sound level meter that meets the Type-I requirements of ANSI S1.4 and S1.4A;

- As an alternative to making direct measurements using a sound level meter, a microphone or sound level meter may be used with a magnetic tape recorder, a graphic level recorder, or an indicating meter, provided the system meets the requirements of ANSI/SAE J184;

- A sound level calibrator (see 6.6.2.4).

The microphone shall be used with a foam windscreen. The windscreen shall not affect the overall reading by more than ± 0.5 dBA for the sound source that is being measured.

6.3 Test site

6.3.1 Measurement of noise in free field

The test area shall be a flat, open space with ground cover not exceeding 3 in (8 cm) in height and free of any large reflecting surfaces such as signboards or buildings for a minimum distance of 100 ft (30 m) from the chain saw and microphone.

The ambient sound level at the point of measurement (including wind effects) coming from sources other than the chain saw being tested shall be at least 10 dB lower than the sound level of the chain saw.

Measurements shall be made only when wind gusts are below 12 mi/hr (5.4 m/s).

6.3.2 Measurement of noise in sound room (alternate method)

An anechoic or semi-anechoic chamber may be used for conducting noise tests, provided that they don't vary more than ±1 dBA from the free field test results.

The correction between the sound room measurement and free field noise measurement shall be applied to the result obtained from the sound room. Sound levels for distances exceeding the dimensions of the chamber may be calculated from measurements taken in the chamber provided that sufficient data is available to substantiate such calculations.

6.4 Chain saw operation

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

The chain saw shall be operated in an upright position, as shown in figure 9 at a minimum distance of 24 in (610 mm) above ground. The chain saw tested shall be equipped with the shortest guide bar recommended by the manufacturer. The log diameter shall be approximately 75% of the guide bar effective length ± 1 in (± 25 mm).

All readings shall be taken with the chain saw at wide-open throttle and best cutting speed while cutting a test log. The best cutting speed shall be determined by a cutting speed test. The cutting speed shall not vary more than ± 5 percent during the sound level test cut.

The log, microphone, and chain saw shall be so oriented as to produce the maximum sound level at the microphone. The cut shall be made within 2 in (5 cm) of the end of the log.

6.5 Measurements

The sound level meter shall be set for slow response and the A-weighting network.

Measurements shall be taken with the microphone 50 ft (15 m) from the chain saw and 4 ft (1.2 m) above ground.

Measurements shall be taken at the operator's ear. The microphone shall be located in the plane of the guide bar 27.5 in (700 mm) from the centerline of the front handle and within 30° from the vertical toward the operator. The observer reading the meter shall be at least 8 ft (2.4 m) from the microphone.

The reported sound level shall be the average of three recorded sound levels that are within 2 dB of each other rounded to the nearest whole decibel.

6.6 General comments

6.6.1 Recommendations

It is recommended that technically trained personnel select the equipment and that the test be conducted only by persons trained in the current techniques of sound measurements and chain saw operation.

6.6.2 Precautions

Proper use of all test instrumentation is essential to obtain valid measurements. Operating manuals and other literature furnished by the instrument manufacturer should be referred to both for recommended operation of the instruments and for precautions to be observed. Specific items to be considered are described in 6.6.2.1 through 6.6.2.5.

6.6.2.1 Instrumentation

The type of microphone and its orientation relative to the source of noise should be considered.

6.6.2.2 Weather

The effects of ambient weather conditions on the performance of all instruments (temperature, humidity, and barometric pressure) should be taken into consideration.

6.6.2.3 Equipment Installation

Proper signal levels, terminating impedances, and cable lengths on multiinstrument measurement systems should be checked.

6.6.2.4 Calibration

Proper acoustical calibration procedures should be observed, including the influence of extension cables, etc. Field calibration shall be made immediately before and after each test sequence. Either an external calibrator or internal calibration means is acceptable for field use, provided that external calibration is accomplished immediately before and after field use. All test results shall be considered invalid should the recheck by external calibration not be within 0.5 dB of the initial calibration.

6.6.2.5 Other influences

Because bystanders may have an appreciable influence on meter response when they are in the vicinity of the chain saw or the microphone, not more than one person other than the observer reading the meter and the operator shall be within 50 ft (15 m) of the chain saw or microphone, and that person shall be directly behind the observer reading the meter, on a line through the microphone and the observer.

6.7 Test data to be recorded

The recorded test data should include the following:

- geographical location;
- date and time;
- names of chain saw operator, sound level meter reader, and observers;
- weather conditions, including ambient temperature, wind velocity, and barometric pressure;
- make, type, and serial number of sound level meter;
- make, model, and serial number of chain saw being tested;
- type of guide bar, saw chain, and sprocket being used;
- wood species and size;
- all meter readings taken;
- engine speed (rpm);
- sketch of photograph of microphone, log, and chain saw orientation.

7 Vibration level test procedure

7.1 Scope

This test procedure establishes the instrumentation, test site, saw operation, and measurements for determining handle vibration levels.

7.2 Instrumentation

7.2.1 General

Trained personnel shall select the equipment and the tests shall be conducted only by qualified persons trained in the current techniques for vibration measurement and chain saw operation.

Since proper use of all test instrumentation is essential to obtain valid measurements, operating manuals and other literature furnished by the instrument manufacturer shall be consulted both for recommended operation of the instruments and for precautions to be observed. The specific items described in 7.2.1.1 through 7.2.1.3 shall be considered.

7.2.1.1 Calibration

All vibration-measuring equipment shall be calibrated properly. Field calibration shall be made immediately before and after each test sequence.

7.2.1.2 Frequency response

The instrumentation for the measurement shall have a uniform frequency response (±2 dB) in terms of acceleration over the whole frequency range of 8 to 1500 Hz. At the reference frequency, 31.5 Hz, the tolerance range shall be ±1 dB. The readings shall be taken using the "slow" response in accordance with IEC 651.

7.2.1.3 Handle covering

When a resilient handle covering lies between the hand and vibrating member, the readings of the solid handle system shall be recorded. Measurements may be made over the handle covering if it can be demonstrated that comparable readings may be obtained.

7.2.2 Hardware

The test instrumentation used shall meet the requirements described in 7.2.2.1 through 7.2.2.5.

7.2.2.1 Accelerometer

For each test location, the weight of the accelerometer(s) shall not exceed 25 g, including mounting hardware but excluding the cables. Each accelerometer shall meet the requirements outlined in IEC 184, or ANSI S2.11. The cross-axis sensitivity shall be no more than 10 percent of the sensitivity in the axis to be measured. The mounting of the accelerometer(s) shall be such that the transfer function is flat up to 1500 Hz in the direction(s) to be measured.

7.2.2.2 Amplifier

The amplifying device and amplitude or level indicator employed shall meet the requirements outlined in IEC 222.

7.2.2.3 Measurement

As an alternative to making direct measurements, a magnetic tape recorder, a graphic

Table 3 – Attenuation factors for 1/3 octave band center frequencies

Central frequency 1/3 octave Hz	Linear gain	Gain dB
<8	0	–
8	1	0
10	1	0
12.5	1	0
16	1	0
20	0.8	–2
25	0.63	–4
31.5	0.5	–6
40	0.4	–8
50	0.315	–10
63	0.25	–12
80	0.2	–14
100	0.156	–16
125	0.125	–18
160	0.1	–20
200	0.078	–22
250	0.0625	–24
315	0.05	–26
400	0.039	–28
500	0.03125	–30
630	0.025	–32
800	0.02	–34
1000	0.0156	–36
>1000	0	–

level recorder, or indicating meter may be used. An alternate measurement technique can be to use a sampling network to record the continuous measurements as a discrete time series, with appropriate anti-alias filtering. Processing of measurements should be conducted using signal analysis provided that it meets the requirements outlined in IEC 222 and ANSI/SAE J184.

7.2.2.4 Tachometer

A tachometer shall be used to measure the engine speed, in revolutions per minute, accurate to within ±3 percent of the reading.

7.2.2.5 Filter

A frequency filter used to weigh the overall vibration level in each axis is defined in figure 10. Table 3 gives the attenuation factors for 1/3-octave-band center frequencies. For other frequency spectral techniques, filter weighting frequencies that comply with the guidelines in the table are acceptable.

7.2.3 Accelerometer location and mounting

The accelerometer(s) shall be rigidly mounted such that the center of gravity is less than 0.8 in (20 mm) from the outside of the handle bar contour and shall be located so as to permit a normal hand grip. The accelerometer(s) shall be located as close to the hand as practical. Care shall be taken that the size, shape, and mounting of the accelerometer(s) or the special accelerometer support do not significantly alter the operator's grip on the handles. The accelerometer(s) should not be in contact with the operator's hand during testing.

7.2.4 Vibration

The vibration level shall be measured in the appropriate directions of an orthogonal coordinate system, as shown in figure 11(a). Where this procedure cannot be followed, the positions of the accelerometer(s) relative to the hand coordinates shall be reported.

7.3 Chain saw operation

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

The chain saw shall be operated in an upright position in accordance with figure 9 and equipped with the guide bar listed in table 2.

The chain saw shall be operated with a wide-open throttle, and the best cutting speed while making at least 5 cuts in a test log. The best cutting speed shall not vary more than ±250 rpm while recording data. The test log shall be squared timber of normal local usage, solid or laminated vertically. Slices shall be cut perpendicular to the longitudinal axis of the timber. The width of the cut shall be 75% of the guide bar effective length ±1 in (±25 mm). No part of the powerhead shall contact the test log during the test.

The chain saw shall be tested with the fuel and oil tanks containing between 1/4 and 3/4 of maximum capacity.

A relaxed grip on the handles sufficient to maintain proper control shall be employed, consistent with day-long use of the chain saw.

7.4 Measurements

7.4.1 Measured quantity

The acceleration in the three orthogonal directions according to figure 11(a) shall be measured by accelerometers and processed to form an overall vibration value, the weighted acceleration sum (WAS) according to figure 11(b). Mathematically, the WAS is the sum of the root mean square (rms) of the weighted signals from each axis.

The WAS can be calculated from a frequency spectra of 1/3 octave or 1/1 octave with the weighting factors for the mid-frequencies calculated as described in ISO 5349. Alternatively, WAS can be calculated from higher-resolution FFT Spectra whose weighting complies with ISO 5349.

The three different acceleration directions may be measured at different times.

7.4.2 Results

The results reported shall be the arithmetic average obtained from a minimum of 5 cuts.

7.5 Test data to be recorded

The following test data shall be recorded:

- geographical location;
- date and time;
- names of chain saw operator, technicians, meter readers, and observers;
- make, model, and serial number of the chain saw being tested;
- wood species and size;
- all vibration levels;
- all meter readings taken;
- engine speeds (rpm) at which readings were taken;
- sketch or photograph of the location and attachment means of the accelerometers;
- pitch size, type, and gauge of saw chain;
- guide bar type and length;
- drive sprocket type and size;
- test equipment.

8 Kickback test procedure

8.1 Scope

For chain saws required to meet acceptance criteria based on the computed kickback angle, measure the energy using the kickback test machine and measure the saw characteristics. Compute the kickback angle utilizing the analytical model.

8.2 Equipment

The following equipment and materials shall be used to determine the computed kickback angle:

a) Computer kickback program (see clause 9) to compute the kickback angle using measured inputs;

b) The chain saw kickback machine for energy level measurements[5]);

c) Instrumentation

1) Tachometer with an accuracy of ±1.5 per cent of the measured value;

2) Carriage velocity timing device, including probes with an accuracy of ±1 ms;

3) Timer control switch box;

4) Chain brake timing device, including probes having an accuracy of ±3 ms;

d) Calibrated Baraboard® samples 1.5 in × 1.5 in × 10 in (38 mm × 38 mm × 250 mm) consisting of medium-density fiberboard. The sample shall be oriented with rough side (end grain) facing bar tip. (Procedures for the control and calibration of the Baraboard® test material are provided in annex L.);

e) Chain brake actuating apparatus.

8.3 Physical measurements

8.3.1 Scope

This subclause specifies the chain saw physical measurements that shall be made in order to position the saw correctly in the kickback machine and to compute the kickback angle.

8.3.2 Measurements

The following measurements are to be made with the bar and chain attached in proper work-

5) The bill of materials and engineering drawings describing the kickback test machine are available from the Portable Power Equipment Manufacturers Association, 7315 Wisconsin Avenue, Suite 702E, Bethesda, MD 20814-3202.

ing position and with oil and fuel tanks full. The saw chain shall be prepared in accordance with 8.4.3 prior to taking measurements:

a) Chain saw weight (lb). An accuracy of ±0.1 lb is acceptable for this measurement;

b) Location of the center of gravity (to be marked on the saw body). Representative methods for making this measurement are given in annex D. An accuracy of ± 0.25 in is acceptable for this measurement;

c) Chain-saw moment of inertia about an axis through the center of gravity and perpendicular to the plane of the guide bar (in-lbf-sec^2). Representative methods for making this measurement are given in annex D;

d) Chain saw bar tip location relative to the center of gravity, expressed as *x*, *y* coordinates (in). An accuracy of ±0.12 in is acceptable for this measurement. See figure 12;

e) Chain saw front-handle location relative to the center of gravity, expressed as *x*, *y* coordinates (in). An accuracy of ±0.12 in is acceptable for this measurement. See figure 12;

f) Chain saw rear-handle location relative to the center of gravity, expressed as *x*, *y* coordinates (in). An accuracy of ±0.12 in is acceptable for this measurement. See figure 12.

8.3.3 Measurement of chain saw coordinates

The bar tip and handle coordinates shall be measured as follows (see figure 12):

a) Position the chain saw on a level surface so that the centerline of the guide bar is level. Locate guide bar tip, point *B*, at the intersection of a horizontal line through the nose radius and the outermost element of the saw chain.

NOTE – For nonsymmetrical bars, this point will not lie on the centerline of the guide bar. The saw chain should be rotated to the greatest horizontal displacement.

Measure and record *BTX*, the horizontal displacement (in inches) from the center of gravity to point *B*. Measure and record *BTY*, the vertical displacement;

b) Locate the front handle, point *F*, at the center of the front handle in the midpoint of the hand-grip segment. Measure and record *FHX*, the horizontal displacement, and *FHY*, the vertical displacement;

c) Locate the rear handle, point *R*, by determining the intersection of a 1-in radius arc and the lower portion of the rear handle. The arc originates at the lowest point the chain saw throttle control trigger intersects the saw casing. Measure and record *RHX*, the horizontal displacement, and *RHY*, the vertical displacement.

8.4 Chain saw preparation

8.4.1 Scope

This subclause establishes the method to be used to prepare the chain saw and saw chain for the kickback energy test.

8.4.2 Saw preparation

a) The chain saw shall be in functionally new condition;

b) The saw shall be run-in according to the manufacturer's recommendation.

8.4.3 Saw chain preparation

a) The saw chain shall be new and shall be prepared for the test by cutting clean or debarked wood for approximately five minutes;

b) Saw chain tension shall be set to provide a maximum clearance between the chain and the bar of 0.017 in per in (mm per mm) of rated bar-cutting capacity. This clearance is measured with a 2-lb (0.9-kg) weight suspended from the chain at the midpoint of the guide-bar length. The chain shall be positioned to achieve the tightest condition for this measurement. See figure 13. The chain should move freely on the bar.

8.5 Kickback test – Chain saw operation

8.5.1 Scope

This subclause establishes the procedure for operation of the chain saw, measuring and recording of data, and the computation of kickback energy .

8.5.2 Preparation

The chain saw shall be installed and balanced in the kickback machine and frictional levels measured to ensure that standard conditions are met.

8.5.2.1 If the saw weighs less than the standard carriage, the standard carriage may be replaced with the lightweight carriage.

8.5.2.2 If necessary, add weight to the carriage until the carriage weight (including Baraboard®) is equal to the weight of the saw (±0.25 lbf).

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

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

8.5.2.5 Chain saw and bracket assembly shall be installed as follows:

a) 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 so that it is level and as nearly parallel to the guide bar as possible;

b) Install the saw and cradle assembly in the kickback machine in accordance with figure 14 and align the guide bar with the centerline of the Baraboard® specimen;

c) Adjust the chain saw, clamp, and cradle so that the saw center of gravity is aligned to within ± 0.12 in with the rotary axis. Make this adjustment by rotating the clamp 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 (a), above.

d) Attach the brace (EX 4444-D)[6] to either leg of the cradle as near as possible to the rotary axis. The brace attachment may be located on either side of the rotary axis. A second brace may be installed as needed to restrict side motion.

8.5.2.6 The chain saw shall be balanced as follows:

a) Fuel tanks and oil tanks shall be filled;

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

b) The system shall be balanced using the minimum amount of mass located as close to the rotary axis as possible;

c) Acceptable initial balance is achieved when the cradle will not rotate at the "horizontal" or "vertical" position or when a 0.13-lb (60-g) weight hung from the rotary pulley will counter any observed rotation. If the center of gravity of the saw shifts due to soft isolators, a compromise between the horizontal and vertical positions is permissible.

8.5.2.7 Horizontal friction shall be measured prior to and after kickback energy tests using procedures in annex F or equivalent. The average of the horizontal friction measurement in the direction of travel away from the powerhead shall not exceed 0.5 lb (0.23 kg).

8.5.2.8 Rotary friction shall be measured prior to and after kickback energy tests using procedures in annex G or equivalent. The average of the rotary friction measurement shall not exceed 0.5 lb (0.23 kg).

8.5.2.9 The Baraboard® angle shall be set to 30°. Move the carriage so that the Baraboard® 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 15.

8.5.2.10 With the guide-bar centerline in horizontal position, adjust the location of the cable attachment pin and adjust the turnbuckle to bring the 2-lb (0.9-kg) weight to the zero position. See figure 16.

8.5.2.11 Adjust the carriage release point to achieve impact velocity of 30 in/s ± 0.5 in/s. See annex H for more information.

8.5.2.12 Adjust the Baraboard® angle to the initial conditions specified in 8.6.2.

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[6] These numbers refer to engineering drawings that are available from the Portable Power Equipment Manufacturers Association.

8.5.2.13 At the start of the test and after every twelve impacts, the centrifugal clutch shall be burned as follows:

a) Clamp the saw chain to the guide bar and run the saw 5 seconds with full throttle. Measure and record the slip speed (rpm);

b) If the slip speed varies more than 500 rpm during the test, replace the clutch.

8.5.2.14 Saw chain tension shall be set initially and adjusted during the test in accordance with 8.4.3(b).

8.5.3 Procedure

a) With the barrier bar in position, start the chain saw. Adjust the engine speed and Baraboard® angle to the required test conditions;

b) Raise the barrier bar and stand clear of the kickback machine;

c) Release the carriage, observing the engine speed at impact;

d) Turn off the chain saw.

8.5.4 Measurements

a) Record the lift in inches (centimeters) of vertical displacement of the horizontal restraining weight and the inches (centimeters) of horizontal displacement of the carriage;

b) Record the lifts in inches (centimeters) of displacement of the upper and the lower rotary restraining weights.

NOTE – The horizontal and rotary restraining systems may have alternate calibrations to permit direct readings.

8.5.5 Additional testing requirements

a) The Baraboard® sample shall be clamped in the carriage with the rough side (end grain) facing the bar tip;

b) The chain saw shall be inspected for unusual conditions and reset for next impact conditions. Do not operate a damaged chain saw;

c) On occasion, balance of unit may change. Check and reset balance if imbalance exceeds 0.25 lbf. (See annex E.) If imbalance of more than 0.25 lbf occurs, previous impact data is invalid;

d) The Baraboard® sample should be examined and exchanged. The orientation of the sample shall be adjusted to preclude vertical runout. Sample splitting may be overcome by addition of a C-clamp. If a C-clamp is used to prevent splitting, the carriage weight shall be compensated;

e) Make only two impacts per specimen (one on each face). All saw penetrations shall start within the middle inch on the face of the specimen. If any penetration track runs off the specimen, do not use the energy readings in the computations. Repeat the test on another specimen;

f) Horizontal and rotary friction levels are to be measured upon the completion of the test using methods specified in annexes F and G, or equivalent methods. The greater measured level is to be used for energy computations. If friction at the end of the test program exceeds specifications, the test shall be repeated.

8.5.6 Kickback energy computation

a) Compute the horizontal energy for each impact as follows:

Horizontal energy = $(W)(D_w) + (f_h)(D_c)$

where

W is the horizontal restraining weight (lbf);

f_h is the horizontal axis friction (lbf). See annex F;

D_w is the displacement of horizontal restraining weight (inches);

D_c is the displacement of carriage (inches).

b) Compute the rotary energy for each impact, as follows:

Rotary Energy = $(W_u + F_r)(D_u) + (W_l)(D_l)$

where

W_u is the upper weight (lbf);

W_l is the lower weight (lbf);

D_u is the displacement of upper weight (inches);

D_l is the displacement of lower weight (inches);

f_r is the rotary friction force (lbf).

NOTE – For the horizontal system, see annex F. For the rotary system, see annex G.

8.6 Kickback test program

8.6.1 Scope

This subclause establishes the test conditions at which impacts are to be performed and the method of analyzing the data to determine kickback energy.

8.6.2 Kickback energy determination

Using the test procedures specified in 8.5, perform impacts at the test conditions specified in tables 4 or 5 and determine kickback energy in accordance with 8.6.3. For saws that cannot be tested as slow as 9000 rpm, the saw may be tested at 9500 or 10 000 rpm, whichever is the saw's lowest stable operating speed.

8.6.3 Data analysis

8.6.3.1 Measurements and calculations

Kickback shall be measured as follows:

a) For each set of conditions in the test sequence, perform three impacts and measure the rotary and horizontal energy for each impact;

b) Compute the average of the three rotary energy measurements and the average of the three horizontal energy measurements;

c) If the rotary energy measurements are each within 10 percent of the average rotary value, use the average of the three measurements;

d) If any of the rotary energy measurements are not within 10 percent of the average, perform three additional impacts and use the average of all six rotary energy measurements. Similarly, use the average of the six horizontal energy measurements.

8.6.3.2 Termination of test sequence

Either test sequence may be discontinued if, at each rpm:

a) there is a 50 percent reduction in average rotary energy between measurements at two consecutive contact angles; or

b) there is a decrease in average rotary energy for two consecutive contact angles.

8.7 Chain brake test procedure

8.7.1 Scope

This subclause establishes the test procedure for saws equipped with a chain brake.

If a chain saw is equipped with a chain brake, it will be necessary to determine (a) the rotary kickback energy with the chain brake actuated, (b) the actuation angle, and (c) the chain stopping time as specified in this section.

8.7.2 Chain brake energy measurement procedure

NOTE – At the discretion of the manufacturer, 8.7.2(a) through 8.7.2(c) may be omitted.

a) At the conclusion of the test sequence specified in 8.6, remove 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 percent of the average, perform three additional impacts and compute the average of all six impacts;

b) Record the energy measurements and note if the chain brake actuates each time;

c) If the chain brake actuates each time, *R4*, the energy value that is input into the computer model as rotary energy with chain brake actuated, equals the average of the rotary energy values. If the chain brake does not actuate each time, proceed to 8.7.2(d);

d) Mount the chain brake actuator on the left side of the mainframe column of the kickback machine;

e) Set the spring-loaded lever so that the lever and the hand guard impact at or immediately past the point the saw exits the test specimen. Refer to 8.7.3(a);

f) Set the spring-loaded lever of the chain brake actuator in set position so that its centerline intersects the saw center of gravity as shown in figure 17;

g) Adjust the position of the spring-loaded lever so that the contact point of the chain brake lever (hand guard) in the set position on the spring-loaded lever is 3.54 in (90 mm) from the pivot point of the spring-loaded lever. See figure 17;

h) Recheck steps 8.7.2(e), 8.7.2(f), and 8.7.2(g). Readjust if necessary;

i) Measure and record the chain brake release force (lbf) with the engine not running. The brake release force shall be measured with a spring scale accurate to 0.25 lbf. The force shall be applied at a uniform rate at the

Table 4 – Test sequence

Data set no.	Contact angle degrees	Impact velocity in/s	Impact velocity m/s	Saw speed (± 200 rpm) rpm
1A	0	30	0.76	11 000 (maximum or highest attainable)
1B	0	30	0.76	9 000 (or maximum minus 2000)
2A	5	30	0.76	11 000
2B	5	30	0.76	9 000
3A	10	30	0.76	11 000
3B	10	30	0.76	9 000
4A	15	30	0.76	11 000
4B	15	30	0.76	9 000
5A	20	30	0.76	11 000
5B	20	30	0.76	9 000
6A	25	30	0.76	11 000
6B	25	30	0.76	9 000
7A	30	30	0.76	11 000
7B	30	30	0.76	9 000

Table 5 – Optional test sequence

Data set no.	Contact angle degrees	Impact velocity in/s	Impact velocity m/s	Saw speed (± 200 rpm) rpm
1A	0	30	0.76	11 000 (maximum or highest attainable)
2A	5	30	0.76	11 000
3A	10	30	0.76	11 000
4A	15	30	0.76	11 000
5A	20	30	0.76	11 000
6A	25	30	0.76	11 000
7A	30	30	0.76	11 000
1B	0	30	0.76	9 000 (or maximum minus 2000 rpm)
2B	5	30	0.76	9 000
3B	10	30	0.76	9 000
4B	15	30	0.76	9 000
5B	20	30	0.76	9 000
6B	25	30	0.76	9 000
7B	30	30	0.76	9 000

center of the top part of the brake lever. The force shall be measured in a direction that is normal to the centerline of the spring-loaded lever when the saw is in the contact position shown in figure 17 and the spring-loaded lever is set as shown in figure 17;

j) Adjust the release force of the spring-loaded lever to the chain brake release force plus 2.2 lbf. Measure the release force of the spring-loaded lever by placing a spring scale at the point 3.54 in from the pivot point of the spring-loaded lever and pulling normal to the centerline of the lever. Record this information on the data sheet shown in annex J;

k) 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 the test program detailed in 8.6.

All tests performed under 8.7.2(l) and 8.7.2(m) shall be conducted at the contact angle and engine speed determined to give the highest average rotary energy;

l) Conduct the chain brake actuation test to determine kickback machine *rotary energy* with operating chain brake actuator and operating chain brake. Using the procedures detailed in 8.5, conduct the kickback test with the actuator and the chain brake operating, and record data. Reset the actuator and repeat for a total of three impacts. If the rotary energy values are not within 10 percent of average, perform three additional impacts and use the average of the six values. If the chain brake activates on each impact, *R3* equals 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 8.6;

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

m) Conduct the kickback test to determine *R2*, rotary energy with operating chain brake actuator but with chain brake not actuated.

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 actuate on impact. Using the procedures detailed in 7.5, conduct the kickback test with the chain brake actuator operating and the chain brake disabled, and record data.

Reset the actuator and repeat for a total of three impacts. If the rotary energy values are not within 10 percent of the average, perform three additional impacts and use the average of the six values. *R2* equals the average of the rotary energy values;

n) *R1* is the peak rotary energy determined in accordance with 8.6, that is, the average of the rotary energy values at the conditions that produced the highest average rotary energy during the test sequence. The test program of 8.6 is conducted without the actuator and with the chain brake disabled.

Calculate the energy absorbed by the chain brake actuator, *EA*, in accordance with 8.7.5:

$EA = R1 - R2.$

Calculate the rotary energy with the chain brake actuated, *R4*. This is the energy value that is input to the computer model:

$R4 = R3 + EA.$

8.7.3 Chain brake actuation angle procedure

a) Measure the angles where the bar tip exits the Baraboard® specimen under peak rotary conditions as determined in 8.6, and compute the average. This is the Baraboard® exit angle. See figure 18;

b) If the rotary energy, *R4*, was determined in accordance with 8.7.2(c), then the actuation angle is one-half of the Baraboard® exit angle. Record this as the chain brake actuation angle (*A2*) on the data sheet, figure J.1, and in the computer program;

c) If the rotary energy, *R4*, was determined in accordance with 8.7.2(n), the chain brake actuation angle is equal to the Baraboard® exit angle. Record this as chain brake actuation angle (*A2*) on the data sheet, figure J.1, and in the computer program.

8.7.4 Chain brake stopping time measurement procedure

8.7.4.1 Scope

The chain brake stopping time test shall be conducted at the rpm setting of the peak rotary energy condition determined in 8.6. Use the pendulum test technique specified in 5.9.5.2. This test may be conducted subsequent to the procedure specified in 5.9.5.

8.7.4.2 Test conditions

a) Chain saws shall be adjusted for best cutting performance in accordance with the chain saw manufacturer's recommendations;

b) Chain saws shall be solidly mounted during the test;

c) No adjustment of brakes shall be permitted during the test;

d) Initially, brakes shall be in a dry and unlubricated condition.

8.7.4.3 Taking measurements

The chain brake shall be activated ten times without recording data. Then actuate the brake three times and record the average stopping time. Refer to 5.9.5 for test apparatus details and test technique.

8.7.5 Chain brake energy calculations

ΔE = energy absorbed by chain brake

Calculations:

$EA = R1 - R2$

$R4 = R3 + EA$

$\Delta E = Rl - R4 = R2 - R3$

where

R1 is the peak rotary energy measured without the chain brake actuator: average of the rotary energy values determined in accordance with 8.6 at the condition that produced the highest rotary energy;

R2 is the rotary energy measured with operating chain brake actuator, but with the chain brake not actuated: average of values;

R3 is the rotary energy measured with operating chain brake and with operating chain brake actuator: average of values.

Calculated Values:

R4 is the rotary energy with chain brake actuated only;

EA is the energy absorbed by chain brake actuator.

8.8 Computed kickback angle computation

8.8.1 Scope

This subclause establishes the computations for determining the computed kickback angle of the chain saw.

8.8.2 Computed kickback angle

The computed kickback angle is an angle, defined as shown in figure 7, used as a measure of the reaction of a hand-held chain saw when subjected under simulated conditions to a rotational kickback impulse.

8.8.3 Values

Values for the following measurements shall be used as input for the computer program .

a) Chain saw weight (lb) in accordance with 8.3;

b) Chain saw moment of inertia (in-lb-sec^2) in accordance with 8.3;

c) Bar tip and handle locations (in) in accordance with 8.3;

d) Energy levels established at the peak rotary conditions in accordance with 8.6

1) Horizontal energy (in-lb);

2) Rotary energy (in-lb).

NOTE – For saws without chain brakes, if the average rotary energies measured at other sets of conditions are within 10 percent of the peak rotary value, calculate the computed kickback angle for each set of conditions and use the highest computed kickback angle.

e) Chain brake data in accordance with 8.7

1) Rotary energy (in-lb), *R4*;

2) Actuation angle (degrees);

3) Saw chain stopping time (seconds).

NOTE – Before input to the computer program, energy values in 8.8.4(d) and 8.8.4(e) should be adjusted as set forth in annex K.

8.8.4 Computation

The computed kickback angle shall be determined in accordance with the mathematical model in the flowchart and the computer programs in FORTRAN and BASIC in clause 9.

9 Mathematical simulation of kickback

9.1 Introduction

The computed kickback angle is determined through a mathematical simulation of the motion of the chain saw during kickback. This simulation is contained in the computer program. See 9.4 and 9.5.

The computer program contains equations that represent the reaction forces exerted by the operator on the saw during kickback. These equations are based on analysis of high-speed films of simulated kickback tests. A summary of the steps that went into the formulation of these equations is provided in "Overview of the KICKBACK Computer Program–Contents and Development."[7]

The computer program uses standard engineering force-motion equations to predict the path of the saw based on the kickback energy and saw characteristics input data from 8.8.3 and the simulated operator reaction forces. The computed kickback angle as illustrated in figure 7 is calculated from this predicted path.

9.2 Energy terminology

The kickback energy is measured on the kickback machine in two parts, "horizontal" and "rotary" (see 8.5.6). The energy determined from the kickback machine measurements is divided within the "KICKBACK" computer program into horizontal, vertical, and rotational parts.

The "horizontal" energy within the computer program is the same as the "horizontal" energy determined from the kickback machine measurements, 8.5.6(a), also referred to as kickback machine "linear" energy in 9.3. The kickback machine "rotary" energy, 8.5.6(b), is divided into "vertical" energy and "rotational" energy within the computer program. Thus, the term "rotary" energy is used to refer to the energy determined from the kickback machine rotary system measurements. The term "rotational" energy is used to refer to that portion of the kickback machine rotary energy that is determined to be rotational (as opposed to vertical or horizontal) within the computer program.

Thus:

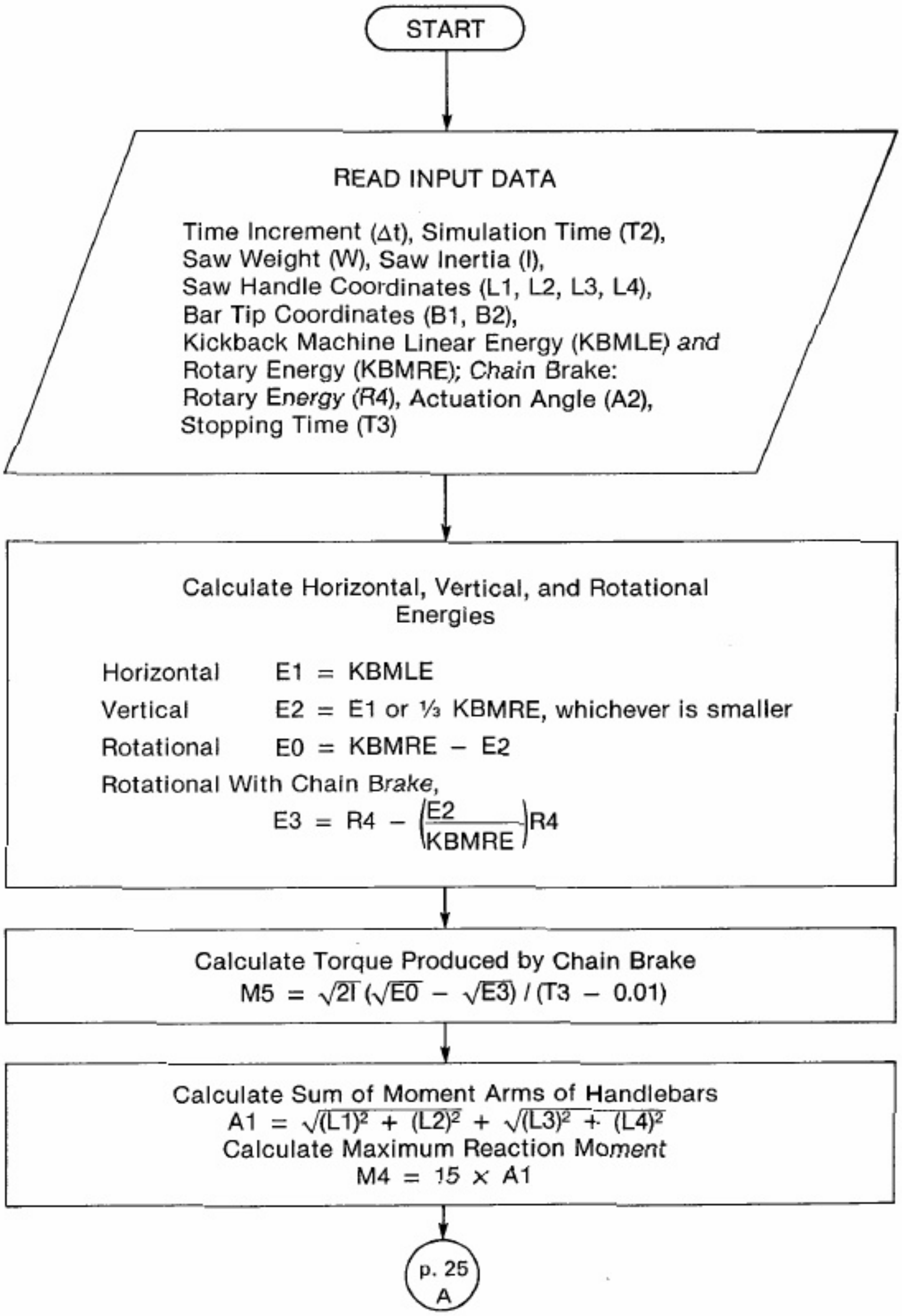
Computer Program "Horizontal Energy" = Kickback Machine "Horizontal Energy"

and:

Computer Program "Vertical Energy" + Computer Program "Rotational Energy" = Kickback Machine "Rotary Energy"

[7] Available from the Portable Power Equipment Manufacturers Association.

9.3 Computer program flowchart (12-12-84 version)



p. 24 A

Calculate Initial Velocities

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

$$V_X = \sqrt{\frac{2(E1)}{W/g}} \quad \text{Horizontal}$$

$$V_Y = \sqrt{\frac{2(E2)}{W/g}} \quad \text{Vertical}$$

$V_{1,1} = \omega$

$V_{2,1} = V_X$

$V_{3,1} = V_Y$

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 = 0.1128

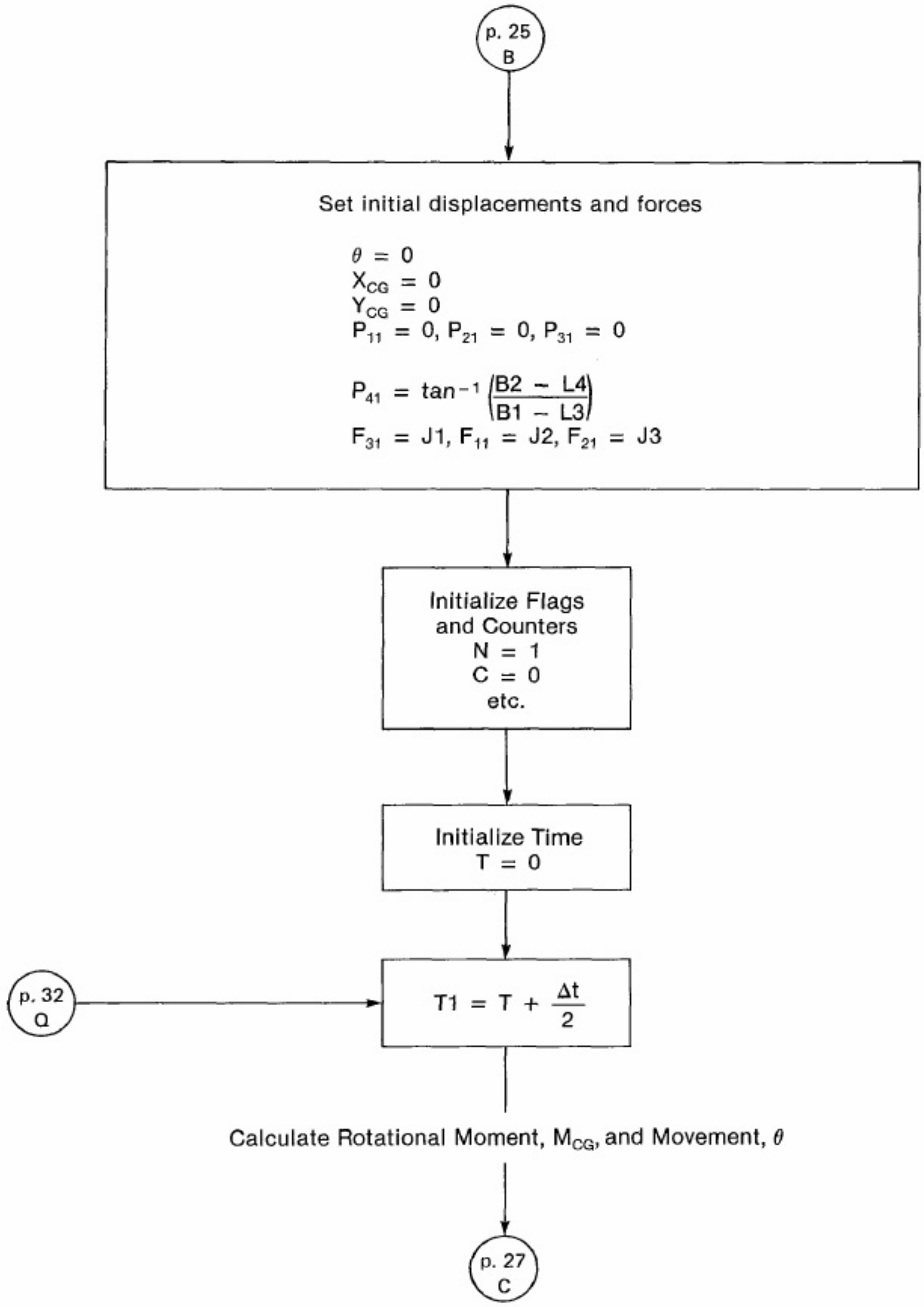
Offset:

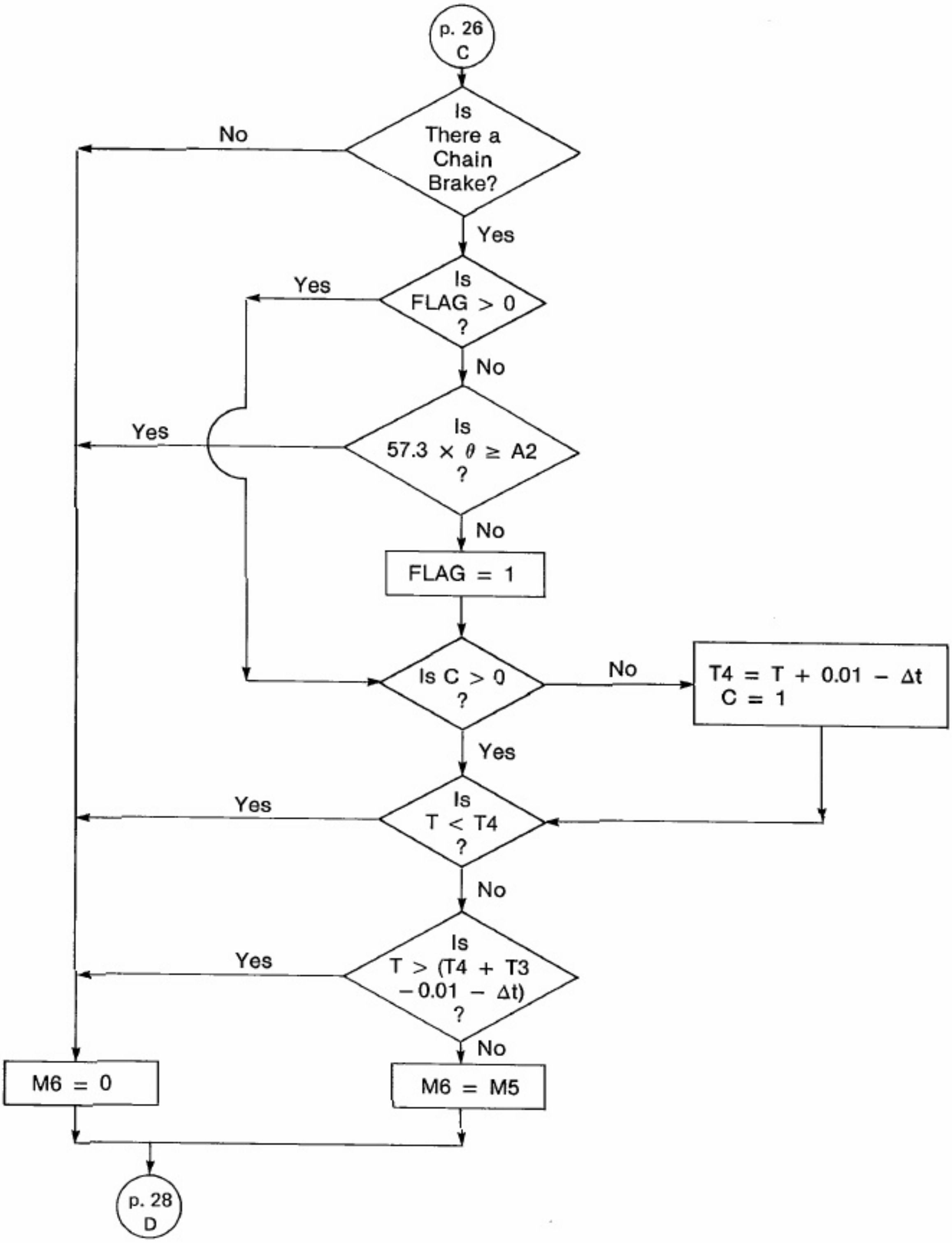
O1 = 0

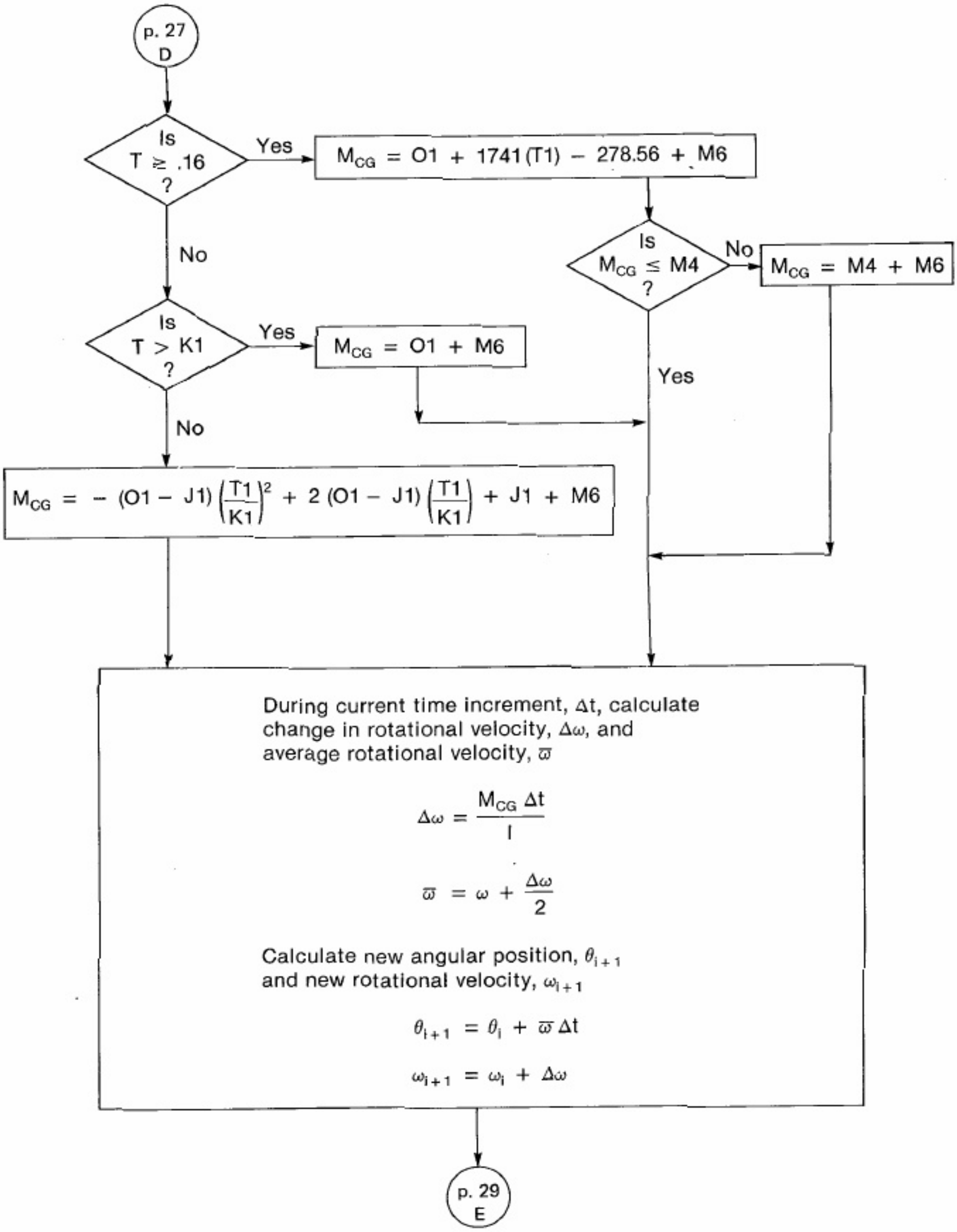
O3 = 0.32764W + 2.063

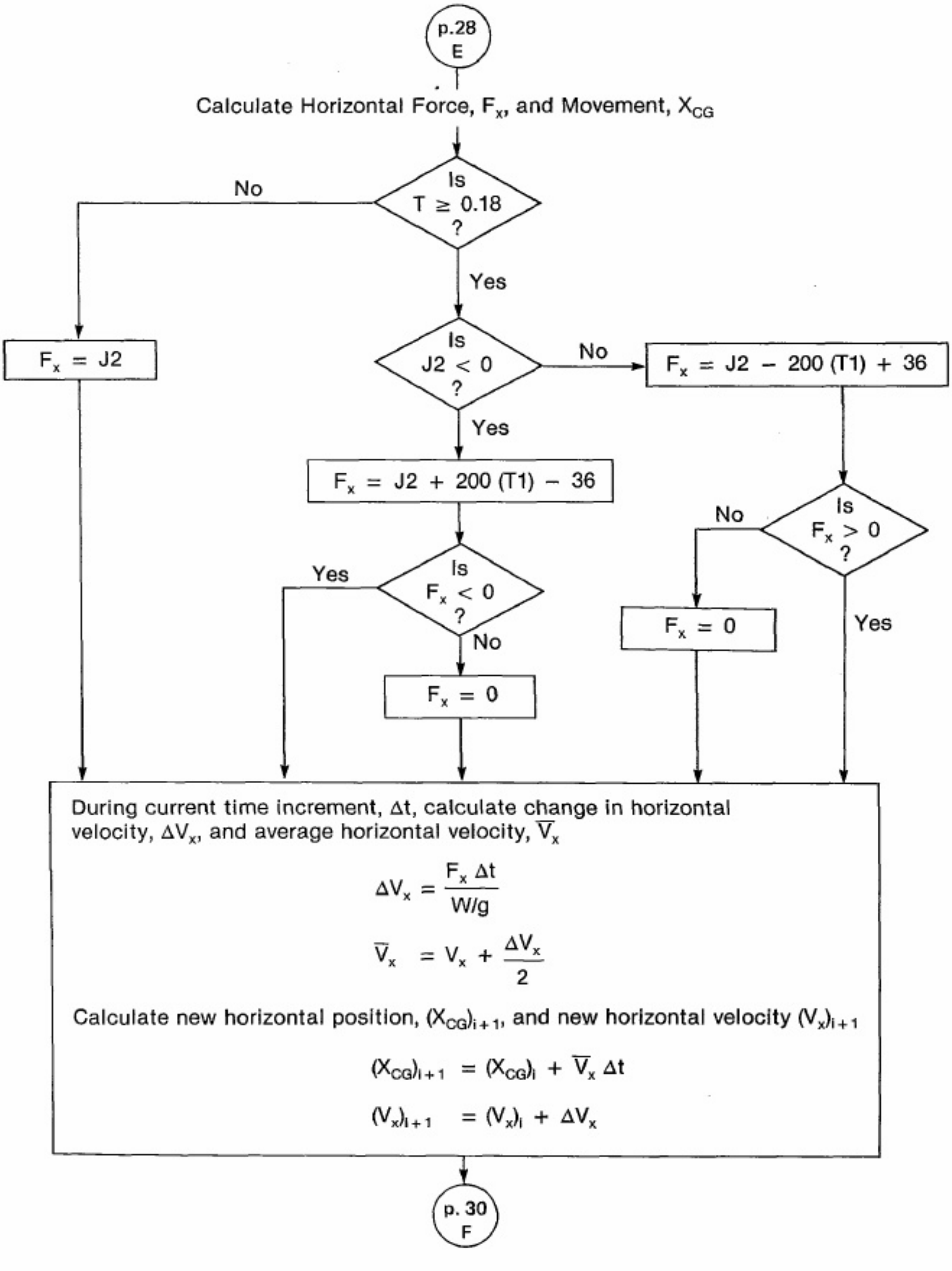
Print Out Input Data

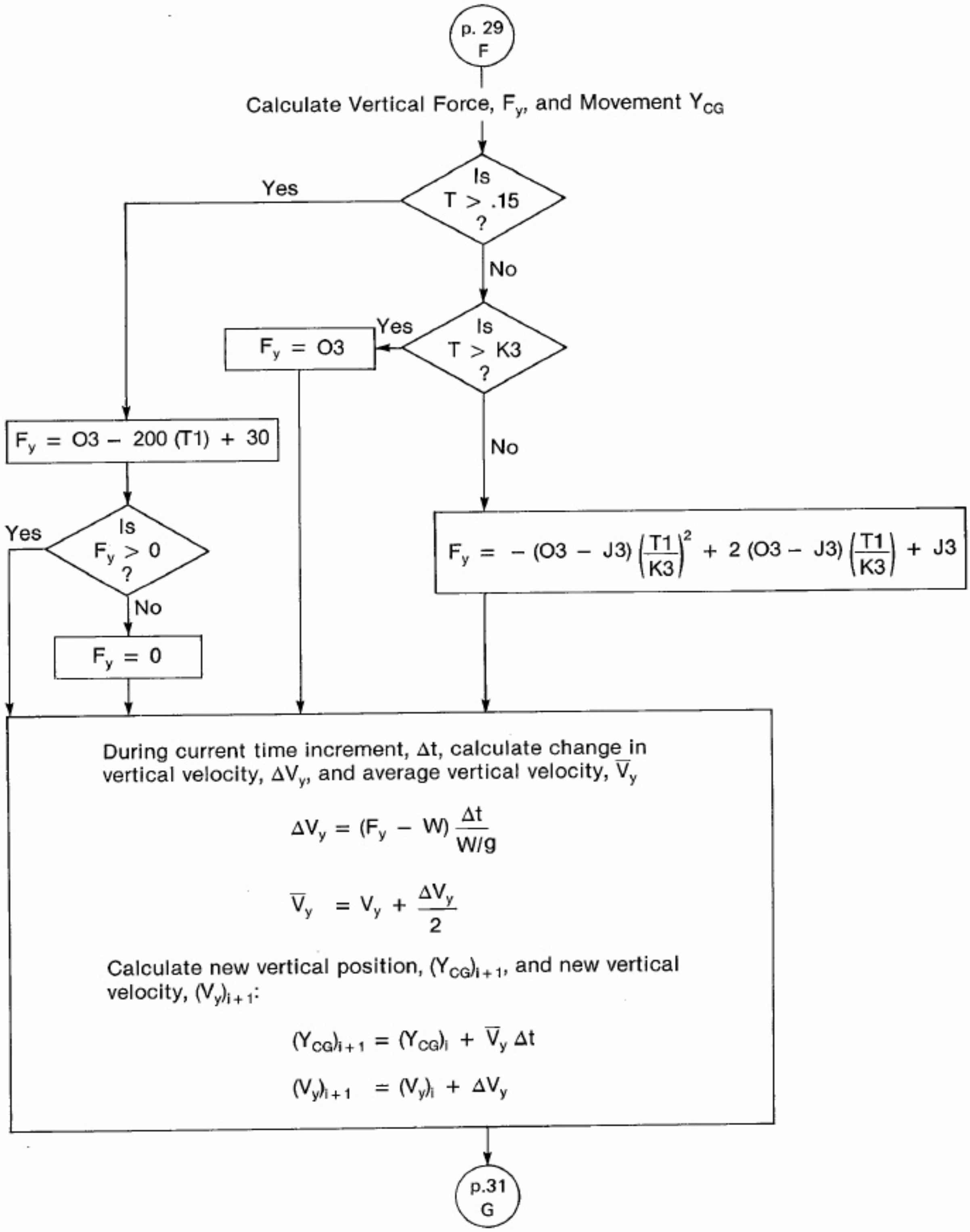
p. 26 B

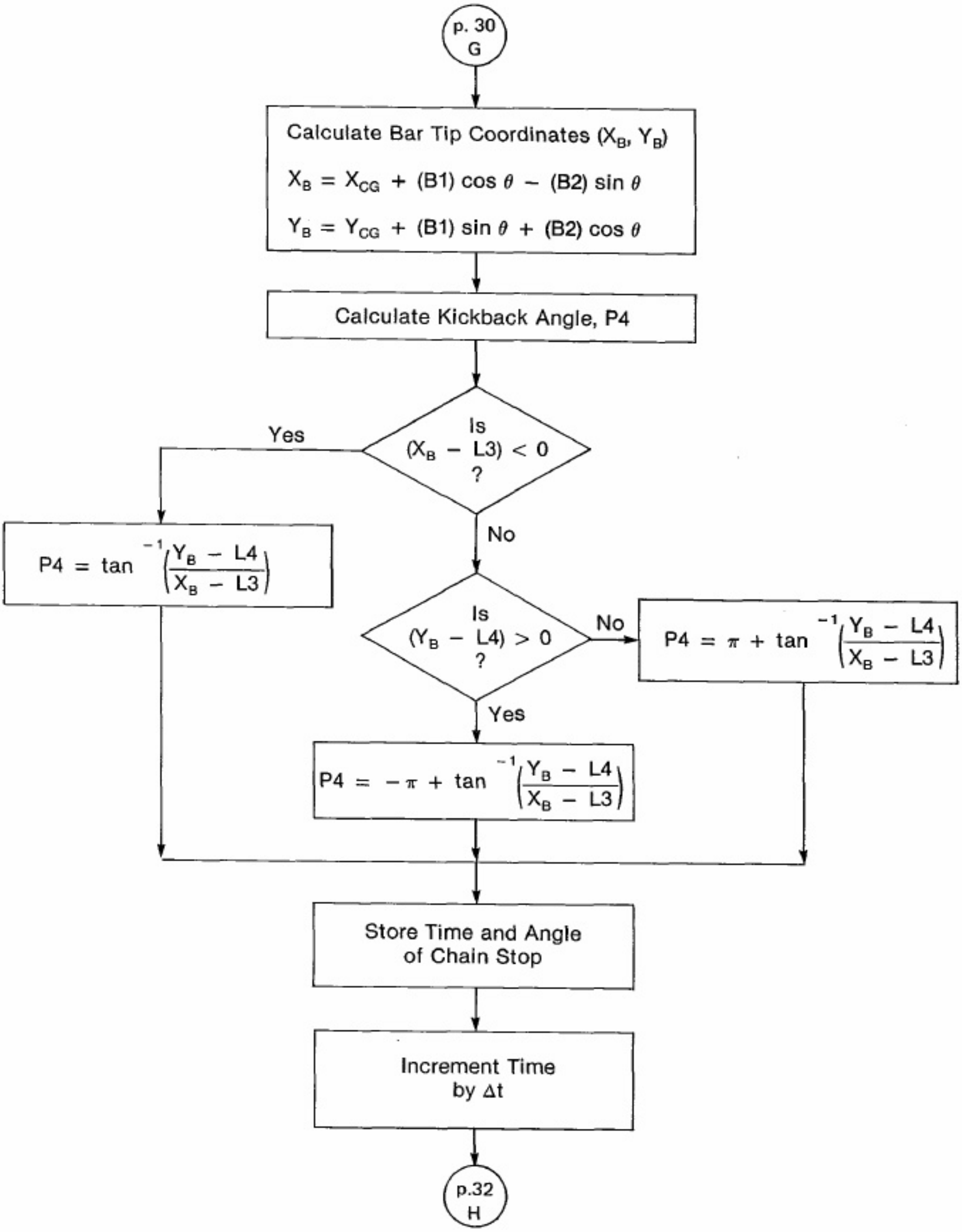

p. 25
B
Set initial displacements and forces
$\theta = 0$
$X_{CG} = 0$
$Y_{CG} = 0$
$P_{11} = 0, P_{21} = 0, P_{31} = 0$
$P_{41} = \tan^{-1}\left(\frac{B2 - L4}{B1 - L3}\right)$
$F_{31} = J1, F_{11} = J2, F_{21} = J3$
Initialize Flags and Counters
N = 1
C = 0
etc.
Initialize Time
T = 0
p. 32
Q
$T1 = T + \frac{\Delta t}{2}$
Calculate Rotational Moment, M_{CG}, and Movement, θ
p. 27
C

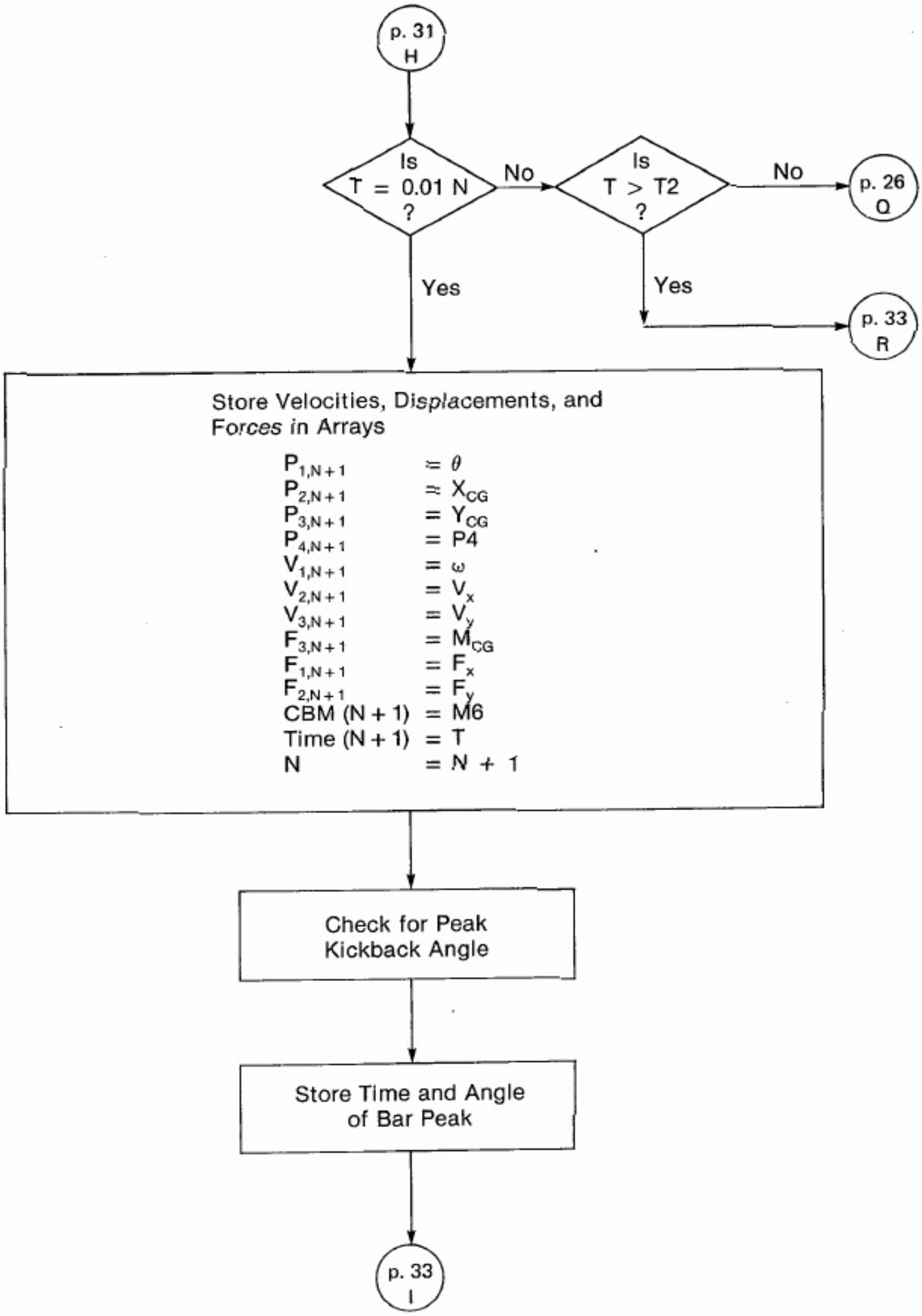

p. 26
C
Is There a Chain Brake?
No
Yes
Is FLAG > 0 ?
Yes
No
Is 57.3 × θ ≥ A2 ?
Yes
No
FLAG = 1
Is C > 0 ?
No
T4 = T + 0.01 − Δt
C = 1
Yes
Is T < T4 ?
Yes
No
Is T > (T4 + T3 − 0.01 − Δt) ?
Yes
No
M6 = 0
M6 = M5
p. 28
D

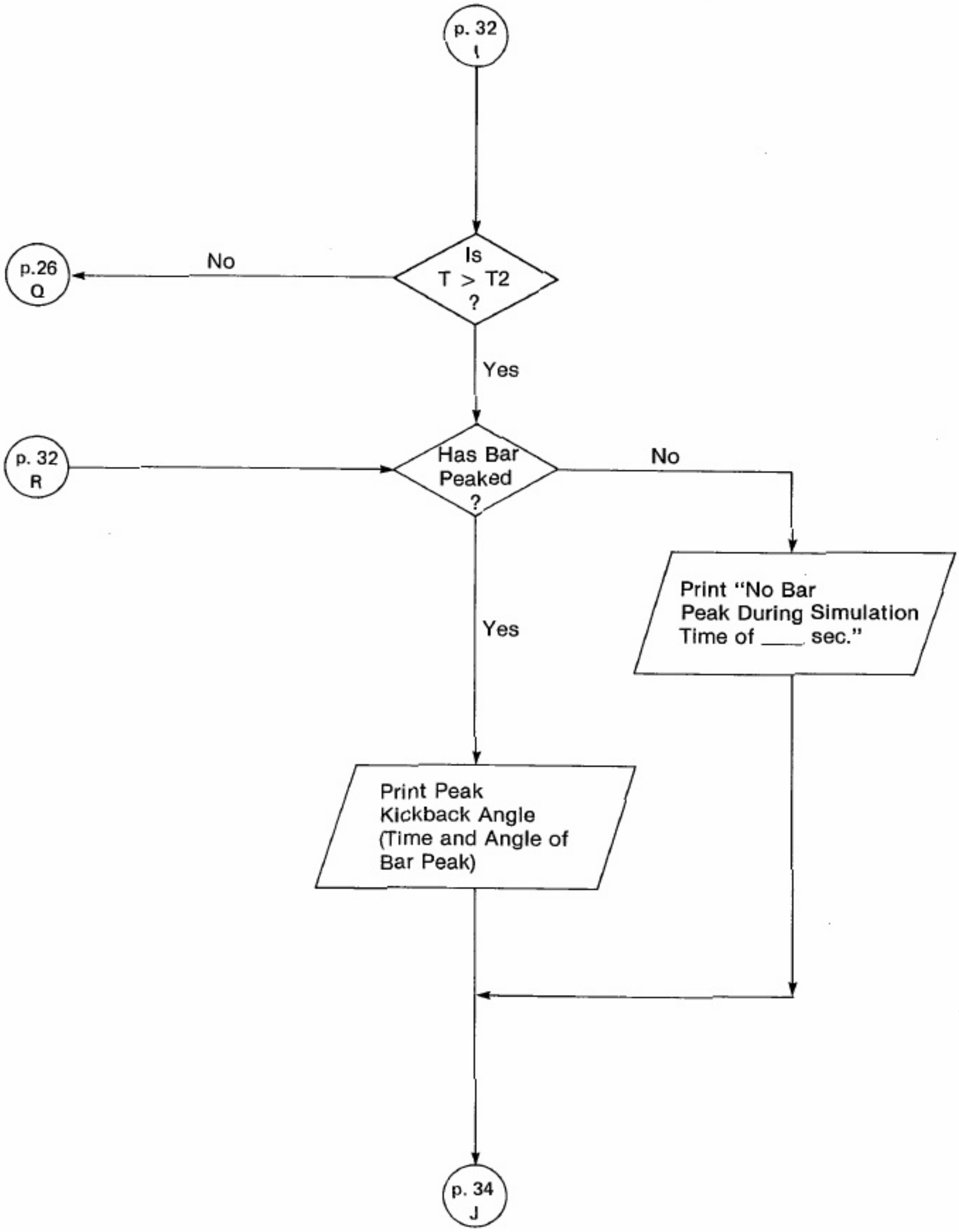

p. 27
D
Is
T ≥ .16
?
Yes
$M_{CG} = O1 + 1741(T1) - 278.56 + M6$
No
Is
$M_{CG} \leq M4$
?
No
$M_{CG} = M4 + M6$
Is
T > K1
?
Yes
$M_{CG} = O1 + M6$
Yes
No
$M_{CG} = -(O1 - J1)\left(\frac{T1}{K1}\right)^2 + 2(O1 - J1)\left(\frac{T1}{K1}\right) + J1 + M6$
During current time increment, Δt, calculate change in rotational velocity, Δω, and average rotational velocity, ϖ
$\Delta\omega = \frac{M_{CG}\,\Delta t}{I}$
$\varpi = \omega + \frac{\Delta\omega}{2}$
Calculate new angular position, θ_{i+1} and new rotational velocity, ω_{i+1}
$\theta_{i+1} = \theta_i + \varpi\,\Delta t$
$\omega_{i+1} = \omega_i + \Delta\omega$
p. 29
E

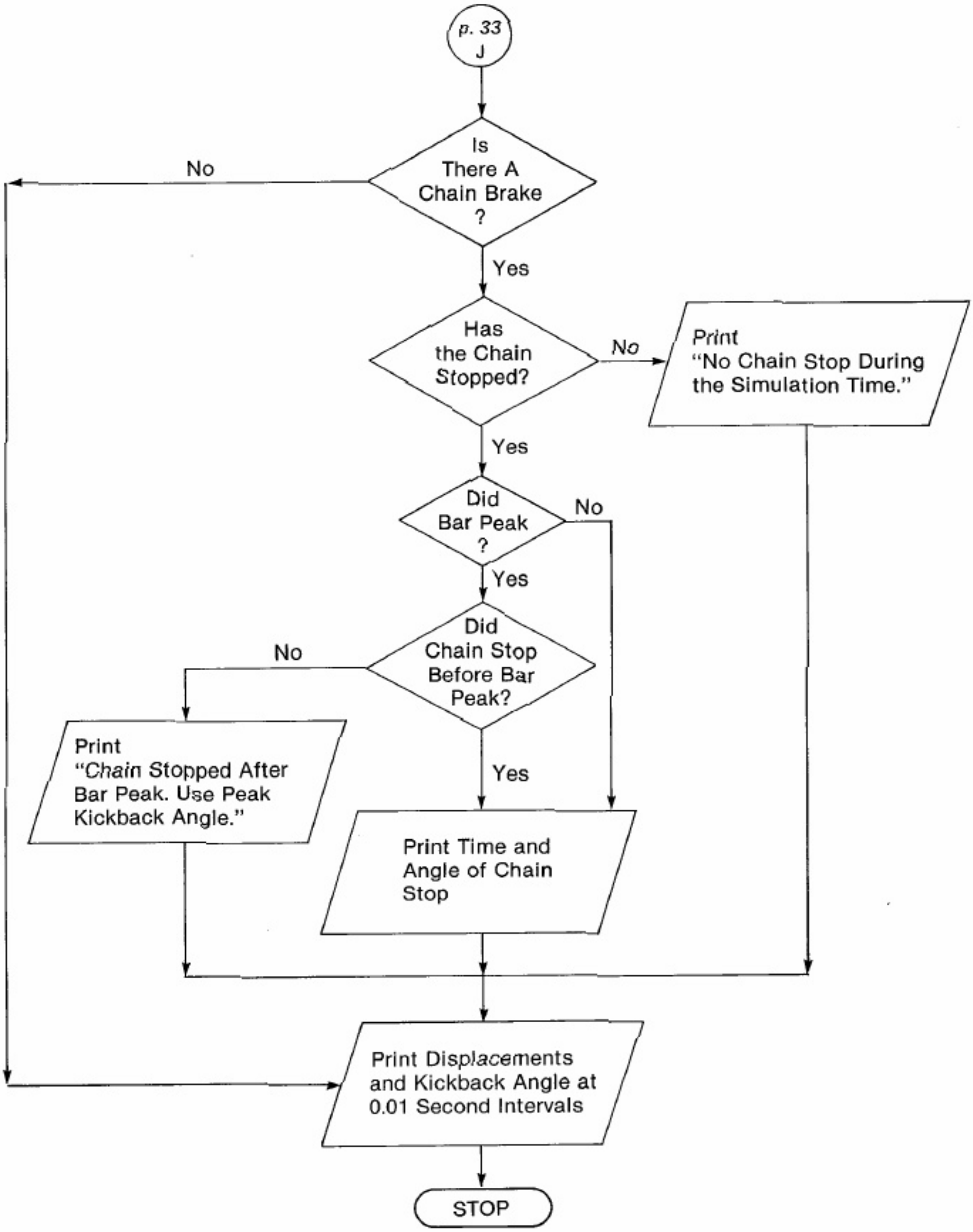

p.28
E
Calculate Horizontal Force, F_x, and Movement, X_{CG}
Is $T \geq 0.18$?
No
Yes
$F_x = J2$
Is $J2 < 0$?
No
Yes
$F_x = J2 - 200\ (T1) + 36$
$F_x = J2 + 200\ (T1) - 36$
Is $F_x > 0$?
No
Yes
Is $F_x < 0$?
Yes
No
$F_x = 0$
$F_x = 0$
During current time increment, Δt, calculate change in horizontal velocity, ΔV_x, and average horizontal velocity, $\overline{V}_x$
$\Delta V_x = \frac{F_x \Delta t}{W/g}$
$\overline{V}_x = V_x + \frac{\Delta V_x}{2}$
Calculate new horizontal position, $(X_{CG})_{i+1}$, and new horizontal velocity $(V_x)_{i+1}$
$(X_{CG})_{i+1} = (X_{CG})_i + \overline{V}_x \Delta t$
$(V_x)_{i+1} = (V_x)_i + \Delta V_x$
p. 30
F


p. 29
F
Calculate Vertical Force, F_y, and Movement Y_{CG}
Is $T > .15$?
Yes
No
Is $T > K3$?
Yes
No
$F_y = O3$
$F_y = O3 - 200\,(T1) + 30$
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, $\overline{V}_y$
$\Delta V_y = (F_y - W)\frac{\Delta t}{W/g}$
$\overline{V}_y = V_y + \frac{\Delta V_y}{2}$
Calculate new vertical position, $(Y_{CG})_{i+1}$, and new vertical velocity, $(V_y)_{i+1}$:
$(Y_{CG})_{i+1} = (Y_{CG})_i + \overline{V}_y\,\Delta t$
$(V_y)_{i+1} = (V_y)_i + \Delta V_y$
p.31
G


p. 30
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
p.32
H


p. 31 H
Is T = 0.01 N ?
No
Is T > T2 ?
No
p. 26 Q
Yes
Yes
p. 33 R
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
Check for Peak Kickback Angle
Store Time and Angle of Bar Peak
p. 33 I


p. 32
I
Is
T > T2
?
No
p.26
Q
Yes
p. 32
R
Has Bar
Peaked
?
No
Print "No Bar
Peak During Simulation
Time of ____ sec."
Yes
Print Peak
Kickback Angle
(Time and Angle of
Bar Peak)
p. 34
J


p. 33
J
Is There A Chain Brake ?
No
Yes
Has the Chain Stopped?
No
Print "No Chain Stop During the Simulation Time."
Yes
Did Bar Peak ?
No
Yes
Did Chain Stop Before Bar Peak?
No
Print "Chain Stopped After Bar Peak. Use Peak Kickback Angle."
Yes
Print Time and Angle of Chain Stop
Print Displacements and Kickback Angle at 0.01 Second Intervals
STOP

9.4 Kickback computer program in FORTRAN

9.4.1 This FORTRAN version was developed to run on an IBM 3033 mainframe computer. If another computer is used, some commands may have to be modified.

9.4.2 A simulation time increment, *T9*, of 0.001 second shall be used. (See lines 200–220 of this program.)

```
00000010 C
00000020 C
00000030 C      ** ANSI KICKBACK PROGRAM **     12-12-84   VERSION
00000040 C
00000050 C           THIS IS THE FORTRAN LANGUAGE VERSION OF THE
00000060 C      ANSI "KICKBACK" PROGRAM
00000070 C
00000080 C
00000090 C           THIS PROGRAM COMPUTES THE KICKBACK ANGLE (SEE PARAGRAPH 8.8)
00000100 C      GIVEN THE SAW CHARACTERISTICS AND ENERGY DATA SPECIFIED AS
00000110 C      INPUT IN PARAGRAPH 8.8.3.
00000120 C
00000130        REAL I,L1,L2,L3,L4,M1,M2,M3,M4,M5,M6,J1,J2,J3,K1,K3,KBMLE,KBMRE
00000140        DIMENSION P(4,42),V(3,42),F(3,42),TIME(42),BX(42),BY(42),PTAX(42),
00000150       #PTAY(42),CBM(42)
00000160        DOUBLE PRECISION P1,P2,P3,R1,H2,V3,C1,S1
00000170        NA=3
00000180        NB=6
00000190 C
00000200 C ***  INPUT TIME INCREMENT (T9) AND TOTAL SIMULATION TIME (T2)
00000210        READ(NA,1000) T9,T2
00000220  1000  FORMAT(2F6.3)
00000230 C
00000240 C ***  INPUT SAW DATA
00000250 C ***  MODEL NAME, WEIGHT(W), INERTIA(I), FRONT HANDLE COORDINATES(L1,L2)
00000260 C ***  REAR HANDLE COORDINATES(L3,L4), BAR TIP COORDINATES(B1,B2)
00000270        READ(NA,1010) NAM1,NAM2,NAM3,NAM4,NAM5,NAM6,NAM7,NAM8,NAM9,NAM10
00000280  1010  FORMAT(10A4)
00000290        READ(NA,1020) W,I
00000300        READ(NA,1020) L1,L2,L3,L4,B1,B2
00000310  1020  FORMAT(6F10.3)
00000320 C
00000330 C ***  INPUT ENERGY DATA:  KBMLE = KICKBACK MACHINE LINEAR ENERGY
00000340 C ***                      KBMRE = KICKBACK MACHINE ROTARY ENERGY
00000350        READ(NA,1020) KBMLE,KBMRE
00000360 C
00000370 C ***  INPUT CHAIN BRAKE DATA: NCB=1=CHAIN BRAKE USED, 0=NO CHAIN BRAKE
00000380 C ***  R4=ROTARY ENERGY WITH CHAIN BRAKE DETERMINED PER
00000390 C          PARAGRAPH 8.7.2.
00000400 C ***  A2=CHAIN BRAKE ACTUATION ANGLE(DEGREES) DETERMINED PER
00000410 C          PARAGRAPH 8.7.3.
00000420 C ***  T3=CHAIN BRAKE STOPPING TIME(SECONDS) DETERMINED PER
00000430 C          PARAGRAPH 8.7.4.
00000440        READ(NA,1030) NCB
00000450  1030  FORMAT(I2)
00000460        IF(FLOAT(NCB)-0.001) 170,170,100
00000470   100  READ(NA,1020) R4,A2,T3
00000480 C ***  CALCULATE COMPUTER ENERGY INPUT:
00000490 C ***  E1=HORIZONTAL, E2=VERTICAL, E0=ROTATIONAL
00000500   170  E1 = KBMLE
00000510        E2MAX = KBMRE/3.
00000520        E2 = E1
00000530        IF(E2.LE.E2MAX) GO TO 180
00000540        E2 = E2MAX
00000550   180  E0 = KBMRE - E2
00000560 C
00000570 C ***  REMOVE VERTICAL PORTION FROM CHAIN BRAKE ROTARY ENERGY
00000580 C ***  COMPUTER ENERGY WITH CHAIN BRAKE:
00000590 C ***  E1=HORIZONTAL, VCB=VERTICAL, E3=ROTATIONAL
00000600        IF(FLOAT(NCB)-0.001) 200,200,190
00000610   190  VCB = E2*R4/KBMRE
00000620        E3 = R4 - VCB
00000630        ECB = E1+VCB+E3
00000640 C
00000650   200  E = E0+E1+E2
00000660        M2 = W/386.4
00000670        M3 = I
00000680        IF(FLOAT(NCB)-0.001) 400,400,300
00000690 C
00000700 C ***  CALCULATING TORQUE PRODUCED BY CHAIN BRAKE
00000710   300  M5 = SQRT(2.*M3) * (SQRT(E0)-SQRT(E3)) / (T3-0.01)
00000720 C
00000730 C ***  CALCULATING SUM OF MOMENT ARMS OF HANDLEBARS
00000740   400  A1 = SQRT(L1**2+L2**2) + SQRT(L3**2+L4**2)
```

```
C
C *** CALCULATING MAXIMUM REACTION MOMENT
      M4 = A1*15.
C
C *** CALCULATING INITIAL VELOCITIES
      R1 = -SQRT(2.*E0/M3)
      H2 = SQRT(2.*E1/M2)
      V3 = SQRT(2.*E2/M2)
      V(1,1) = R1
      V(2,1) = H2
      V(3,1) = V3
C
C *** CALCULATING INTERCEPTS OF THE HAND FORCE EQUATIONS
C *** K(I)=TIME INTERCEPT; J(I)=FORCE INTERCEPT; O(I)=OFFSET
      J1=1.3*E0**0.25*SQRT(SQRT(L1**2+L2**2)+SQRT(L3**2+L4**2))*
     #SQRT(I*386.4)
      J2 = -3.614*(E1*W)**0.25 + 6.012
      J3 = 0.0713*J1 + 3.047*W - 5.215*SQRT(E2) + 2.989
      K1 = 0.107
      K3 = 0.1128
      O1 = 0.0
      O3 = 0.32764*W + 2.063
C
C *** PRINTOUT OF INPUT DATA
C
      WRITE(NB,2000)
 2000 FORMAT(1H1,//,25X,'*** KICKBACK PROGRAM ***',//,29X,
     #'12-12-84 VERSION'///)
C
      WRITE(NB,2010) NAM1,NAM2,NAM3,NAM4,NAM5,NAM6,NAM7,NAM8,NAM9,NAM10
 2010 FORMAT(2X,'MODEL:',10A4//)
C
      WRITE(NB,2011)
 2011 FORMAT(2X,'PHYSICAL CHARACTERISTICS OF THE SAW - ')
C
      WRITE(NB,2020) W,I
 2020 FORMAT(6X,'WEIGHT=',F6.2,' LBS',/,6X,'INERTIA=',F6.3,' IN-LB-SEC**
     #2'/)
C
      WRITE(NB,2021)
 2021 FORMAT(6X,'COORDINATES (IN): ')
      WRITE(NB,2030) L1,L2
 2030 FORMAT(9X,'FRONT HANDLE     FHX:',F6.2,'     FHY:',F6.2)
C
      WRITE(NB,2040) L3,L4
 2040 FORMAT(9X,'REAR HANDLE      RHX:',F6.2,'     RHY:',F6.2)
C
      WRITE(NB,2050) B1,B2
 2050 FORMAT(9X,'BAR TIP          BTX:',F6.2,'     BTY:',F6.2,//)
C
      IF(FLOAT(NCB)-0.001) 550,550,500
  500 WRITE(NB,2060) A2
 2060 FORMAT(2X,'CHAIN BRAKE CHARACTERISTICS - ',/,6X,'ACTUATION ANGLE (
     #DEGREES) =',F6.1)
      WRITE(NB,2070) T3
 2070 FORMAT(6X,'CHAIN BRAKE STOPPING TIME (SECONDS) =',F6.3//)
C
  550 WRITE(NB,2071)
 2071 FORMAT(2X,'KBM ENERGY (IN-LB) - ')
      WRITE(NB,2072) KBMLE
 2072 FORMAT(6X,'HORIZONTAL:',F5.1)
      IF(FLOAT(NCB)-0.001) 570,570,560
  560 WRITE(NB,2073) KBMRE,R4
 2073 FORMAT(6X,'ROTARY WITHOUT CHAIN BRAKE:',F7.1,/,6X,'ROTARY WITH CHA
     #IN BRAKE, R4:',F6.1//)
      WRITE(NB,2080)
 2080 FORMAT(2X,'ENERGY SPLIT -',/,27X,'WITHOUT CHAIN BRAKE')
      GO TO 600
  570 WRITE(NB,2085) KBMRE
 2085 FORMAT(6X,'ROTARY:',F6.1,//,2X,'ENERGY SPLIT -')
C
  600 WRITE(NB,2090)
 2090 FORMAT(2X,'HORIZONTAL ENERGY',5X,'VERTICAL ENERGY',5X,
     #'ROTATIONAL ENERGY',6X,'TOTAL ENERGY')
      WRITE(NB,2100) E1,E2,E0,E
 2100 FORMAT(4X,F5.1,' INCH-LB',3(8X,F5.1,' INCH-LB')//)
```

```
C
      IF(FLOAT(NCB)-0.001) 800,800,700
  700 WRITE(NB,2110)
 2110 FORMAT(27X,'WITH CHAIN BRAKE')
      WRITE(NB,2090)
      WRITE(NB,2100) E1,VCB,E3,ECB
C
      A2 = -A2
C
C *** INITIALIZE POSITION AND FORCE VARIABLES
  800 N = 1
      ICOUNT = 1
      P1 = 0.0
      P2 = 0.0
      P3 = 0.0
      P(1,1) = 0.0
      P(2,1) = 0.0
      P(3,1) = 0.0
      P(4,1) = ATAN((B2-L4)/(B1-L3))
      BX(1) = B1
      BY(1) = B2
      F(3,1) = J1
      F(1,1) = J2
      F(2,1) = J3
      TIME(1) = 0.0
      C = 0.0
      XY = 0.0
      T = 0.0
      LIMIT = 0
      LIMIT2 = 30000
  808 CBM(1) = 0.0
  809 FLAG = 0.0
      FLAG2 = 0.0
C
  810 IF(T.GT.T2)GO TO 2700
      T1 = T + T9/2.
C
C *** CALCULATING ROTATIONAL MOMENT AND CORRESPONDING MOVEMENT
      IF(FLOAT(NCB)-0.001) 840,840,820
  820 IF(FLAG.GT.0.0) GO TO 825
      XX=P1*57.3
      IF(XX.GE.A2) GO TO 840
  824 FLAG = 1.0
  825 IF(C.GT.0.0) GO TO 830
  826 T4 = T + 0.01 - T9
      C = 1.
  830 IF((T+0.00001).LT.T4) GO TO 840
  831 XY = T4 + T3 - 0.01 -T9
C     XY IS LAST TIME AT WHICH CHAIN BRAKE MOMENT IS APPLIED
      IF((T-0.00001).GT.XY) GO TO 840
      M6 = M5
      GO TO 850
  840 M6 = 0.0
  850 IF(T.GT.0.15999) GO TO 870
      IF(T.GT.K1) GO TO 860
      M1 = -(O1-J1)/K1**2*T1**2 + 2.*(O1-J1)/K1*T1 + J1 + M6
      GO TO 880
  860 M1 = O1 + M6
      GO TO 880
  870 M1 = O1 + 1741.*T1 - 278.56 + M6
      IF(M1.LE.M4) GO TO 880
      M1 = M4 + M6
  880 R9 = M1/M3*T9
      R8 = R1 + R9/2.
      P1 = P1 + R8*T9
      R1 = R1 + R9
C
C *** CALCULATING HORIZONTAL FORCE AND CORRESPONDING MOVEMENT
      IF(T.GT.0.17999) GO TO 890
      F1 = J2
      GO TO 910
  890 IF(J2.LT.0.0) GO TO 900
      F1 = J2 - 200.*T1 + 36.
      IF(F1.GT.0.0) GO TO 910
      F1 = 0.0
      GO TO 910
```

```
  900 F1 = J2 + 200.*T1 - 36.
      IF(F1.LT.0.0) GO TO 910
      F1 = 0.0
  910 H9 = F1*T9/M2
      H8 = H2 + H9/2.
      P2 = P2 + H8*T9
      H2 = H2 + H9
C
C *** CALCULATING VERTICAL FORCE AND CORRESPONDING MOVEMENT
      IF(T.GT.0.15) GO TO 930
      IF(T.GT.K3) GO TO 920
      F2 = -(O3-J3)/K3**2*T1**2 + 2.*(O3-J3)/K3*T1 + J3
      GO TO 940
  920 F2 = O3
      GO TO 940
  930 F2 = O3 - 200.*T1 + 30.
      IF(F2.GT.0.0) GO TO 940
      F2 = 0.0
  940 V9 = (F2-W)*T9/M2
      V8 = V3 + V9/2.
      P3 = P3 + V8*T9
      V3 = V3 + V9
C
C *** CALCULATING KICKBACK ANGLE
      ANG = P1
      C1 = COS(ANG)
      S1 = SIN(ANG)
C *** CALCULATING LOCATION OF TIP POINT B
      D1 = P2 + B1*C1 - B2*S1
      D2 = P3 + B1*S1 + B2*C1
C *** CALCULATING CSMA KICKBACK ANGLE
      IF(D1-L3.LT.0.0) GO TO 950
      IF(D2-L4.GT.0.0) GO TO 960
      IF(D2-L4.LT.0.0) GO TO 970
  950 P4 = ATAN((D2-L4)/(D1-L3))
      GO TO 980
  960 P4 = -3.14159 + ATAN((D2-L4)/(D1-L3))
      GO TO 980
  970 P4 = 3.14159 + ATAN((D2-L4)/(D1-L3))
  980 CONTINUE
C
C *** STORING TIME AND ANGLE OF CHAIN STOP
      IF(FLOAT(NCB)-0.001) 2400,2400,2300
 2300 IF(XY) 2400,2400,2350
 2350 IF(FLAG2.GT.0.0) GO TO 2400
      IF(.NOT.((T-0.00001).GT.XY)) GO TO 2400
      FLAG2 = 1.0
      TCB = T + T9
      CSTOP = -P4*57.3
 2400 CONTINUE
C
C *** TIME INCREMENTING
      T = FLOAT(ICOUNT)*T9
      ICOUNT = ICOUNT + 1
C
C *** STORING POSITIONS, VELOCITIES, FORCES IN A MATRIX AT 10MS
C *** INTERVALS
  985 XZ = FLOAT(N)*.01
      TL = T - .00001
      TU = T + .00001
      IF(.NOT.(XZ.GT.TL.AND.XZ.LT.TU)) GO TO 810
      P(1,N+1) = P1
      P(2,N+1) = P2
      P(3,N+1) = P3
      P(4,N+1) = P4
      BX(N+1) = D1
      BY(N+1) = D2
      V(1,N+1) = R1
      V(2,N+1) = H2
      V(3,N+1) = V3
      F(3,N+1) = M1
      F(1,N+1) = F1
      F(2,N+1) = F2
      CBM(N+1) = M6
      TIME(N+1) = T
      N = N + 1
```

```
C
C *** CHECKING FOR CUTOFFS AND PEAK ANGLE
      IF(N.GT.LIMIT2) GO TO 2700
      IF(LIMIT.GT.0) GO TO 810
      IF(P4.GT.P(4,N-1)) GO TO 2500
      GO TO 810
C
C *** STORING PEAK KICKBACK ANGLE AND TIME (BAR PEAK)
 2500 LIMIT = 1
      TPEAK = T - 0.010
      APEAK = -P(4,N-1)*57.3
      LIMIT2 = N + 4
      GO TO 810
 2700 CONTINUE
C
C *** PRINTING OUT DISPLACEMENTS AND COMPUTED KICKBACK ANGLE
C
C *** PRINTOUT OF KICKBACK ANGLE -- BAR PEAK AND CHAIN STOP
C
 3100 IF(LIMIT)3400,3400,3200
 3200 WRITE(NB,3300)
      WRITE(NB,3310) APEAK,TPEAK
 3300 FORMAT(1H ,//,2X,'KICKBACK RESULTS -')
 3310 FORMAT(1H ,/,5X,'COMPUTED KICKBACK ANGLE :',F6.1,' DEGREES',/,21X,
     #'AT TIME : ',F7.3,' SECOND')
      GO TO 3500
 3400 WRITE(NB,3410) T2
 3410 FORMAT(1H ,/,5X,'NO BAR PEAK DURING THE SIMULATION TIME OF ',
     #F5.3,' SEC.')
 3500 IF(FLOAT(NCB)-0.001) 3900,3900,3550
 3550 IF(FLAG2) 3850,3850,3600
 3600 IF(LIMIT) 3700,3700,3650
 3650 IF(TCB.GT.TPEAK) GO TO 3800
 3700 WRITE(NB,3710) CSTOP,TCB
 3710 FORMAT(1H ,//,5X,'CHAIN STOP ANGLE :',F6.1,' DEGREES',/,14X,'AT TI
     #ME :',F8.3,' SECOND')
      GO TO 3900
 3800 WRITE(NB,3810)
 3810 FORMAT(1H ,//,5X,'CHAIN STOPPED AFTER BAR PEAK.  USE PEAK KICKBACK
     # ANGLE.')
      GO TO 3900
 3850 WRITE(NB,3860)
 3860 FORMAT(1H ,/,5X,'NO CHAIN STOP DURING THE SIMULATION TIME .')
 3900 CONTINUE
C
C *** PRINTOUT OF DISPLACEMENTS
C
 3910 WRITE(NB,3915) NAM1,NAM2,NAM3,NAM4,NAM5,NAM6,NAM7,NAM8,NAM9,NAM10
 3915 FORMAT(1H1,///,3X,'MODEL:',10A4///)
      WRITE(NB,2090)
      WRITE(NB,2100) E1,E2,E0,E
      IF(FLOAT(NCB)-0.001) 3925,3925,3920
 3920 WRITE(NB,2110)
      WRITE(NB,2090)
      WRITE(NB,2100) E1,VCB,E3,ECB
 3925 WRITE(NB,3930)
 3930 FORMAT(1H ,///,7X,'TIME',5X,'-----------DISPLACEMENT-----------',
     #6X,'KICKBACK',4X,'CHAIN BRAKE')
      WRITE(NB,3940)
 3940 FORMAT(1H ,15X,'HORIZONTAL',3X,'VERTICAL',3X,'ROTATIONAL',7X,
     #'ANGLE',8X,'MOMENT')
      WRITE(NB,3950)
 3950 FORMAT(1H ,6X,'(SEC)',7X,'(IN)',8X,'(IN)',6X,'(DEGREES)',6X,
     #'(DEGREES)',5X,'(IN-LB)')
      DO 3960 K = 1,N
      P(1,K) = -P(1,K)*57.3
 3960 P(4,K) = -P(4,K)*57.3
      DO 3970 K =1,N
 3970 WRITE(NB,3980) TIME(K),P(2,K),P(3,K),P(1,K),P(4,K),CBM(K)
 3980 FORMAT(1H ,6X,F5.3,2(3X,F9.3),3X,F10.3,4X,F10.3,4X,F10.3)
      END
```

*** KICKBACK PROGRAM ***

12-12-84 VERSION

MODEL: CHECKOUT

PHYSICAL CHARACTERISTICS OF THE SAW -
WEIGHT= 12.79 LBS
INERTIA= 0.839 IN-LB-SEC**2

COORDINATES (IN):

FRONT HANDLE	FHX: -0.44	FHY: 4.31
REAR HANDLE	RHX: 3.75	RHY: 2.31
BAR TIP	BTX: -15.62	BTY: -0.94

KBM ENERGY (IN-LB) -
HORIZONTAL: 7.0
ROTARY: 63.0

ENERGY SPLIT -

HORIZONTAL ENERGY	VERTICAL ENERGY	ROTATIONAL ENERGY	TOTAL ENERGY
7.0 INCH-LB	7.0 INCH-LB	56.0 INCH-LB	70.0 INCH-LB

KICKBACK RESULTS -

COMPUTED KICKBACK ANGLE : 51.6 DEGREES
AT TIME : 0.220 SECOND

TIME	-----------DISPLACEMENT-----------			KICKBACK	CHAIN BRAKE
	HORIZONTAL	VERTICAL	ROTATIONAL	ANGLE	MOMENT
(SEC)	(IN)	(IN)	(DEGREES)	(DEGREES)	(IN-LB)
0.0	0.0	0.0	0.0	-9.525	0.0
0.010	0.198	0.246	6.014	-4.062	0.0
0.020	0.380	0.562	10.963	0.907	0.0
0.030	0.548	0.930	15.056	5.454	0.0
0.040	0.699	1.336	18.478	9.639	0.0
0.050	0.836	1.767	21.391	13.515	0.0
0.060	0.956	2.212	23.935	17.132	0.0
0.070	1.062	2.660	26.228	20.532	0.0
0.080	1.152	3.105	28.365	23.752	0.0
0.090	1.226	3.538	30.417	26.818	0.0
0.100	1.285	3.957	32.435	29.749	0.0
0.110	1.329	4.357	34.446	32.551	0.0
0.120	1.358	4.738	36.456	35.223	0.0
0.130	1.370	5.099	38.466	37.761	0.0
0.140	1.368	5.440	40.477	40.167	0.0
0.150	1.350	5.761	42.487	42.441	0.0
0.160	1.316	6.062	44.497	44.586	0.0
0.170	1.268	6.337	46.487	46.580	0.0
0.180	1.203	6.580	48.359	48.344	0.0
0.190	1.125	6.786	49.992	49.791	0.0
0.200	1.037	6.953	51.269	50.856	0.0
0.210	0.945	7.082	52.071	51.478	0.0
0.220	0.854	7.172	52.278	51.588	0.0
0.230	0.762	7.224	51.771	51.109	0.0
0.240	0.671	7.236	50.434	49.963	0.0
0.250	0.579	7.210	48.205	48.104	0.0
0.260	0.487	7.146	45.081	45.523	0.0
0.270	0.396	7.043	41.062	42.208	0.0
0.280	0.304	6.901	36.148	38.141	0.0

*** KICKBACK PROGRAM ***

12-12-84 VERSION

MODEL: CHECKOUT #1 WITH CHAIN BRAKE

PHYSICAL CHARACTERISTICS OF THE SAW -
WEIGHT= 12.79 LBS
INERTIA= 0.839 IN-LB-SEC**2

COORDINATES (IN):

FRONT HANDLE	FHX: -0.44	FHY: 4.31
REAR HANDLE	RHX: 3.75	RHY: 2.31
BAR TIP	BTX: -15.62	BTY: -0.94

CHAIN BRAKE CHARACTERISTICS -
ACTUATION ANGLE (DEGREES) = 20.0
CHAIN BRAKE STOPPING TIME (SECONDS) = 0.100

KBM ENERGY (IN-LB) -
HORIZONTAL: 7.0
ROTARY WITHOUT CHAIN BRAKE: 63.0
ROTARY WITH CHAIN BRAKE, R4: 45.0

ENERGY SPLIT -

WITHOUT CHAIN BRAKE

HORIZONTAL ENERGY	VERTICAL ENERGY	ROTATIONAL ENERGY	TOTAL ENERGY
7.0 INCH-LB	7.0 INCH-LB	56.0 INCH-LB	70.0 INCH-LB

WITH CHAIN BRAKE

HORIZONTAL ENERGY	VERTICAL ENERGY	ROTATIONAL ENERGY	TOTAL ENERGY
7.0 INCH-LB	5.0 INCH-LB	40.0 INCH-LB	52.0 INCH-LB

KICKBACK RESULTS -

COMPUTED KICKBACK ANGLE : 43.2 DEGREES
AT TIME : 0.200 SECOND

CHAIN STOP ANGLE : 37.8 DEGREES
AT TIME : 0.146 SECOND

TIME	-----------DISPLACEMENT-----------			KICKBACK	CHAIN BRAKE
	HORIZONTAL	VERTICAL	ROTATIONAL	ANGLE	MOMENT
(SEC)	(IN)	(IN)	(DEGREES)	(DEGREES)	(IN-LB)
0.0	0.0	0.0	0.0	-9.525	0.0
0.010	0.198	0.246	6.014	-4.062	0.0
0.020	0.380	0.562	10.963	0.907	0.0
0.030	0.548	0.930	15.056	5.454	0.0
0.040	0.699	1.336	18.478	9.639	0.0
0.050	0.836	1.767	21.391	13.515	0.0
0.060	0.956	2.212	23.921	17.120	16.678
0.070	1.062	2.660	26.100	20.423	16.678
0.080	1.152	3.105	28.009	23.448	16.678
0.090	1.226	3.538	29.720	26.227	16.678
0.100	1.285	3.957	31.282	28.779	16.678
0.110	1.329	4.357	32.723	31.116	16.678
0.120	1.358	4.738	34.050	33.240	16.678
0.130	1.370	5.099	35.263	35.153	16.678
0.140	1.368	5.440	36.362	36.859	16.678
0.150	1.350	5.761	37.361	38.374	0.0
0.160	1.316	6.062	38.346	39.769	0.0
0.170	1.268	6.337	39.311	41.032	0.0
0.180	1.203	6.580	40.158	42.079	0.0
0.190	1.125	6.786	40.766	42.820	0.0
0.200	1.037	6.953	41.018	43.183	0.0
0.210	0.945	7.082	40.794	43.102	0.0
0.220	0.854	7.172	39.976	42.504	0.0
0.230	0.762	7.224	38.444	41.307	0.0
0.240	0.671	7.236	36.082	39.427	0.0
0.250	0.579	7.210	32.828	36.814	0.0
0.260	0.487	7.146	28.679	33.452	0.0

*** KICKBACK PROGRAM ***

12-12-84 VERSION

MODEL:CHECKOUT #2 WITH CHAIN BRAKE

PHYSICAL CHARACTERISTICS OF THE SAW -
WEIGHT= 13.52 LBS
INERTIA= 0.895 IN-LB-SEC**2

COORDINATES (IN):

FRONT HANDLE	FHX: 1.38	FHY: 4.75
REAR HANDLE	RHX: 6.69	RHY: 3.00
BAR TIP	BTX: -18.50	BTY: -0.12

CHAIN BRAKE CHARACTERISTICS -
ACTUATION ANGLE (DEGREES) = 15.0
CHAIN BRAKE STOPPING TIME (SECONDS) = 0.100

KBM ENERGY (IN-LB) -
HORIZONTAL: 8.1
ROTARY WITHOUT CHAIN BRAKE: 43.3
ROTARY WITH CHAIN BRAKE, R4: 28.5

ENERGY SPLIT -

WITHOUT CHAIN BRAKE

HORIZONTAL ENERGY	VERTICAL ENERGY	ROTATIONAL ENERGY	TOTAL ENERGY
8.1 INCH-LB	8.1 INCH-LB	35.2 INCH-LB	51.4 INCH-LB

WITH CHAIN BRAKE

HORIZONTAL ENERGY	VERTICAL ENERGY	ROTATIONAL ENERGY	TOTAL ENERGY
8.1 INCH-LB	5.3 INCH-LB	23.2 INCH-LB	36.6 INCH-LB

KICKBACK RESULTS -

COMPUTED KICKBACK ANGLE : 18.9 DEGREES
AT TIME : 0.170 SECOND

CHAIN STOPPED AFTER BAR PEAK. USE PEAK KICKBACK ANGLE.

TIME	-----------DISPLACEMENT-----------			KICKBACK	CHAIN BRAKE
	HORIZONTAL	VERTICAL	ROTATIONAL	ANGLE	MOMENT
(SEC)	(IN)	(IN)	(DEGREES)	(DEGREES)	(IN-LB)
0.0	0.0	0.0	0.0	-7.061	0.0
0.010	0.207	0.256	4.462	-3.271	0.0
0.020	0.398	0.581	7.836	-0.038	0.0
0.030	0.572	0.958	10.335	2.726	0.0
0.040	0.731	1.374	12.148	5.103	0.0
0.050	0.873	1.814	13.441	7.167	0.0
0.060	0.999	2.268	14.357	8.986	0.0
0.070	1.109	2.725	15.017	10.619	0.0
0.080	1.202	3.178	15.516	12.114	16.643
0.090	1.279	3.619	15.865	13.459	16.643
0.100	1.340	4.046	16.073	14.646	16.643
0.110	1.385	4.453	16.167	15.687	16.643
0.120	1.413	4.841	16.153	16.583	16.643
0.130	1.426	5.209	16.034	17.336	16.643
0.140	1.422	5.557	15.807	17.944	16.643
0.150	1.402	5.884	15.475	18.409	16.643
0.160	1.365	6.191	15.035	18.731	16.643
0.170	1.313	6.472	14.471	18.887	0.0
0.180	1.244	6.721	13.752	18.847	0.0
0.190	1.160	6.933	12.811	18.551	0.0
0.200	1.065	7.107	11.535	17.921	0.0
0.210	0.966	7.242	9.813	16.885	0.0
0.220	0.865	7.339	7.534	15.367	0.0
0.230	0.765	7.397	4.586	13.288	0.0

9.5 Kickback computer program in BASIC

9.5.1 This BASIC version was developed to run on a Tektronix 4052 microcomputer. If another computer is used, some commands may have to be modified.

9.5.2 For the purposes of this standard, a simulation time increment, *T9*, of 0.001 second shall be used.

CAUTION – If the time increment at line 210 is changed, incorrect values of chain stop angle may result.

```
95 INIT
100 REM**********************************************************
102 P$="Program: 'KICKBACK' (revision: December 12,1984)"
105 REM**********************************************************
110 REM  This is the BASIC version of the ANSI 'KICKBACK' program
115 REM
120 REM
125 REM
130 REM  This program computes the kickback angle (see paragraph
135 REM  8.8) given the saw characteristics and energy data
140 REM  specified as input in paragraph 8.8.3.
150 REM
170 DIM P(4,32),V(3,32),F(3,32)
180 REM  ***************************************************
190 REM  DATA STATEMENTS OF TIME PERIOD & TIME INCREMENTS
200 REM  ***************************************************
210 DATA 1.0E-3,0.3
220 READ T9,T2
230 PAGE
240 REM  ***************
250 REM  INPUT SAW DATA
260 REM  ***************
262 PRINT P$
264 PRINT
266 PRINT "INPUT SAW DATA -"
270 PRINT " Model: ";
275 INPUT A$
280 PRINT " Weight(lb): ";
285 INPUT W
290 PRINT " Inertia(in-lb-sec↑2): ";
295 INPUT I
298 PRINT " Coordinates(in) -"
300 PRINT "  Front handle - FHX: ";
302 INPUT L1
306 PRINT "                 FHY: ";
308 INPUT L2
310 PRINT "  Rear handle -  RHX: ";
312 INPUT L3
316 PRINT "                 RHY: ";
318 INPUT L4
320 PRINT "  Bar tip -      BTX: ";
322 INPUT B1
326 PRINT "                 BTY: ";
328 INPUT B2
340 REM  ***************************************************
350 REM  INPUT ENERGY MEASUREMENTS FROM KICKBACK MACHINE
360 REM  ***************************************************
365 PRINT
370 PRINT "KBM linear energy(in-lb): ";
380 INPUT E1
390 PRINT "KBM rotary energy(in-lb): ";
400 INPUT E0
405 IF E1/E0>0.333 THEN 430
410 E2=E1
415 E0=E0-E2
420 GO TO 445
430 E2=0.333*E0
440 E0=E0-E2
445 PRINT
450 PRINT "Was a chain brake used, Y/N: ";
455 INPUT F$
460 IF F$="N" THEN 550
490 PRINT
500 PRINT "Rotary energy with chain brake, R4(in-lb): ";
505 INPUT R4
510 PRINT "Chain brake actuation angle(deg): ";
515 INPUT A2
520 PRINT "Chain brake stopping time(sec): ";
525 INPUT T3
```

```
535 A2=-A2
538 E5=E2*R4/(E2+E0)
540 E3=R4-E5
550 E=E0+E1+E2
560 M2=W/386.4
570 M3=I
580 IF F$="N" THEN 680
590 REM  ****************************************
600 REM  CALCULATE TORQUE PRODUCED BY CHAIN BRAKE
610 REM  ****************************************
630 M5=SQR(2*M3)/(T3-0.01)*(SQR(E0)-SQR(E3))
635 REM
640 REM  The chain brake is considered to start slowing the chain
650 REM  .010 seconds after the chain brake activation angle has
660 REM  been reached with the acceleration considered to be constant.
680 REM  **************************************************
690 REM  CALCULATE THE SUM OF THE MOMENT ARMS OF HANDLEBARS
700 REM  **************************************************
710 A1=SQR(L1↑2+L2↑2)+SQR(L3↑2+L4↑2)
720 REM  *********************************
730 REM  CALCULATE MAXIMUM REACTION MOMENT
740 REM  *********************************
750 M4=A1*15
760 REM  ***************************
770 REM  CALCULATE INITIAL VELOCITIES
780 REM  ***************************
790 R1=-SQR(2*E0/M3)
800 H2=SQR(2*E1/M2)
810 V3=SQR(2*E2/M2)
820 V(1,1)=R1
830 V(2,1)=H2
840 V(3,1)=V3
850 REM  *******************************************************
860 REM  CALCULATE INTERCEPTS OF THE HAND FORCE EQUATIONS
870 REM  K(i)=TIME INTERCEPT; J(i)=FORCE INTERCEPT; O(i)=OFFSET
880 REM  *******************************************************
890 J1=1.3*E0↑0.25*SQR(SQR(L1↑2+L2↑2)+SQR(L3↑2+L4↑2))*SQR(I*386.4)
900 J2=-3.614*(E1*W)↑0.25+6.012
910 J3=0.0713*J1+3.047*W-5.215*SQR(E2)+2.989
920 K1=0.107
930 REM  J2= A CONSTANT
940 K3=0.1128
950 O1=0
960 O3=0.32764*W+2.063
970 REM  *****************
980 REM  DISPLAY INPUT DATA
990 REM  *****************
1000 PAGE
1010 PRINT P$
1015 PRINT
1020 PRINT "MODEL: ";A$
1030 PRINT
1035 PRINT "PHYSICAL CHARACTERISTICS OF SAW -"
1040 PRINT " Weight(lb): ";W
1045 PRINT " Inertia(in-lb-sec↑2): ";I
1050 PRINT " Coordinates(in) -"
1060 PRI USI "FA,14T,2(5X,4A,3D.3D)":" Front handle","FHX:",L1,"FHY:",L2
1070 PRI USI "FA,14T,2(5X,4A,3D.3D)":" Rear handle","RHX:",L3,"RHY:",L4
1080 PRINT USING "FA,14T,2(5X,4A,3D.3D)":" Bar tip","BTX:",B1,"BTY:",B2
1100 IF F$="N" THEN 1140
1110 PRINT
1115 PRINT "CHAIN BRAKE CHARACTERISTICS -"
1120 PRINT " Actuation angle(deg): ";-A2
1130 PRINT USING "FA,FD.3D":" Stopping time(sec): ",T3
1140 PRINT
1145 PRINT "KBM ENERGY(in-lb) MEASUREMENTS -"
1150 PRINT " Horizontal: ";E1
1151 IF F$="N" THEN 1156
1152 PRINT " Rotary w/o chain brake: ";E0+E2
1154 PRINT " Rotary with chain brake, R4: ";R4
```

```
1155 GO TO 1160
1156 PRINT " Rotary: ";E0+E2
1160 PRINT
1170 PRINT "ENERGY(in-lb) COMPONENTS - Horizontal  Vertical  Rotational"
1175 IF F$="N" THEN 1285
1210 PRINT USING "FA,24T,3(9D.D)":" w/o chain brake:",E1,E2,E0
1270 PRINT USING "FA,24T,3(9D.D)":" with chain brake:",E1,E5,E3
1280 GO TO 1290
1285 PRINT USING "24T,3(9D.D)":E1,E2,E0
1290 PRINT
1295 PRINT "KICKBACK RESULTS -"
1300 N=1
1305 P1=0
1310 P2=0
1315 P3=0
1320 P(1,1)=0
1330 P(2,1)=0
1340 P(3,1)=0
1350 P(4,1)=ATN((B2-L4)/(B1-L3))
1360 F(3,1)=J1
1370 F(1,1)=J2
1380 F(2,1)=J3
1390 C=0
1399 F9=0
1400 FOR T=0 TO T2 STEP T9
1410 T1=T+T9/2
1420 REM  *****************************************************
1430 REM  CALCULATE ROTATIONAL MOMENT & CORRESPONDING MOVEMENT
1440 REM  *****************************************************
1450 IF F$="N" THEN 1540
1455 IF F9>0 THEN 1470
1460 IF P1*57.3=>A2 THEN 1540
1465 F9=1
1470 IF C>0 THEN 1500
1480 T4=T+0.01-T9
1490 C=1
1500 IF T<T4 THEN 1540
1510 IF T>T4+T3-0.01-T9 THEN 1540
1520 M6=M5
1530 GO TO 1550
1540 M6=0
1550 IF T=>0.16 THEN 1610
1560 IF T>K1 THEN 1590
1570 M1=-(O1-J1)/K1↑2*T1↑2+2*(O1-J1)/K1*T1+J1+M6
1580 GO TO 1640
1590 M1=O1+M6
1600 GO TO 1640
1610 M1=O1+1741*T1-278.56+M6
1620 IF M1<=M4 THEN 1640
1630 M1=M4+M6
1640 R9=M1/M3*T9
1650 R8=R1+R9/2
1660 P1=P1+R8*T9
1670 R1=R1+R9
1680 REM  *****************************************************
1690 REM  CALCULATE HORIZONTAL FORCE & CORRESPONDING MOVEMENT
1700 REM  *****************************************************
1710 IF T=>0.18 THEN 1740
1720 F1=J2
1730 GO TO 1820
1740 IF J2<0 THEN 1790
1750 F1=J2-200*T1+36
1760 IF F1>0 THEN 1820
1770 F1=0
1780 GO TO 1820
1790 F1=J2+200*T1-36
1800 IF F1<0 THEN 1820
1810 F1=0
1820 H9=F1*T9/M2
1830 H8=H2+H9/2
```

```
1840 P2=P2+H8*T9
1850 H2=H2+H9
1860 REM  *************************************************
1870 REM  CALCULATE VERTICAL FORCE & CORRESPONDING MOVEMENT
1880 REM  *************************************************
1890 IF T>0.15 THEN 1950
1900 IF T>K3 THEN 1930
1910 F2=-(O3-J3)/K3↑2*T1↑2+2*(O3-J3)/K3*T1+J3
1920 GO TO 1980
1930 F2=O3
1940 GO TO 1980
1950 F2=O3-200*T1+30
1960 IF F2>0 THEN 1980
1970 F2=0
1980 V9=(F2-W)*T9/M2
1990 V8=V3+V9/2
2000 P3=P3+V8*T9
2010 V3=V3+V9
2020 REM  ************************
2030 REM  CALCULATE KICKBACK ANGLE
2040 REM  ************************
2050 C1=COS(P1)
2060 S1=SIN(P1)
2070 D1=P2+B1*C1-B2*S1
2080 D2=P3+B1*S1+B2*C1
2090 IF D1-L3<0 THEN 2120
2100 IF D2-L4>0 THEN 2140
2110 IF D2-L4<0 THEN 2160
2120 P4=ATN((D2-L4)/(D1-L3))
2130 GO TO 2161
2140 P4=-PI+ATN((D2-L4)/(D1-L3))
2150 GO TO 2161
2160 P4=PI+ATN((D2-L4)/(D1-L3))
2161 IF F$="N" OR C=0 THEN 2170
2163 IF T<>T4+INT(1000*(T3+5.0E-4))/1000-0.01 THEN 2170
2164 A5=P4*57.3
2165 T5=T+T9
2170 IF T+T9<>N*0.01 THEN 2350
2180 REM  ***************************************************
2190 REM  STORE VELOCITIES, DISPLACEMENTS, & FORCES (MOMENTS)
2210 REM  ***************************************************
2220 P(1,N+1)=P1
2230 P(2,N+1)=P2
2240 P(3,N+1)=P3
2250 P(4,N+1)=P4
2260 V(1,N+1)=R1
2270 V(2,N+1)=H2
2280 V(3,N+1)=V3
2290 F(3,N+1)=M1
2300 F(1,N+1)=F1
2310 F(2,N+1)=F2
2320 N=N+1
2330 IF P4>P(4,N-1) THEN 2360
2340 IF P4<-70/57.3 THEN 2400
2350 NEXT T
2360 PRI USI "FA,FD.D":" COMPUTED KICKBACK ANGLE(deg): ",-P(4,N-1)*57.3
2370 PRINT USING "FA,D.3D":"                          at time(sec): ",T+T9-0.01
2371 IF F$="N" THEN 2390
2372 IF T5<T+T9-0.01 THEN 2380
2373 PRINT " Chain stopped after bar peak."
2374 GO TO 2390
2380 PRINT USING """ CHAIN STOP ANGLE(deg): "",FD.D":-A5
2381 PRINT "             at time(sec): ";T5
2390 GO TO 2430
2400 B$=" The COMPUTED KICKBACK ANGLE has exceeded 70 degrees at time: "
2405 PRINT USING "//,FA,D.3D":B$,T+T9
2410 IF F$="N" THEN 2430
2411 IF T5<T+T9-0.01 THEN 2420
2412 PRINT " Chain has not stopped."
2413 GO TO 2430
```

```
2420 PRINT USING """ Chain stopped at KB angle(deg): "",FD.D,S":-A5
2421 PRINT USING """ at "",FD.3D,"" sec."""":T5
2430 INPUT S$
2440 PAGE
2450 REM  **********************************
2460 REM  DISPLAY VELOCITIES & DISPLACEMENTS
2470 REM  **********************************
2472 PRINT P$
2474 PRINT
2480 PRINT USING 2490:"HORIZONTAL","VERTICAL","ROTATIONAL"
2490 IMAGE 11X,10A,9X,8A,10X,10A
2500 PRI USI 2520:"TIME","VEL.","DISP.","VEL.","DISP.","VEL.","DISP."
2510 PRINT "KB ANGLE"
2520 IMAGE X,4A,5X,4A,4X,5A,5X,4A,4X,5A,6X,4A,4X,5A,4X,S
2530 PRINT USING 2550:"sec","in/sec","in","in/sec","in","deg/sec","deg"
2540 PRINT "deg"
2550 IMAGE 2X,3A,4X,6A,4X,2A,6X,6A,4X,2A,6X,7A,4X,3A,7X,S
2560 FOR S1=0 TO N-1
2570 S=S1+1
2580 PRINT USING 2591:S1/100,V(2,S),P(2,S),V(3,S),P(3,S),-V(1,S)*57.3
2590 IMAGE D.3D,7D.2D,5D.2D,7D.2D,5D.2D,8D.2D,S
2591 IMAGE D.3D,6D.3D,4D.3D,6D.3D,4D.3D,7D.3D,S
2600 PRINT USING 2611:-P(1,S)*57.3,-P(4,S)*57.3
2610 IMAGE 5D.2D,9D.2D
2611 IMAGE 4D.3D,8D.3D
2620 NEXT S1
2630 IF T>0.3 THEN 2660
2640 PRINT
2650 PRINT "WOULD YOU LIKE TO CONTINUE Y/N?GGG";
2660 INPUT S$
2670 PAGE
2680 IF S$="N" THEN 2740
2690 PRINT "WOULD YOU LIKE TO RERUN THE SAME SAW Y/N?GGG"
2700 INPUT S$
2710 PAGE
2720 IF S$="Y" THEN 350
2730 GO TO 95
2740 END
```

Program: 'KICKBACK' (revision: December 12,1984)

MODEL: 'Checkout #1' (without chain brake)

PHYSICAL CHARACTERISTICS OF SAW -
Weight(lb): 12.79
Inertia(in-lb-sec↑2): 0.839
Coordinates(in) -

Front handle	FHX: -0.440	FHY: 4.310
Rear handle	RHX: 3.750	RHY: 2.310
Bar tip	BTX:-15.620	BTY: -0.940

KBM ENERGY(in-lb) MEASUREMENTS -
Horizontal: 7
Rotary: 63

ENERGY(in-lb) COMPONENTS -	Horizontal	Vertical	Rotational
	7.0	7.0	56.0

KICKBACK RESULTS -
COMPUTED KICKBACK ANGLE(deg): 51.6
at time(sec): 0.220

Program: 'KICKBACK' (revision: December 12,1984)

	HORIZONTAL		VERTICAL		ROTATIONAL		
TIME sec	VEL. in/sec	DISP. in	VEL. in/sec	DISP. in	VEL. deg/sec	DISP. deg	KB ANGLE deg
0.000	20.566	0.000	20.566	0.000	662.038	0.000	-9.525
0.010	19.024	0.198	28.367	0.246	544.484	6.014	-4.062
0.020	17.481	0.380	34.439	0.562	448.833	10.963	0.907
0.030	15.939	0.548	38.951	0.930	372.027	15.056	5.454
0.040	14.397	0.699	42.072	1.336	314.206	18.478	9.639
0.050	12.855	0.836	43.968	1.767	270.715	21.391	13.515
0.060	11.313	0.956	44.809	2.212	240.094	23.935	17.132
0.070	9.770	1.062	44.761	2.660	220.085	26.228	20.532
0.080	8.228	1.152	43.995	3.105	208.431	28.365	23.752
0.090	6.686	1.226	42.677	3.538	202.874	30.417	26.818
0.100	5.144	1.285	40.975	3.957	201.155	32.435	29.749
0.110	3.601	1.329	39.058	4.357	201.026	34.446	32.551
0.120	2.059	1.358	37.084	4.738	201.026	36.456	35.223
0.130	0.517	1.370	35.110	5.099	201.026	38.466	37.761
0.140	-1.025	1.368	33.135	5.440	201.026	40.477	40.167
0.150	-2.567	1.350	31.160	5.761	201.026	42.487	42.441
0.160	-4.110	1.316	28.886	6.062	201.026	44.497	44.586
0.170	-5.652	1.268	26.005	6.337	195.001	46.487	46.580
0.180	-7.194	1.203	22.520	6.580	177.246	48.359	48.344
0.190	-8.434	1.125	18.660	6.786	147.520	49.992	49.791
0.200	-9.070	1.037	14.796	6.953	105.904	51.269	50.856
0.210	-9.162	0.945	10.932	7.082	52.398	52.071	51.478
0.220	-9.162	0.854	7.068	7.172	-12.999	52.278	51.508
0.230	-9.162	0.762	3.204	7.224	-90.285	51.771	51.110

WOULD YOU LIKE TO CONTINUE Y/N?

```
Program: 'KICKBACK' (revision: December 12,1984)

MODEL: 'Checkout #1' (with chain brake)

PHYSICAL CHARACTERISTICS OF SAW -
 Weight(lb): 12.79
 Inertia(in-lb-sec↑2): 0.839
 Coordinates(in) -
 Front handle      FHX: -0.440      FHY:  4.310
 Rear handle       RHX:  3.750      RHY:  2.310
 Bar tip           BTX:-15.620      BTY: -0.940

CHAIN BRAKE CHARACTERISTICS -
 Actuation angle(deg): 20
 Stopping time(sec): 0.100

KBM ENERGY(in-lb) MEASUREMENTS -
 Horizontal: 7
 Rotary w/o chain brake: 63
 Rotary with chain brake, R4: 45

ENERGY(in-lb) COMPONENTS - Horizontal  Vertical  Rotational
 w/o chain brake:               7.0        7.0        56.0
 with chain brake:              7.0        5.0        40.0

KICKBACK RESULTS -
 COMPUTED KICKBACK ANGLE(deg): 43.2
                at time(sec): 0.200
 CHAIN STOP ANGLE(deg): 37.8
          at time(sec): 0.146
```

Program: 'KICKBACK' (revision: December 12,1984)

	HORIZONTAL		VERTICAL		ROTATIONAL		
TIME	VEL.	DISP.	VEL.	DISP.	VEL.	DISP.	KB ANGLE
sec	in/sec	in	in/sec	in	deg/sec	deg	deg
0.000	20.566	0.000	20.566	0.000	662.038	0.000	-9.525
0.010	19.024	0.198	28.367	0.246	544.484	6.014	-4.062
0.020	17.481	0.380	34.439	0.562	448.833	10.963	0.907
0.030	15.939	0.548	38.951	0.930	372.827	15.056	5.454
0.040	14.397	0.699	42.072	1.336	314.206	18.478	9.639
0.050	12.855	0.836	43.968	1.767	270.715	21.391	13.515
0.060	11.313	0.956	44.809	2.212	234.399	23.921	17.120
0.070	9.770	1.062	44.761	2.660	203.000	26.100	20.423
0.080	8.228	1.152	43.995	3.105	179.955	28.009	23.448
0.090	6.686	1.226	42.677	3.538	163.007	29.720	26.227
0.100	5.144	1.285	40.975	3.957	149.898	31.282	28.779
0.110	3.601	1.329	39.058	4.357	138.379	32.723	31.116
0.120	2.059	1.358	37.084	4.738	126.988	34.050	33.240
0.130	0.517	1.370	35.110	5.099	115.598	35.263	35.153
0.140	-1.025	1.368	33.135	5.440	104.208	36.362	36.859
0.150	-2.567	1.350	31.160	5.761	98.512	37.361	38.374
0.160	-4.110	1.316	28.886	6.062	98.512	38.346	39.769
0.170	-5.652	1.268	26.005	6.337	92.567	39.311	41.032
0.180	-7.194	1.203	22.520	6.580	74.732	40.158	42.079
0.190	-8.434	1.125	18.660	6.786	45.006	40.766	42.820
0.200	-9.070	1.037	14.796	6.953	3.390	41.018	43.183
0.210	-9.162	0.945	10.932	7.082	-50.116	40.794	43.102

WOULD YOU LIKE TO CONTINUE Y/N?

Program: 'KICKBACK' (revision: December 12,1984)

MODEL: 'Checkout #2' (with chain brake)

PHYSICAL CHARACTERISTICS OF SAW -
Weight(lb): 13.52
Inertia(in-lb-sec↑2): 0.895
Coordinates(in) -

Front handle	FHX: 1.380	FHY: 4.750
Rear handle	RHX: 6.690	RHY: 3.000
Bar tip	BTX:-18.500	BTY: -0.120

CHAIN BRAKE CHARACTERISTICS -
Actuation angle(deg): 15
Stopping time(sec): 0.100

KBM ENERGY(in-lb) MEASUREMENTS -
Horizontal: 8.1
Rotary w/o chain brake: 43.3
Rotary with chain brake, R4: 28.5

ENERGY(in-lb) COMPONENTS -	Horizontal	Vertical	Rotational
w/o chain brake:	8.1	8.1	35.2
with chain brake:	8.1	5.3	23.2

KICKBACK RESULTS -
COMPUTED KICKBACK ANGLE(deg): 18.9
at time(sec): 0.170
Chain stopped after bar peak.

Program: 'KICKBACK' (revision: December 12,1984)

	HORIZONTAL		VERTICAL		ROTATIONAL		
TIME	VEL.	DISP.	VEL.	DISP.	VEL.	DISP.	KB ANGLE
sec	in/sec	in	in/sec	in	deg/sec	deg	deg
0.000	21.517	0.000	21.517	0.000	508.194	0.000	-7.061
0.010	19.894	0.207	29.320	0.256	388.054	4.462	-3.271
0.020	18.271	0.398	35.389	0.581	290.299	7.836	-0.038
0.030	16.648	0.572	39.891	0.958	212.620	10.335	2.726
0.040	15.025	0.731	42.996	1.374	152.711	12.148	5.103
0.050	13.402	0.873	44.873	1.814	108.262	13.441	7.167
0.060	11.779	0.999	45.690	2.268	76.968	14.357	8.986
0.070	10.156	1.109	45.617	2.725	56.519	15.017	10.619
0.080	8.533	1.202	44.821	3.178	43.543	15.516	12.114
0.090	6.910	1.279	43.471	3.619	27.208	15.865	13.459
0.100	5.287	1.340	41.737	4.046	14.796	16.073	14.646
0.110	3.664	1.385	39.787	4.453	4.009	16.167	15.687
0.120	2.041	1.413	37.779	4.841	-6.647	16.153	16.583
0.130	0.417	1.426	35.771	5.209	-17.302	16.034	17.336
0.140	-1.206	1.422	33.763	5.557	-27.958	15.807	17.944
0.150	-2.829	1.402	31.754	5.884	-38.613	15.475	18.409
0.160	-4.452	1.365	29.463	6.191	-49.269	15.035	18.731
0.170	-6.075	1.313	26.597	6.472	-64.432	14.471	18.887
0.180	-7.698	1.244	23.160	6.721	-81.151	13.752	18.847

WOULD YOU LIKE TO CONTINUE Y/N?

9.6 Background documents[7)]

The following documents contain background information used in the development of the standard.

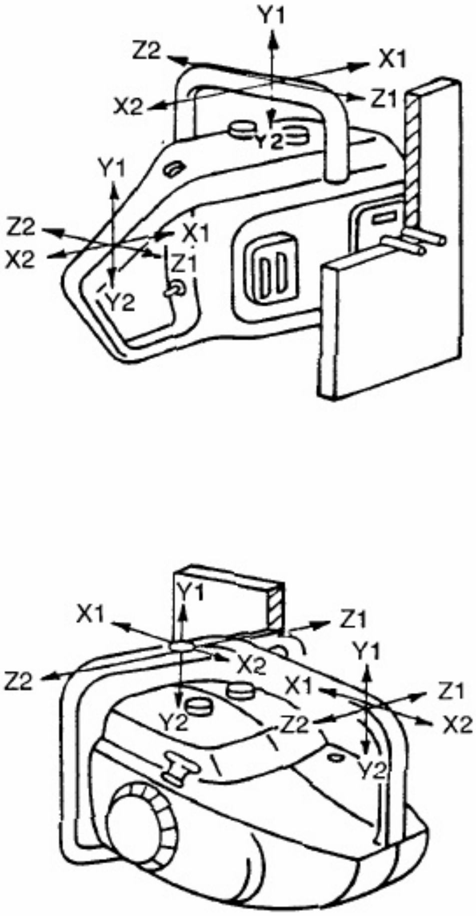
– "Overview of the KICKBACK Computer Program – Contents and Development."

– Excerpt from Draft Proposed Kickback Standard, Section III, "Explanation of the Proposed Standard," December 1981.

– "CSMA High Speed Film Test on Hand Held Kickback," CSMA, October 1981.

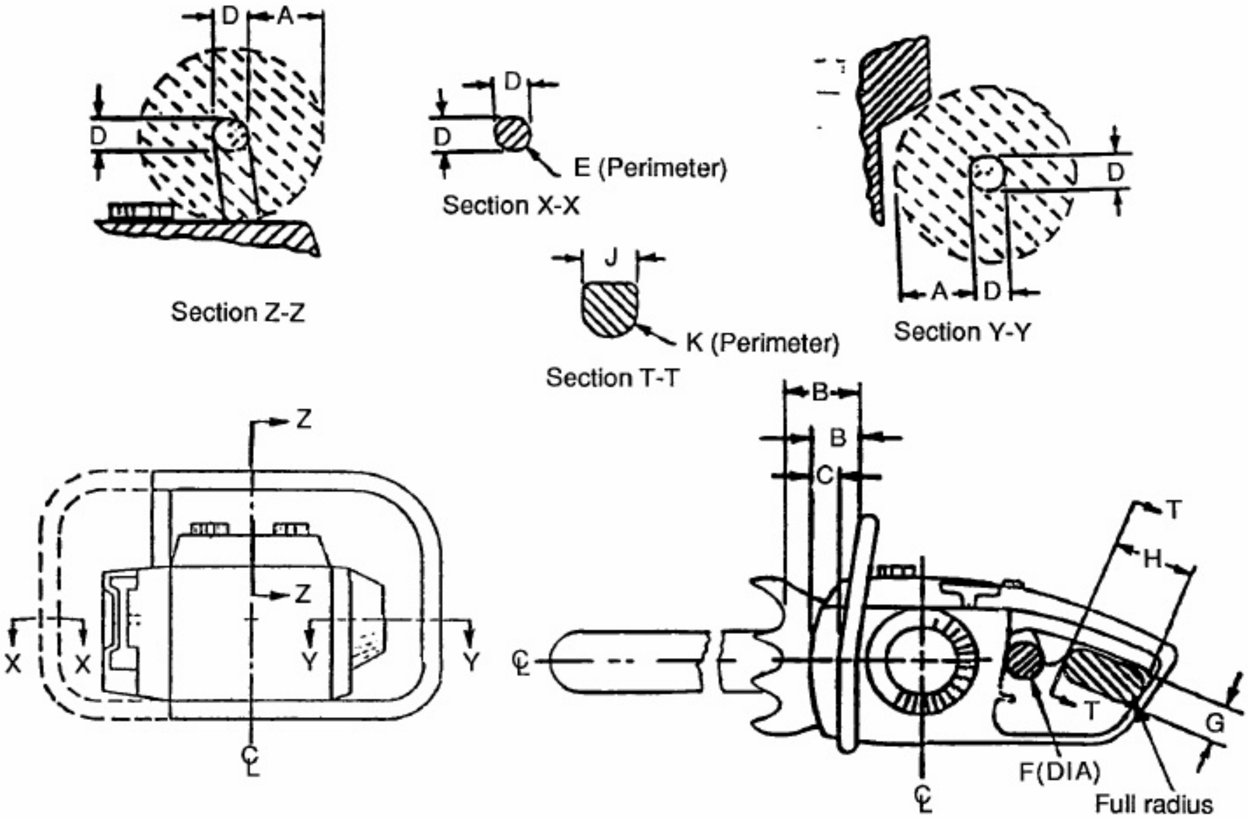
– Santelli, Lynda, "Sensitivity Study of the CSMA KICKBACK Computer Program (01/25/82 Version)," Consumer Product Safety Commission, June 1982.

– Santelli, Lynda, "Study of the Simulation Time Increment Used in the Kickback Computer Program (10/27/82 Version)," Consumer Product Safety Commission, January 1983.



Chain saw engine Displacement		Handle strength test load (Applied at handle gate midpoint)					
		Front and rear X1 and X2		Up and down Y1 and Y2		Right and left Z1 and Z2	
cubic inches	cubic centimeters	pounds force	newtons	pounds force	newtons	pounds force	newtons
<3.0 ≥3.0	<49.2 ≥49.2	150 300	670 1340	150 300	670 1340	75 150	335 670

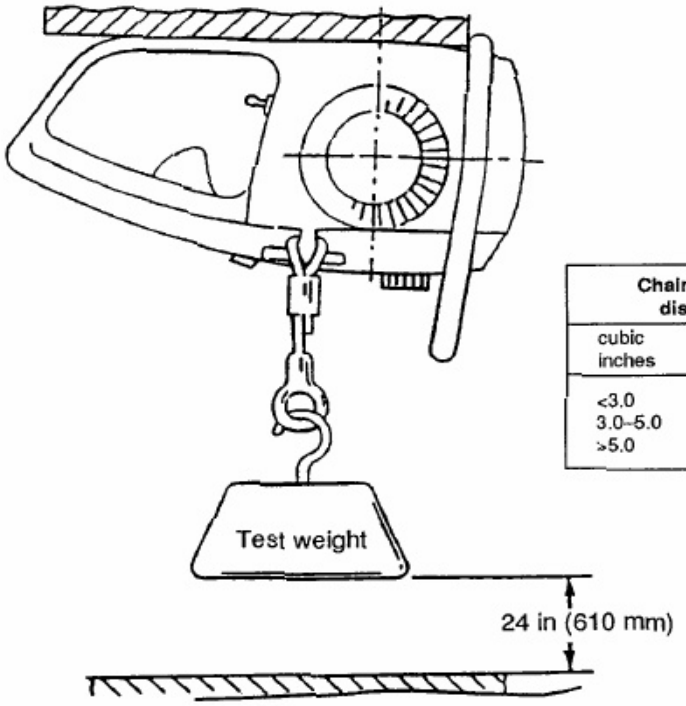
Figure 1 – Handle strength test loads



NOTE – Dimensions B and C shall be measured parallel to the centerline of the guide bar

Handle	Description	Dimension in fig. 2	Minimum size	
			inches	mm
Front	Finger clearance in the handle grip area	A	1.00	25
	Clearance between the front of the chain saw body and the handle at the top. If the chain saw has an integral (nonremovable) bumper spike, then the measurement is to be made from the root of the bumper spike.	B	1.50	38
	Clearance between the front of the chain saw and the handle at the engine centerline	C	1.00	25
	Projected thickness	D	0.44	11
	Handle perimeter	E	2.35	60
Rear	Finger clearance at the released throttle control trigger	F	1.00	25
	Finger clearance behind the throttle control trigger	G	1.00	25
	Hand width clearance	H	2.50	64
	Projected thickness	J	0.7	19
	Handle perimeter	K	3.50	89

Figure 2 – Handle clearances and sizes



Chain saw engine displacement		Test weight		Minimum cranking speed
cubic inches	cubic centimeters	lb	kg	rpm
<3.0	<49.16	30	14	600
3.0–5.0	49.16–81.94	70	32	600
>5.0	>81.94	120	54	600

Figure 3 – Pull-type starter test

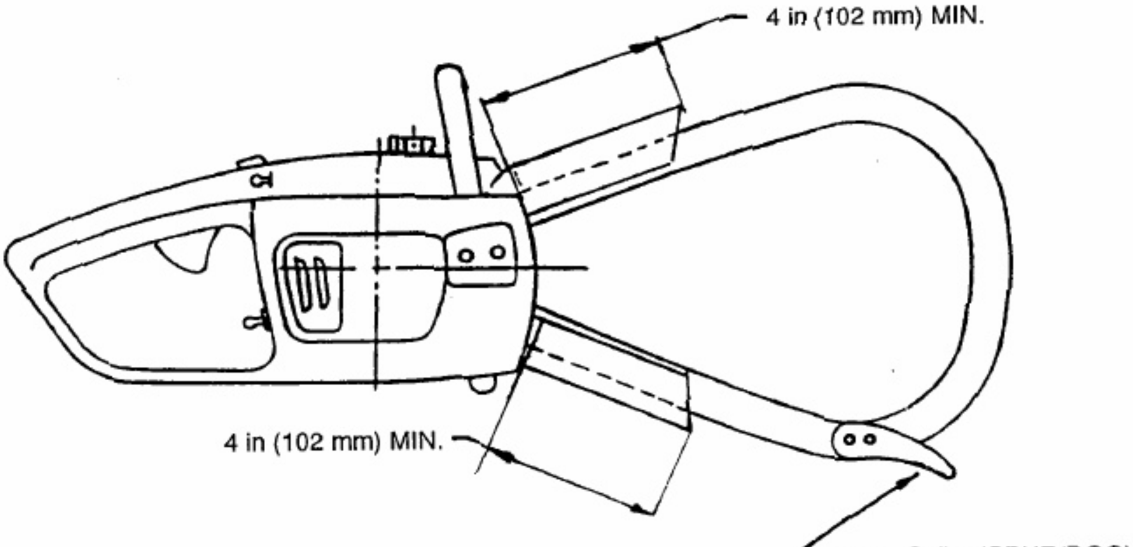
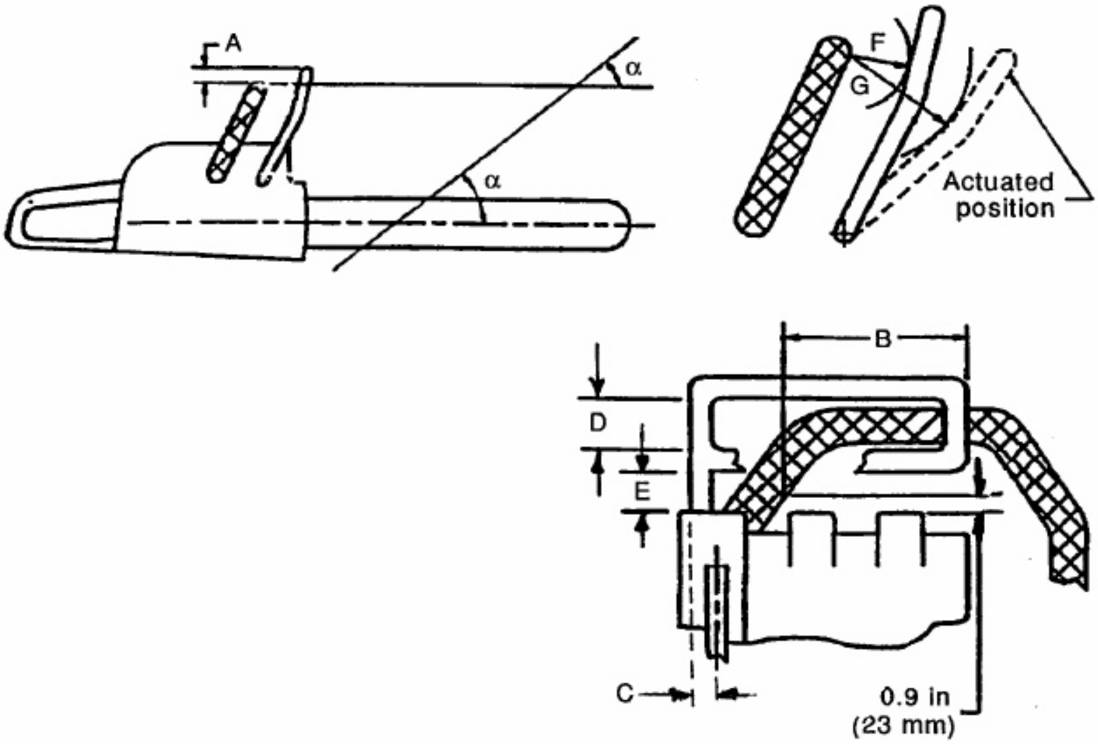


Figure 4 – Bow guide guard

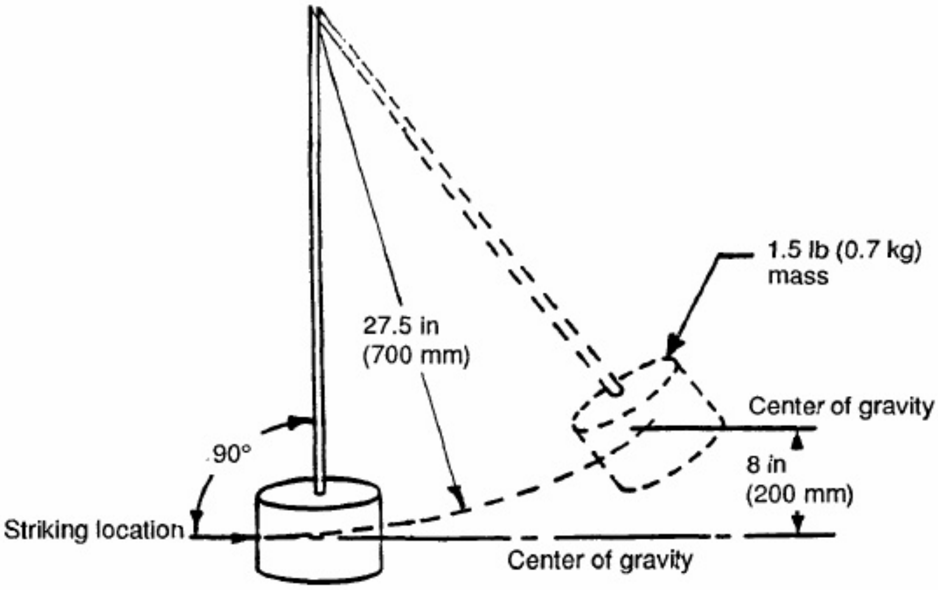


Dimension in fig. 5	Description	Dimension	
		in	mm
A	Minimum guard extension above top of front handle 1), 2), 3)	0.79	20
B	Minimum effective guard length4)	4.0	100
C	Minimum right end overlap 5)	0.0	0
D	Maximum guard opening(s) 6)	2.16	55
E	Maximum clearance between lower edge of the guard and the nearest part of the saw (for example, fuel caps) 1), 3), 6)	2.16	55
F	Clearance between any part of guard and the front handle1), 3)	>1.6 <2.8	>40 <70
G	Clearance between any guard and front handle when guard is actuated 3),7)	>1.6 <4.0	>40 <100

NOTE – All dimensions with the exception of "F" and "G" shall be measured parallel or perpendicular to the centerline of the guide bar.

1) Dimension "A" applies to hand guard in normal forward operating position.
2) For hand guard used as chain brake actuator, dimension "A" applies in the nonactuated position.
3) A force of 2.3 lbf (10 N) shall be applied to the front hand guard at 45 degrees in a forward and downward direction, at the center of the top edge when dimensions "A", "E", "F", and "G" are measured.
4) The measurement shall apply from the right inside surface of the right side of the front handle, or the 0.9-in. (23-mm) gage point measured to the closest part of the saw directly below the handle.
5) If the chain saw has a barrier between the front handle and the moving saw chain, dimension "C" can be disregarded.
6) The intention is to provide an obstacle to the hand passing through. This measurement may be made with a cylindrical gage, 2.20 in (56 mm) in diameter and 3.2 in (82 mm) long, held parallel to the hand guard. When pushed forward with a force of 7 lbf (30 N), this gage shall not pass through. For dimension "E", this measurement shall apply over the whole range of 4.0 in (100 mm).
7) Applies only to the hand guard used as actuator for chain brakes.

Figure 5 – Front hand guard and chain brake



Chain brake pendulum test sequence

Step	Engine speed	Time	Actuations	Remarks
1.1	Max power	4'45"	–	Warm up, no measurement
1.2	Racing	15"	1	Record stopping time
2.1	Idling	3'	–	Cooling down
2.2	Max power	1'45"	–	Heating up, no measurement
2.3	Racing	15"	1	Record stopping time
2.4	Idling	3'	–	Cooling down
2.5	Max power	1'45"	–	Heating up, no measurement
2.6	Racing	15"	1	Record stopping time
2.7	Idling	3'	–	Cooling down
2.8	Max power	1'45"	–	Heating up, no measurement
2.9	Racing	15"	1	Record stopping time
3.1	Racing	10"–30"	15	15 times wear-in, no measurement
3.2	Racing	10"–30"	5	Record stopping time

Report:

a) The average of the nine measured stopping times, in steps 1.2, 2.3, 2.6, 2.9 and 3.2;

b) The highest single measurement of recorded stopping times.

Figure 6 – Chain brake test pendulum and test sequence

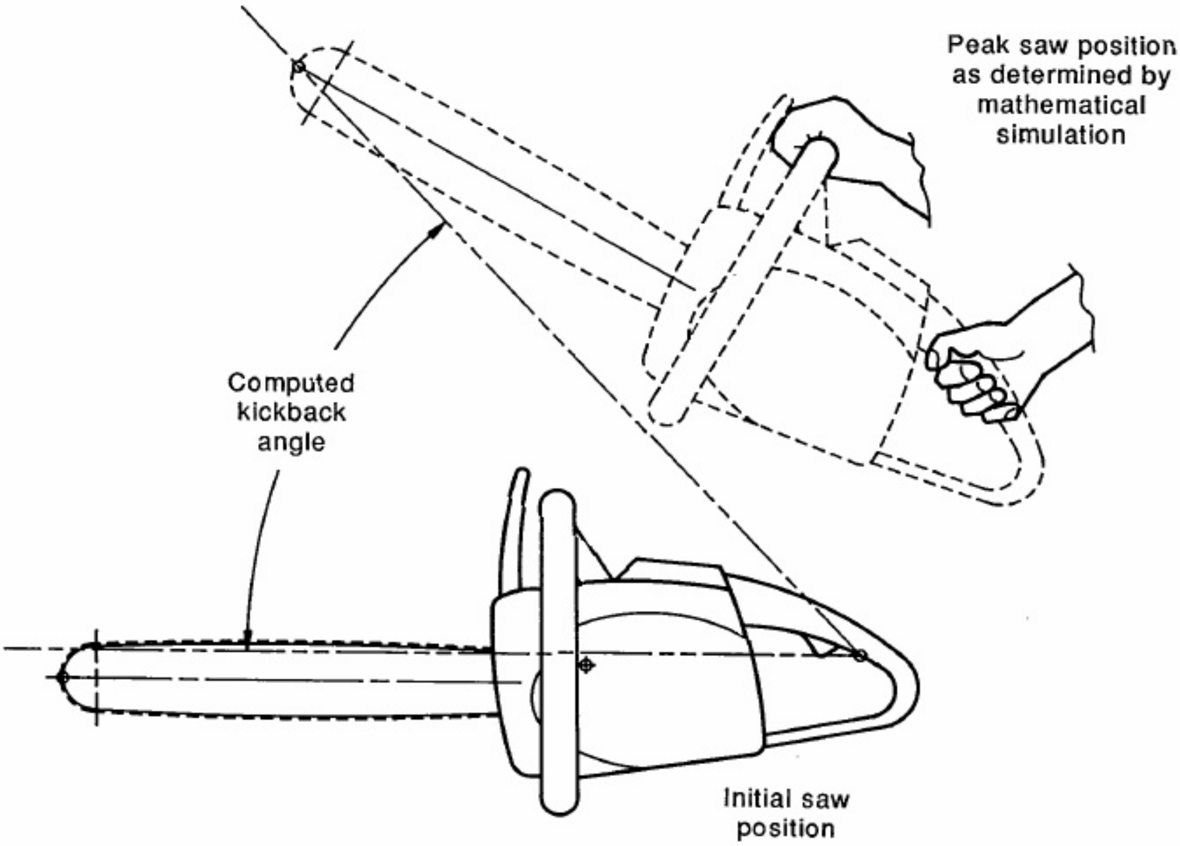
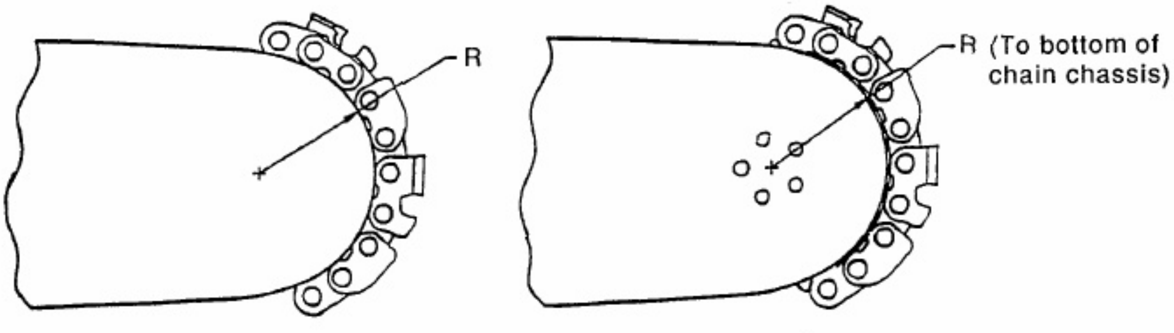


Figure 7 – Illustration of computed kickback angle



(a) Hard-nose guide bar *(b) Sprocket nose bar*

Figure 8 – Guide bar nose definition

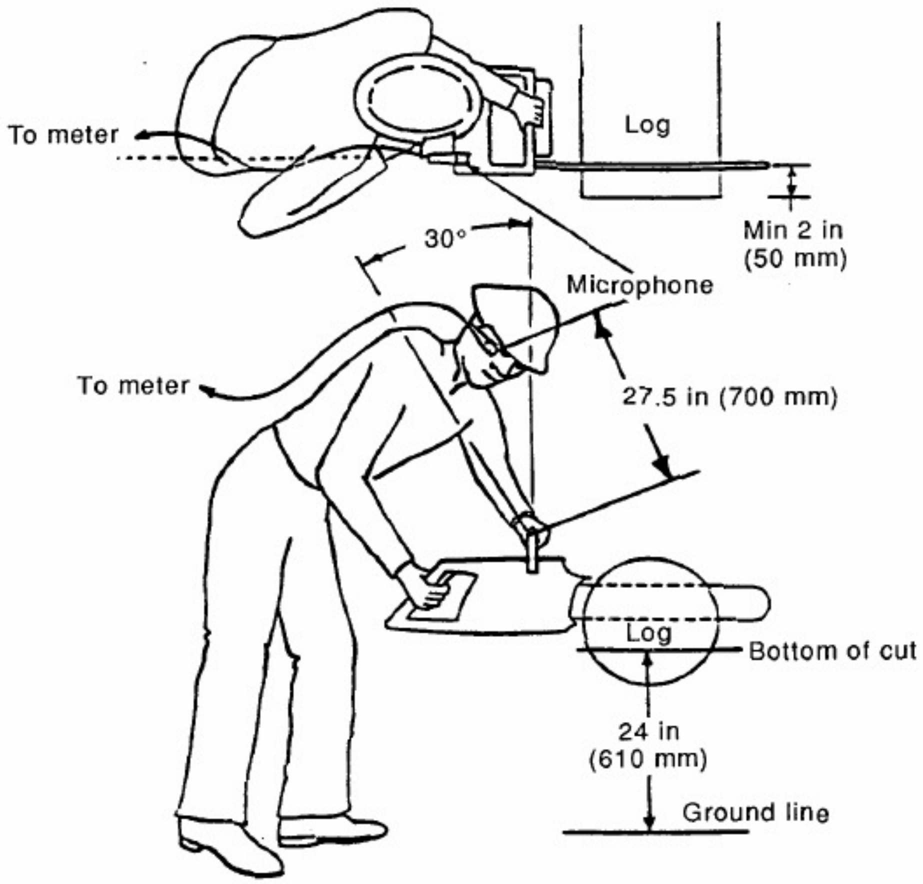


Figure 9 – Chain saw operation

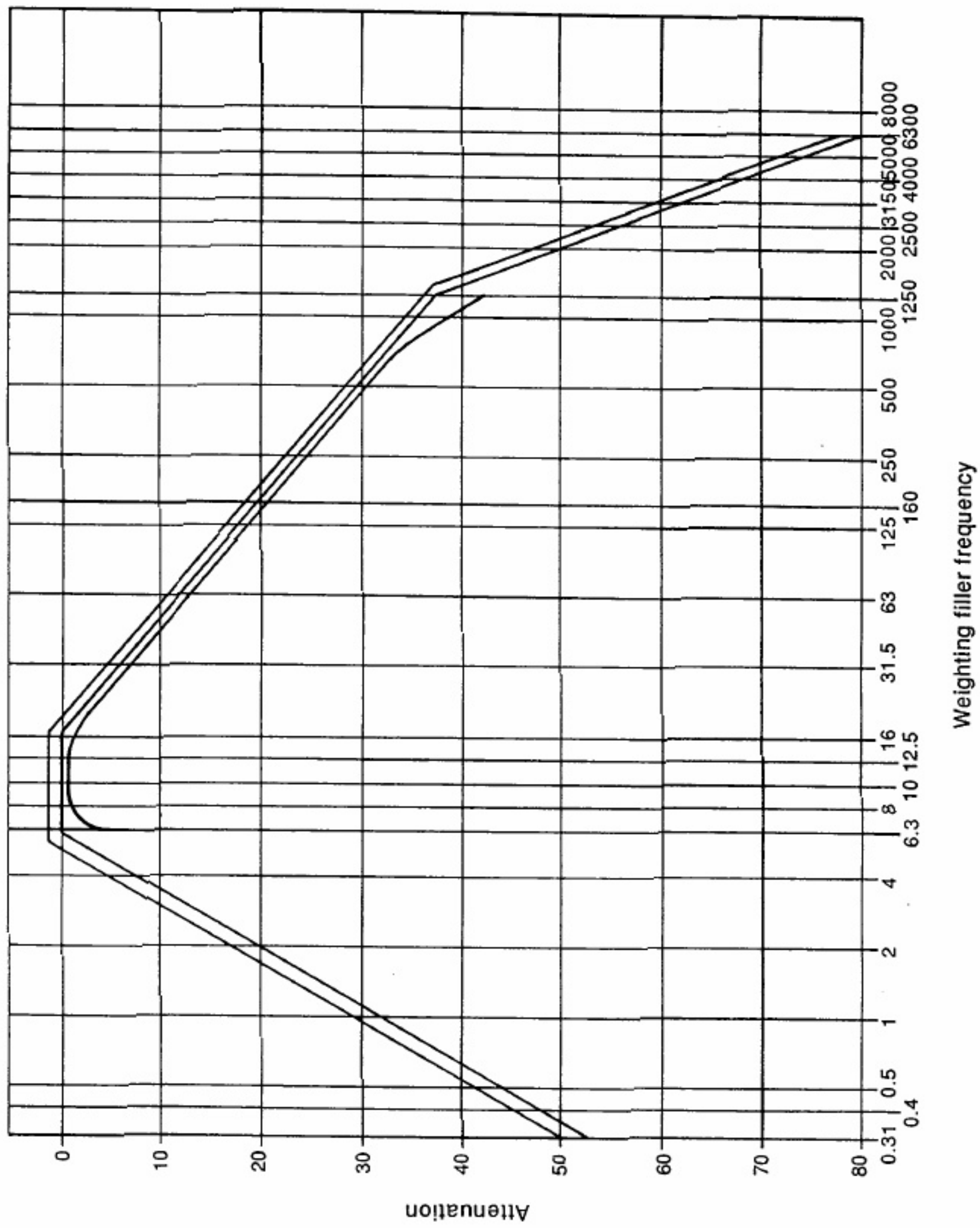
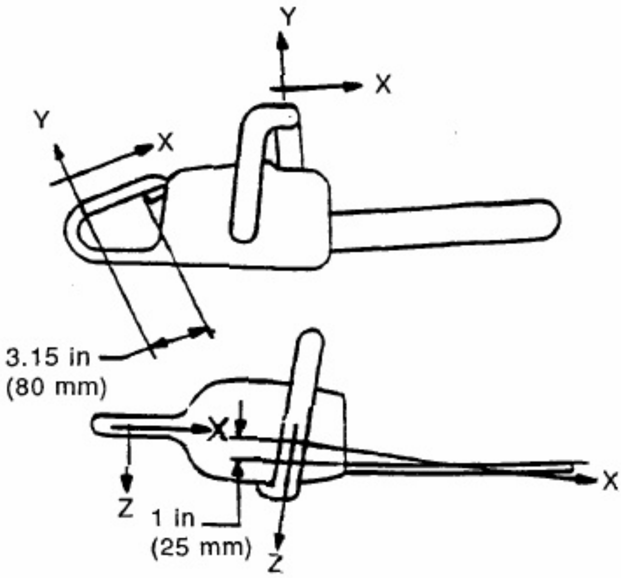
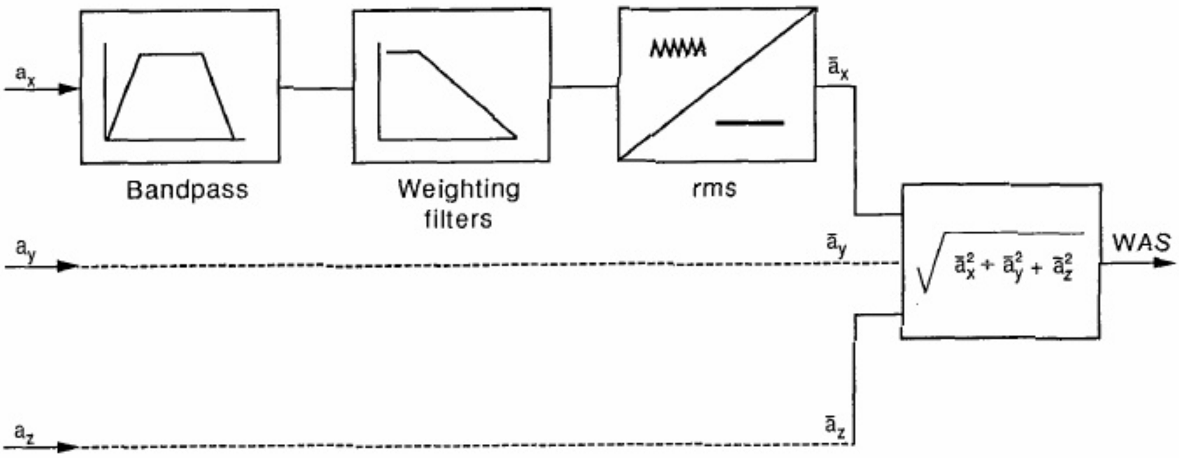


Figure 10 – Weighting filter frequency attenuation curve

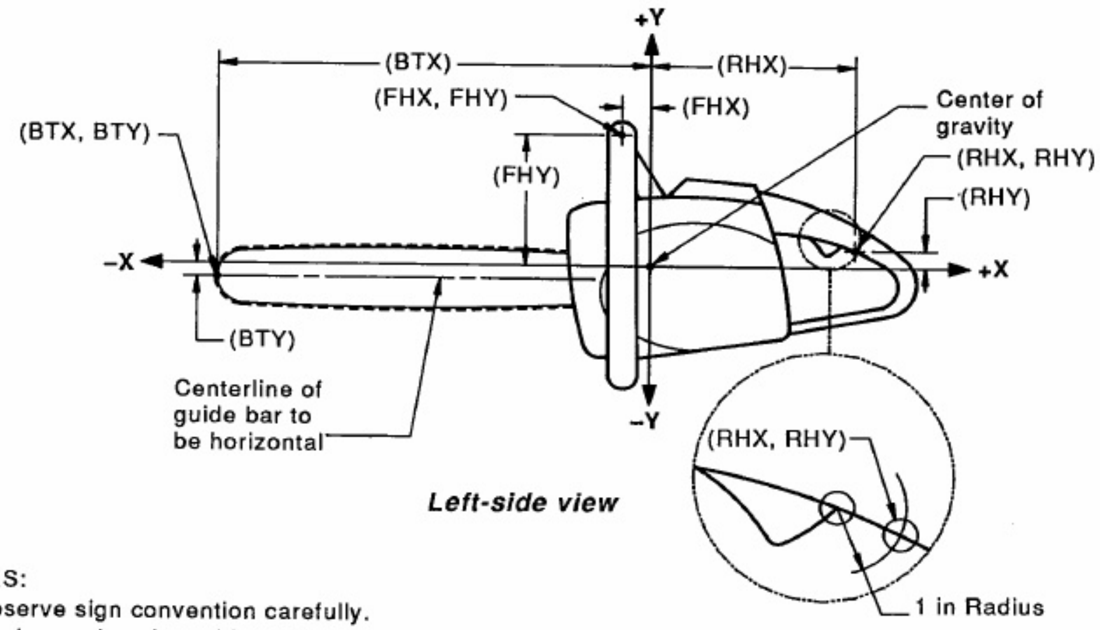


(a) Accelerator mounting locations



(b) Weighted acceleration sum (WAS)

Figure 11 – Accelerometer mounting locations and weighted acceleration sum (WAS)



NOTES:

1 Observe sign convention carefully.

2 Chain saw bar tip and handle locations shall be measured from the center of gravity.

Key:

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

(FHX, FHY) are the front handle coordinates, measured to the center of the front handle bar. NOTE – if the handle is angled in any plane or direction, use the midpoint of the grip area.

(RHX, RHY) are the rear handle coordinates, measured 1.0 inch behind the rear edge of the throttle trigger on the underside of the handle surface.

Figure 12 – Chain saw handle and bar tip coordinates

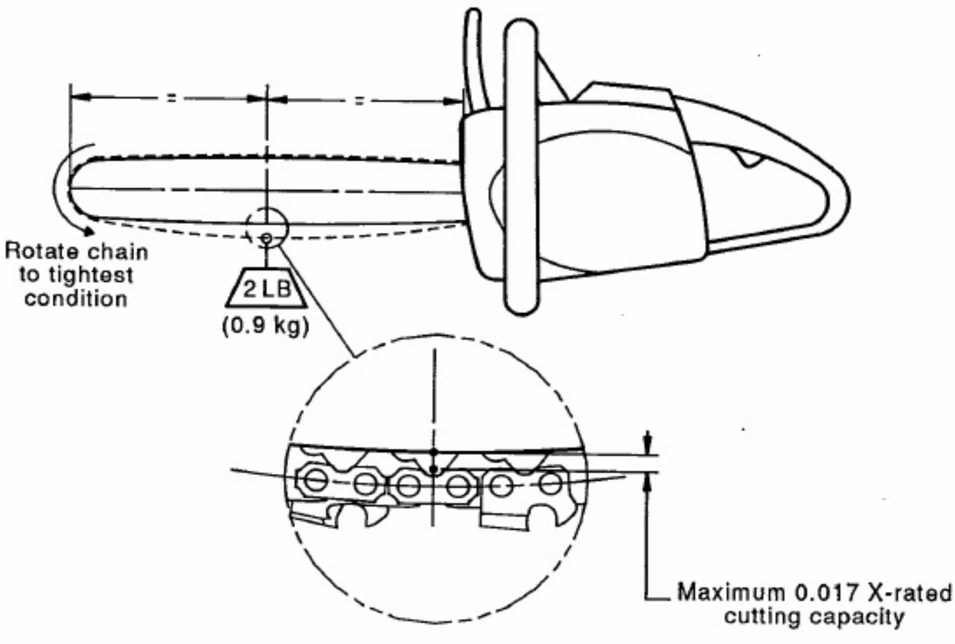


Figure 13 – Saw chain tension adjustment

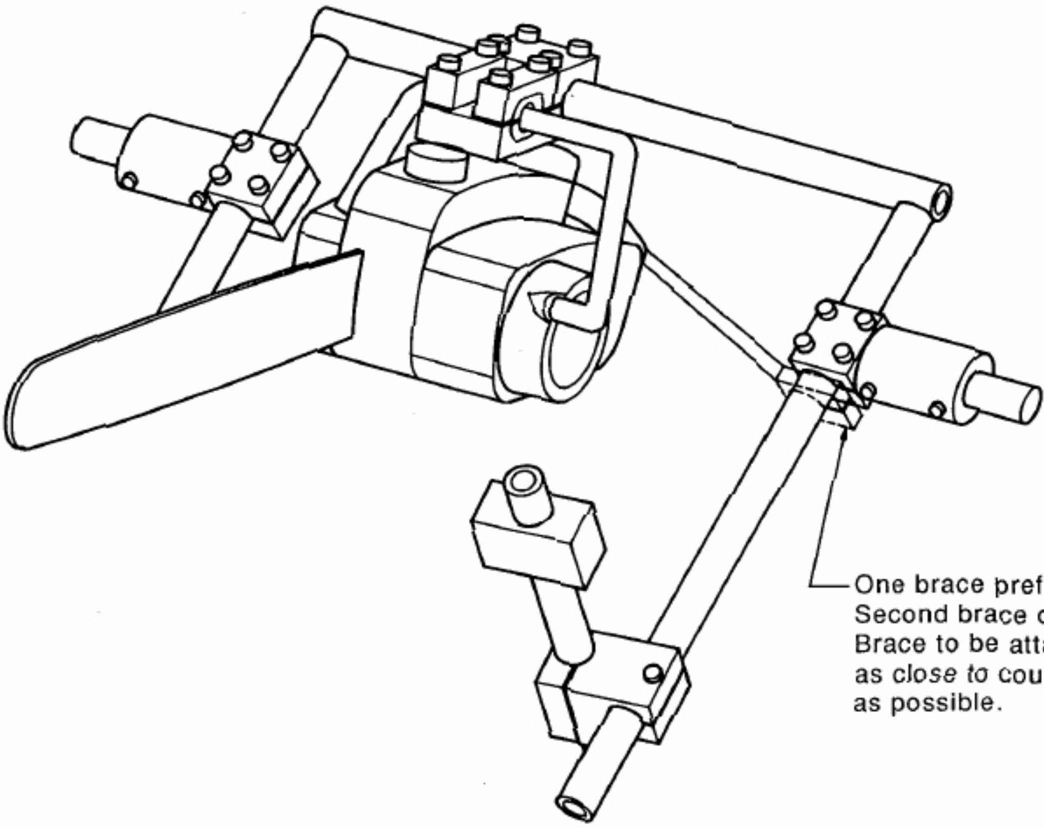
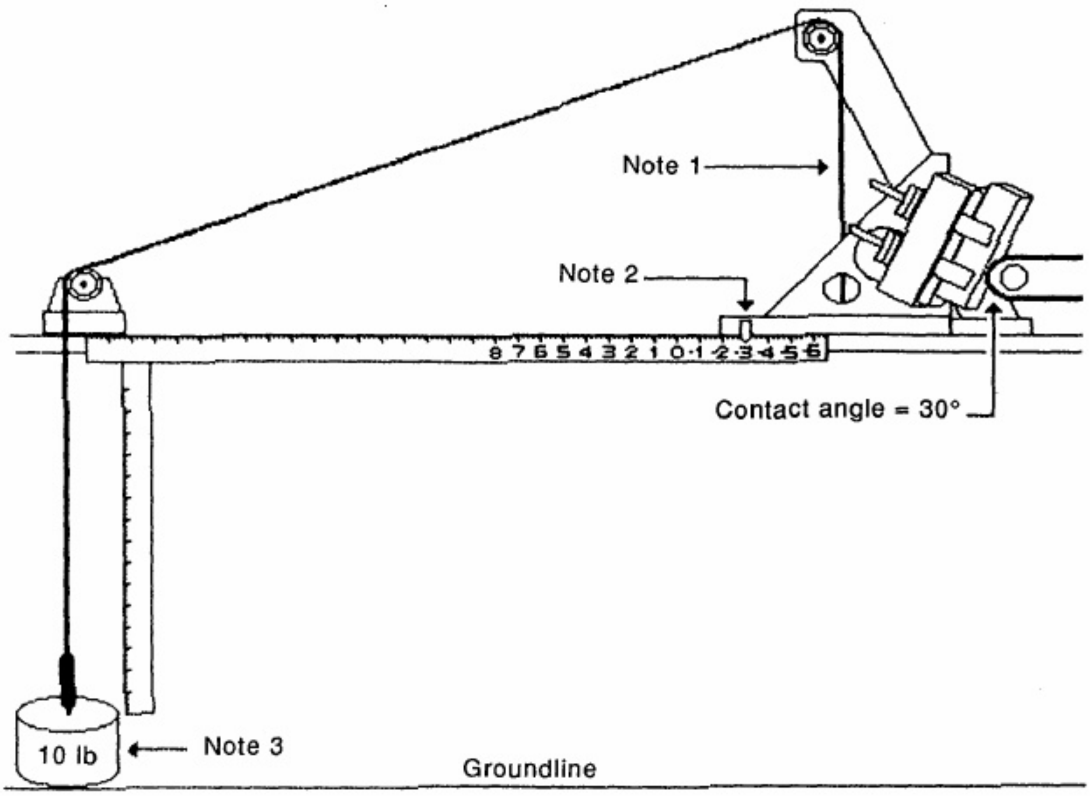


Figure 14 – Installation of saw and cradle assembly in kickback machine



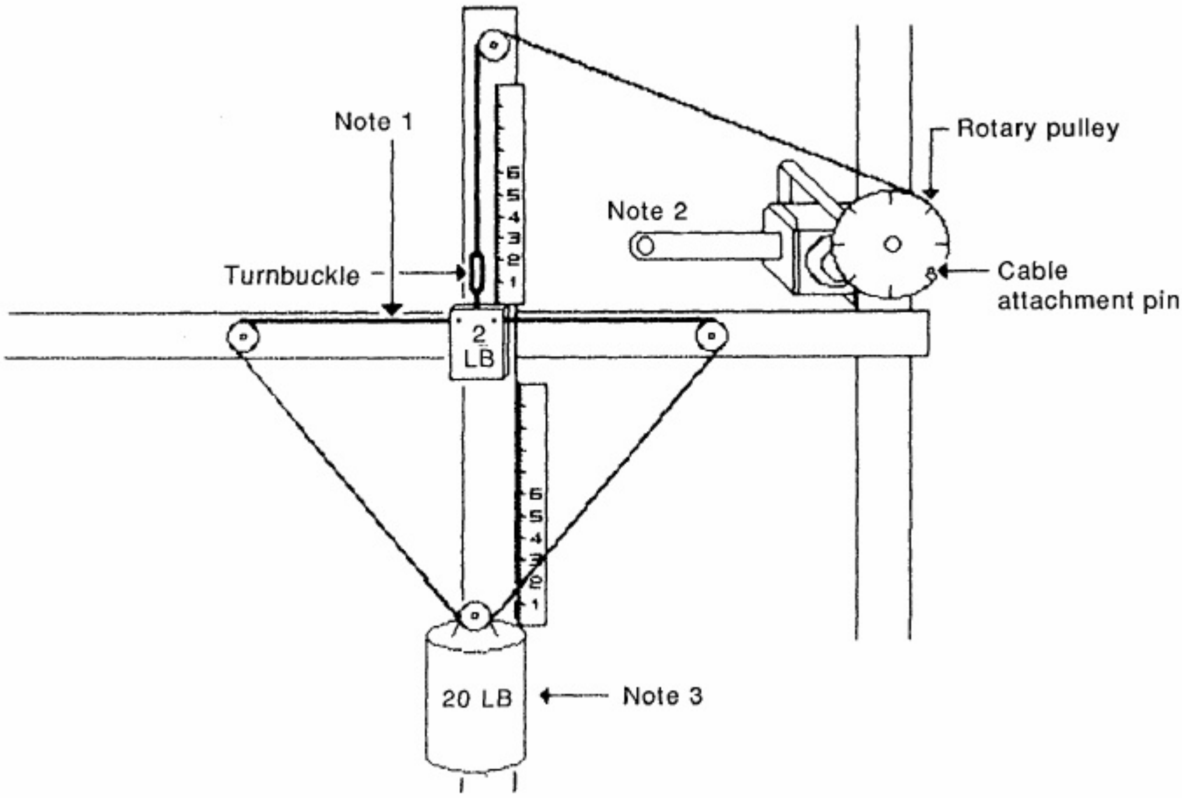
NOTES

1 This section of cable is vertical.

2 The wood carriage is 2 to 4 inches to the right of the point at which the weight will lift.

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

Figure 15 – Location of rack/horizontal restraining system assembly



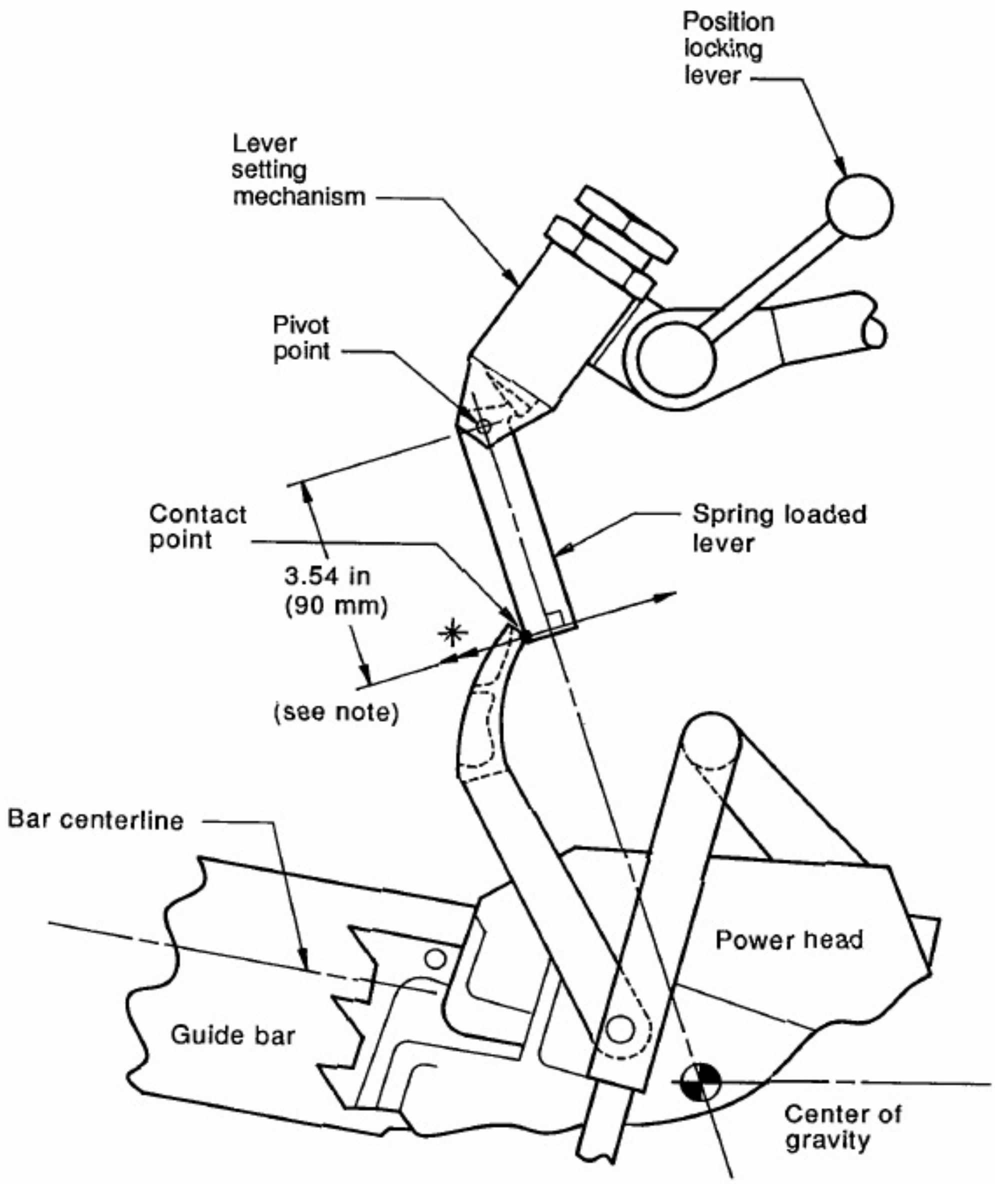
NOTES

1 Adjust location of cable attachment pin in rotary pulley and adjust turnbuckle so that this section of cable is horizontal. (This is the "0" position of the 2-lb weight.

2 Guide bar centerline is horizontal.

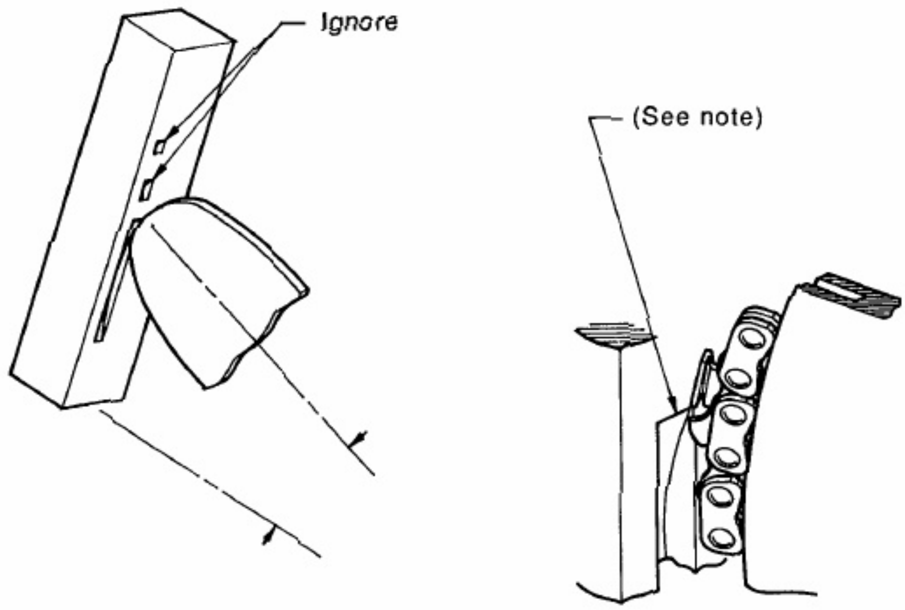
3 A larger weight may be used only if necessary.

Figure 16 – Adjustment of cable of rotary restraining assembly



NOTE – Measure brake release force in this direction.

Figure 17 – Chain brake actuation diagram



NOTE – Measure angle with chain in contact at highest point in *cut* area. Ignore any following tracks where cutters may have hit.

Figure 18 – Baraboard® exit angle measurement

Annex A
(informative)

Rationale

This annex gives the rationale behind the various requirements of this voluntary safety standard. The clause and subclause numbers used in this annex correspond to those used in the body of the standard.

3.15 guide bar effective length: This subclause provides a definition of bar cutting capacity that may be used when sizing bars for conducting certain tests, such as the test for chain saw operation in 6.4.

3.23 on/off or stop control: The words, "or stop," were added to the term being defined so as to incorporate the changes in 5.4.1.

5.14 Throttle control linkage

The revision of the first paragraph is needed in order to clarify means of evaluating the suitability of throttle control linkage. When using the current terminology, it is difficult to apply the requirement regarding the two parallel planes to various handle configurations.

The changes to the second paragraph ensure that the intent of the phrase, "to prevent chain movement," is met.

5.2.1 Handle strength

In order to properly evaluate handle strength of a saw, the length of the handle grip area needs to be defined. This revision will provide a uniform means for evaluation. Test loads and displacements in figure 1 were updated to conform to international standards.

5.2.3.2 Handle clearance

This subclause was added with the 1983 revision. It should be noted that some chain saws provide for a front hand guard that is hinged so as to fold backwards towards the top handle. Such hand guards, if impacted from the front, could provide a pinch area for an operator's hand between the hand guard and the handle if the front of the saw did not extend out to meet the Dimension B of figure 2. The rewording of this subclause was intended to provide a means to evaluate this construction.

5.4.1 On/off or stop controls

This subclause was revised to accept only the word "stop" as the saw marking to indicate the off or stop position for this control. This is more universally recognized and is consistent with International Standard proposals. The definition in 3.23 is amended to agree with these changes.

This revision is also being made to recognize development of new technology for on, off, or stop controls that can be used for chain saws. For example, an additional function may be provided that stops the engine completely and then permits restart without deliberate activation of the control by the operator but only after a delay sufficient to ensure that the engine has come to a complete stop.

5.6.3 Spark-arresting mufflers

Spark-arresting mufflers are already mandatory in many states and on Federal Government land. The revision indicates that the mufflers shall comply with SAE J335-SEPT90. This requirement allowed the B175 Committee to delete the original Appendix C, which dealt with the spark arrester test procedure.

5.8.2 Bow guides

The terms "guard(s) and/or spur(s)" has been pluralized to make it consistent with changes in 5.9.3.

5.9.2 Sprocket and clutch guards

Where a wraparound front handle is provided on saws, more definitive requirements are needed to define the extent of guarding that has to be provided along the length of the sprocket and clutch guard. This is intended to clarify these requirements.

5.9.3 Bow guide guard(s) and spike(s)

This subclause and the changes to figure 4 provide additional requirements. The B175 committee recognizes that the function of the lower guard in figure 4 may be accomplished by the design of gear drive chain saws.

5.9.4 Front hand guard

The chain brake provisions were separated from the hand guard provisions for clarity (see 5.9.4 and 5.9.5). The temperature changes in 5.9.4.2 are for the purpose of harmonizing the standard with ISO 6534.

5.9.5 Chain brakes

The primary purpose of this subclause is to evaluate the function of a chain brake system. The revisions of requirements for front hand guards and chain brakes are to provide a consistency with ISO requirements. The changes are based on ISO 6535, *International Standard for Forest machinery – Portable chain saw – Chain brake – Performance*.

The centerline of the guide bar is a better reference for measuring the dimensions because the bar determines the position of the saw during its operation.

An average stopping time of 0.12 seconds is the international standard. This value is a more stringent requirement due to the changed higher test speed.

A test procedure and limits on static release force have been added, which are consistent with the requirements of ISO 6535.

5.9.6 Rear handle

This subclause provides the clarification that was needed to define the extent of hand guard needed. The proposed dimensional requirement is similar to that of the Canadian Standards Association, CSA 62.1-1990.

5.10 Chip discharge

It is felt that this revision will provide better definition of the requirement pertaining to the flow of wood chips.

5.12 Chain saw kickback

The word, "Requirements," was deleted from the heading of this subclause to provide consistency with the rest of the standard. The word is not needed as the entire standard pertains to requirements.

5.12.1 Scope

In the 1985 edition of this American National Standard, the scope contained a paragraph that read as follows:

> The B175 Committee will undertake a good-faith effort to propose amendments to the standard by December 31, 1986, to address the potential risks of injury associated with "pinch" (linear) and rotational kickback, non-kickback moving-chain injuries, and other hazard patterns.

This paragraph has been deleted because the Committee has made the good-faith effort described.

5.12.2.5 Replacement guide bars

Relative guide bar kickback energy expressed in this subclause is based upon analysis and evaluation of current technology.

5.14 Vibration

This paragraph was amended to conform with ISO 7505. The Committee recognizes that this subject is complex and requires further analysis.

6.3 Test site

6.3.1 Measurement of noise in free field

This subclause is identical to 6.3 in the 1985 edition of this standard. The change to 6.3.1 was necessary to allow the addition of an alternate method in 6.3.2.

6.3.2 Measurement of noise in sound room

This subclause describes the alternate method of noise measurement. The addition of an alternate method of testing in an anechoic or semi-anechoic chamber allows the manufacturer the option to conduct the test indoors, in case of bad weather.

6.4 Chain saw operation

The 1985 edition of this standard referenced a CSMA Recommended Practice for cutting position. This document is no longer available. The same information is now shown in figure 9 of this standard.

Because bar capacity was also referenced to CSMA Recommended Practices, it is also deleted.

The log diameter is established as 75% of the guide bar effective length. This is the same way it is defined for vibration testing in this standard.

6.5 Measurements

All references to figure 9 (figure 8 in the 1985 edition) were removed because the figure does not depict microphone position for bystander noise measurement.

The location of the microphone was modified to conform with ISO 7182.

7.4.2 Results

A reduction in the number of tests from 10 cuts in each of five days to the present 5 cuts in a single day was made in response to findings that redundant testing was found to yield no improvement in accuracy of the test data.

8.6.2 Kickback energy determination

Chainsaw speeds were expanded because some chain saws will not operate properly at the lower RPM without load.

Annex B
(informative)

Chain saw nomenclature

The commonly used nomenclature for chain saw parts is illustrated in figure B.1. (*Note* that the position of the parts shown may vary on different models of chain saws.)

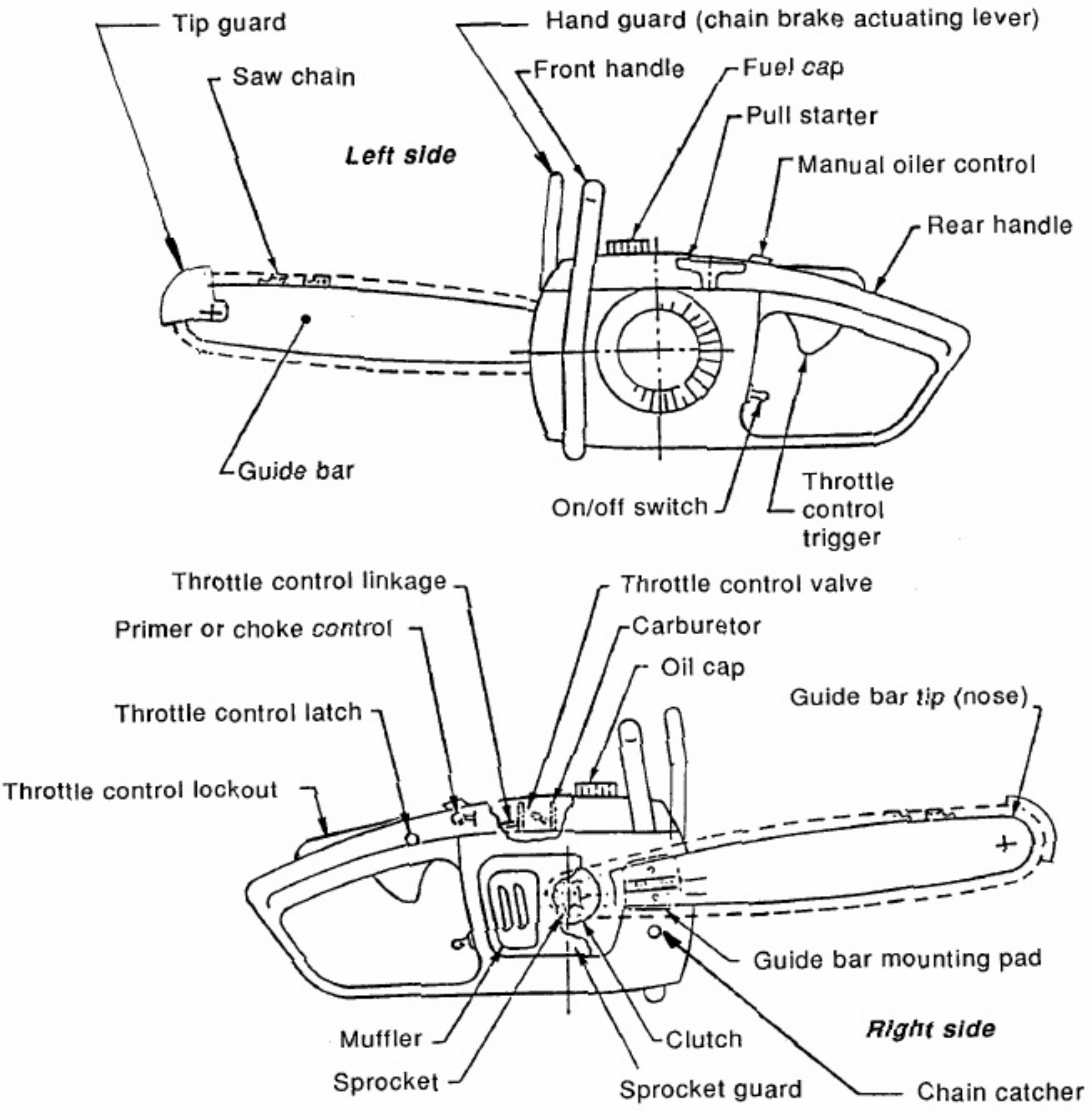


Figure B.1 – Chain saw diagram with nomenclature

Annex C
(informative)

Safety precautions for chain saw users

C.1 Kickback safety precautions

WARNING!: Kickback may occur when the nose or tip of the guide bar touches an object, or when the wood closes in and pinches the saw chain in the cut. Tip contact in some cases may cause a lightning-fast reverse reaction, kicking the guide bar up and back toward the operator. Pinching the saw chain along the top of the guide bar may push the guide bar rapidly back toward the operator. Either of these reactions may cause you to lose control of the saw, which could result in serious personal injury. Do not rely exclusively upon the safety devices built into your saw. As a chain saw user, you should take several steps to keep your cutting jobs free from accident or injury.

a) With a basic understanding of kickback, you can reduce or eliminate the element of surprise. Sudden surprise contributes to accidents;

b) Keep a good firm grip on the saw with both hands, the right hand on the rear handle and the left hand on the front handle, when the engine is running. Use a firm grip with thumbs and fingers encircling the chain saw handles. A firm grip will help you reduce kickback and maintain control of the saw. Don't let go;

c) Make sure that the area in which you are cutting is free from obstructions. Do not let the nose of the guide bar contact a log, branch, or any other obstruction that could be hit while you are operating the saw;

d) Cut at high engine speeds;

e) Do not overreach or cut above shoulder height;

f) Follow the manufacturer's sharpening and maintenance instructions for the saw chain;

g) Only use replacement bars and chains specified by the manufacturer or the equivalent.

C.2 Other safety precautions

– Do *not* operate a chain saw with one hand! Serious injury to the operator, helpers, bystanders, or any combination of these persons may result from one-handed operation. A chain saw is intended for two-handed use.

– Do not operate a chain saw when you are fatigued;

– Use safety footwear; snug-fitting clothing; protective gloves; and eye, hearing, and head protection devices;

– Use caution when handling fuel. Move the chain saw at least 10 feet (3 m) from the fueling point before starting the engine;

– Do not allow other persons to be near the chain saw when starting or cutting with the chain saw. Keep bystanders and animals out of the work area;

– Do not start cutting until you have a clear work area, secure footing, and a planned retreat path from the falling tree;

– Keep all parts of your body away from the saw chain when the engine is running;

– Before you start the engine, make sure that the saw chain is not contacting anything;

– Carry the chain saw with the engine stopped, the guide bar and saw chain to the rear, and the muffler away from your body;

– Do not operate a chain saw that is damaged, improperly adjusted, or not completely and securely assembled. Be sure that the saw chain stops moving when the throttle control trigger is released;

– Shut off the engine before setting the chain saw down;

– Use extreme caution when cutting small-size brush and saplings because slender material may catch the saw chain and be whipped toward you or pull you off balance;

– When cutting a limb that is under tension, be alert for springback so that you will not be struck when the tension in the wood fibers is released;

– Keep the handles dry, clean, and free of oil or fuel mixture;

– Operate the chain saw only in well-ventilated areas;

– Do not operate a chain saw in a tree unless you have been specifically trained to do so;

– All chain saw service, other than the items listed in the owner's manual maintenance instructions, should be performed by competent chain saw service personnel. (For example, if improper tools are used to remove the flywheel or if an improper tool is used to hold the flywheel in order to remove the clutch, structural damage to the flywheel could occur and subsequently could cause the flywheel to burst.);

– When transporting your chain saw, use the appropriate guide-bar scabbard.

NOTE – This annex is intended primarily for the consumer or occasional user.

Annex D
(informative)

Chain saw center of gravity and inertia measurements

D.1 Introduction

The center of gravity of the chain saw and the inertia of the chain saw about an axis passing through its center 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 are examples only. Other technically adequate methods of making these measurements are acceptable.

D.2 Inertia measurement method A: Three-wire platform

D.2.1 Center of gravity

To determine the center of gravity, suspend the chain saw by the front handle and, dropping a plumb line from the point of suspension, mark a vertical line on the saw. Suspend the saw by the center of the rear handle and similarly mark a second line on the saw. The intersection of the two marked lines locates the center of gravity.

D.2.2 Taking measurements

Place the saw on the disc, drawing number EX4485C,[6] with the center of gravity aligned with the disc center as illustrated in figure D.1. The saw must be adjusted so that the guide bar is parallel and level to the platform. Rotate the platform through a 10° arc. Measure three time intervals of 20 cycles each. Compute average seconds per cycle for the 60-cycle sample.

D.2.3 Inertia computation

$$I_{\text{chain saw}} = K(W_1 + W_2)T^2 - I_t$$

where

$I_{\text{chain saw}}$ is the inertia of the chain saw (in-lb-sec^2)

I_t is the tare moment of inertia of the empty assembly (in-lb-sec^2). Refer to calibration procedure E.4;

W_1 is the weight of chain saw (lb);

W_2 is the weight of platform (lb);

T is the period of oscillation (sec/cycle);

K is the calibration constant.

D.3 Inertia measurement method B: Single-wire platform

D.3.1 Center of gravity

Place the saw in the single-wire facility as shown in figure D.2. The saw must be adjusted so that the guide is parallel to the platform. Rigid foam support blocks may be required under the guide bar to maintain the bar in a position parallel to the platform. Move the saw on two axes until the platform is leveled. When the saw is positioned so that the platform is level in all directions, locate the center of gravity of the saw by marking the saw through a centered hole located in the bottom of the platform.

D.3.2 Taking measurements

Rotate the platform through a large angle (90°–180°) from the equilibrium position and release. Allow the assembly to rotate through six complete cycles. Measure the time interval to the nearest 0.1 second and compute the period of oscillation T(sec/cycle). Repeat the six-cycle measurement and compute the average of the two periods. Measure the length of the single support wire, L, in inches.

D.3.3 Inertia computation

$$I_{\text{chain saw}} = \left(\frac{KT^2}{L}\right) - I_t,$$

where L is the length of the support wire (in) and $I_{\text{chain saw}}$, I_t, T, and K are defined as in Method A (D.2.3).

D.4 Calibration of inertia platforms

To calibrate the inertia platform, place two calibration blocks equidistant from the center of the platform. Measure the period of oscillation, T, as described in D.3.2. Measure the distance, D, from the center of the platform to the center of gravity (CG) of the blocks. See figure D.3.

Repeat the above measurements for at least six different distances, D, with the blocks in positions ranging from near the center of the platform to near the outer edges of the platform. Repeat the period measurements without the blocks, that is, with the platform empty. Measure the weights of the blocks. Also, for the three-wire platform, measure the weight of the platform. For the single-wire platform, measure the length of the support wire with and without the blocks.

The two calibration blocks must be of the same size, weight, and shape. The blocks should be of a heavy material such as steel. The size and shape of the blocks should be selected so that, as nearly as possible, when the blocks are placed at various distances, the inertias of the blocks about a vertical axis through the center of the platform cover about the same range as the inertias of the chain saw to be measured.

When the calibration blocks are placed equidistant from the center of the platform as described above, the inertia equations can be written

$$\left(\frac{2W_bD^2}{g}\right) = KwT^2 - (I_t + 2I_b)$$

three-wire platform,

$$\left(\frac{2W_bD^2}{g}\right) = \left(\frac{KT^2}{L}\right) - (I_t + 2I_b)$$

single-wire platform,

where

T is the period of oscillation (sec/cycle);

W_b is the weight of each calibration block;

I_b is the moment of inertia of the calibration block about its centroidal axis;

I_t is the tare moment of inertia of the empty assembly;

D is the distance from the center of the platform to the CG of the calibration block;

L is the length of the support wire for the single-wire facility;

w is the weight of the platform plus the weights of the two blocks;

g is the acceleration due to gravity.

These equations are in the form of the straightline equation

$y = mx + b$,

where

$y = 2W_bD^2$

and

x is the wT^2 for the three-wire platform;

x is the T^2/L for the single-wire platform.

The calibration measurements described in this subclause are taken, and, for each placement of the blocks, the values of x and y are calculated. A least squares fit (linear regression) of this data will provide the slope, m, of the line. This is the value of the calibration constant K. Using this value of K and the period, T_0, measured with the empty platform, calculate the tare inertia of the facility, I_t

$I_t = KW_2T_0^2$ for the three-wire platform,

$$I_t = \frac{KT_0^2}{L_0}$$ for the single-wire platform,

where

W_2 is the weight of the three-wire platform;

L_0 is the length of the support wire for the single-wire platform when empty;

T_0 is the period of oscillation with platform empty (sec/cycle).

An example of the calibration of the single-wire facility for measuring inertia follows.

Weight

Block 1	6.667 lb
Block 2	6.666 lb

Dimensions (inches)

Block 1	1.990 × 2.953 × 3.998
Block 2	1.988 × 2.952 × 3.997

Torsion Wire Length (L) with block 47-1/8 inches

Torsion Wire Length (L) without blocks 47-1/16 inches

Approximate d (inches)	Measured d (inches)	$T1$ (sec) (6 cycles)	$T2$ (sec) (6 cycles)	T (sec) $(T1 + T2)/12$
2	1.989	98.1	98.0	16.342
3	2.964	100.9	101.4	16.858
4	3.989	105.2	105.2	17.533
5	5.021	110.5	110.7	18.433
6	5.977	116.0	116.2	19.350
7	6.975	123.0	123.2	20.517
8	7.981	130.3	130.3	21.717
9	8.99	138.3	138.2	23.042
10	9.99	146.2	146.0	24.350
No Blocks		93.0	93.0	15.500

NOTE – $d = 2D$ = distance between the centers of gravity of the two blocks. $D = d/2$ = distance from the center of gravity of each block to the center of the platform.

Using the measured data, the values of x and y are calculated.

$d = 2D$	x (T^2/L)	y $(2W_bD^2/g)$ or $(W_bd^2/2g)$
1.989	5.668	0.03412
2.964	6.031	0.07578
3.989	6.524	0.13725
5.021	7.211	0.21746
5.977	7.946	0.30815
6.975	8.934	0.41965
7.981	10.009	0.54943
8.99	11.268	0.69714
9.99	12.583	0.86085

$$y = Kx + b$$

A least squares linear fit of this data gives a slope

$K = 0.1191$ in^2-lb (See figure E.4).

The inertia equation becomes

$$I = \left(\frac{0.1191\ T^2}{L}\right) - I_t$$

Using the data measured without the blocks (empty platform)

$$0 = \left(0.1191\ \frac{(15.50^2)^2}{47.06}\right) - I_t$$

$I_t = 0.6080$ in-lb-sec^2.

The final equation for this facility becomes

$$I_{chain\ saw} = \left(\frac{0.1191\ T^2}{L}\right) - 0.6080$$

where

T is in seconds;

L is in inches;

$I_{chain\ saw}$ is in in-lb-sec^2.

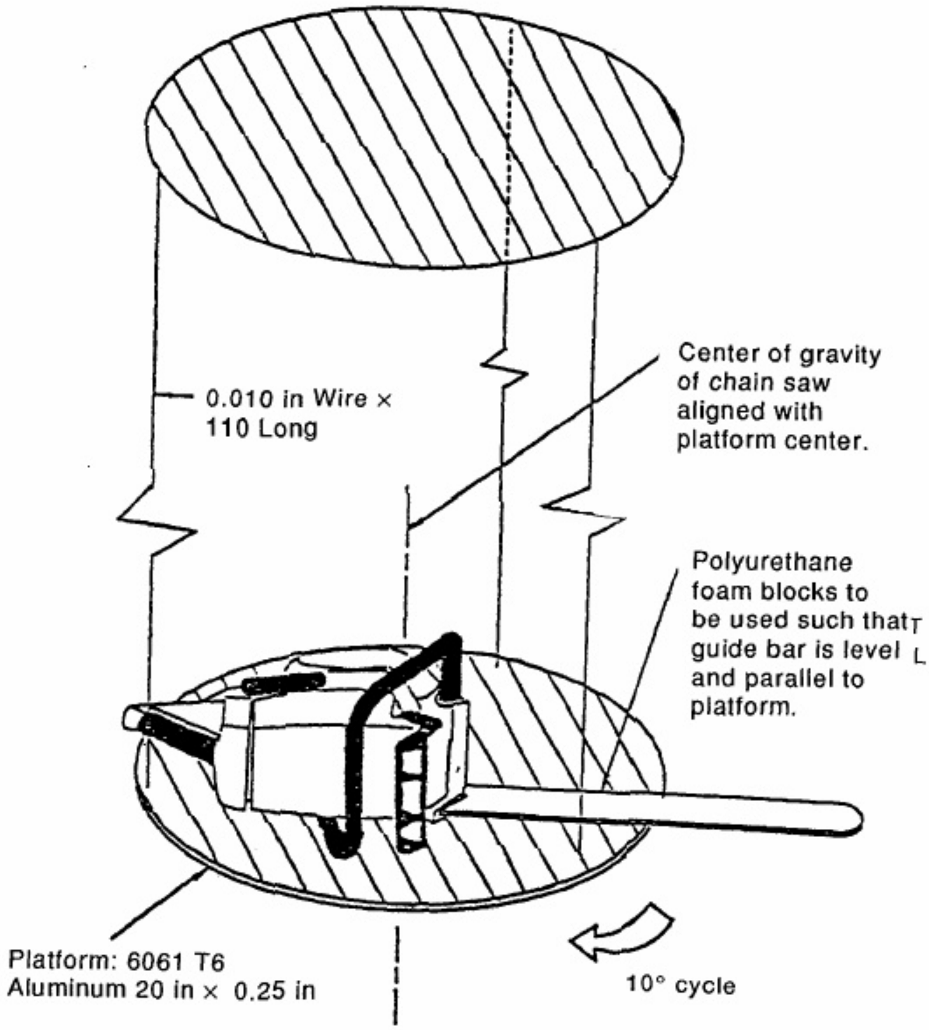


Figure D.1 – Three-wire facility for measuring inertia of the chain saw

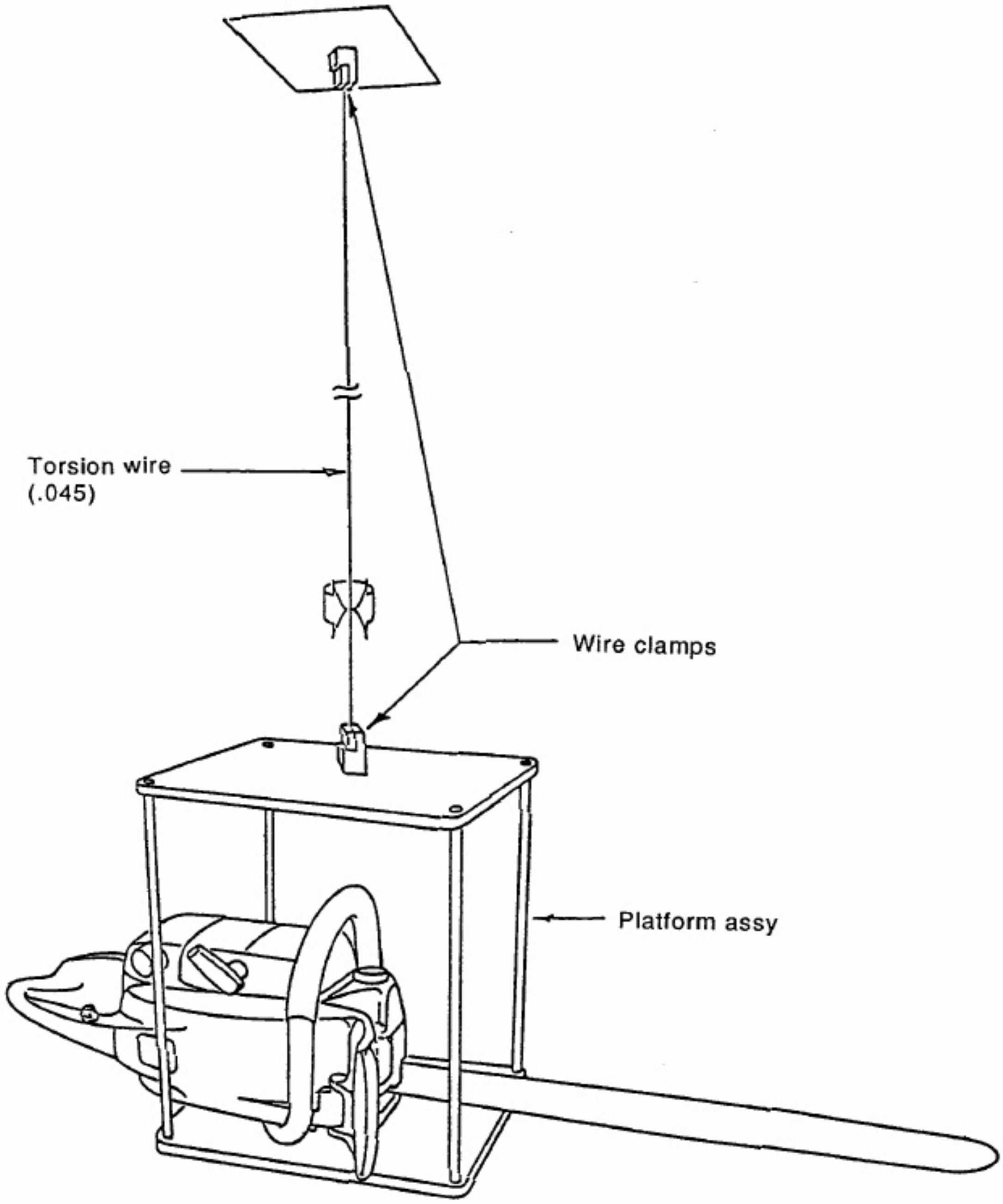


Figure D.2 – Single-wire facility for measuring inertia of the chain saw

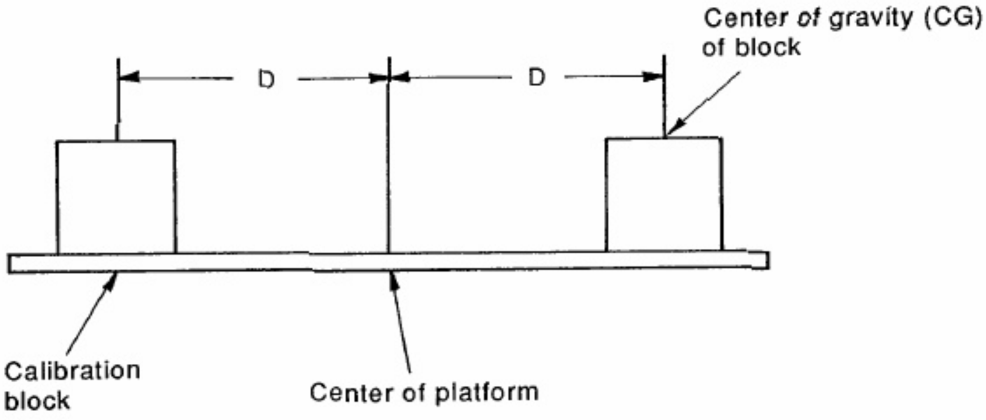


Figure D.3 – Calibration of inertia platform

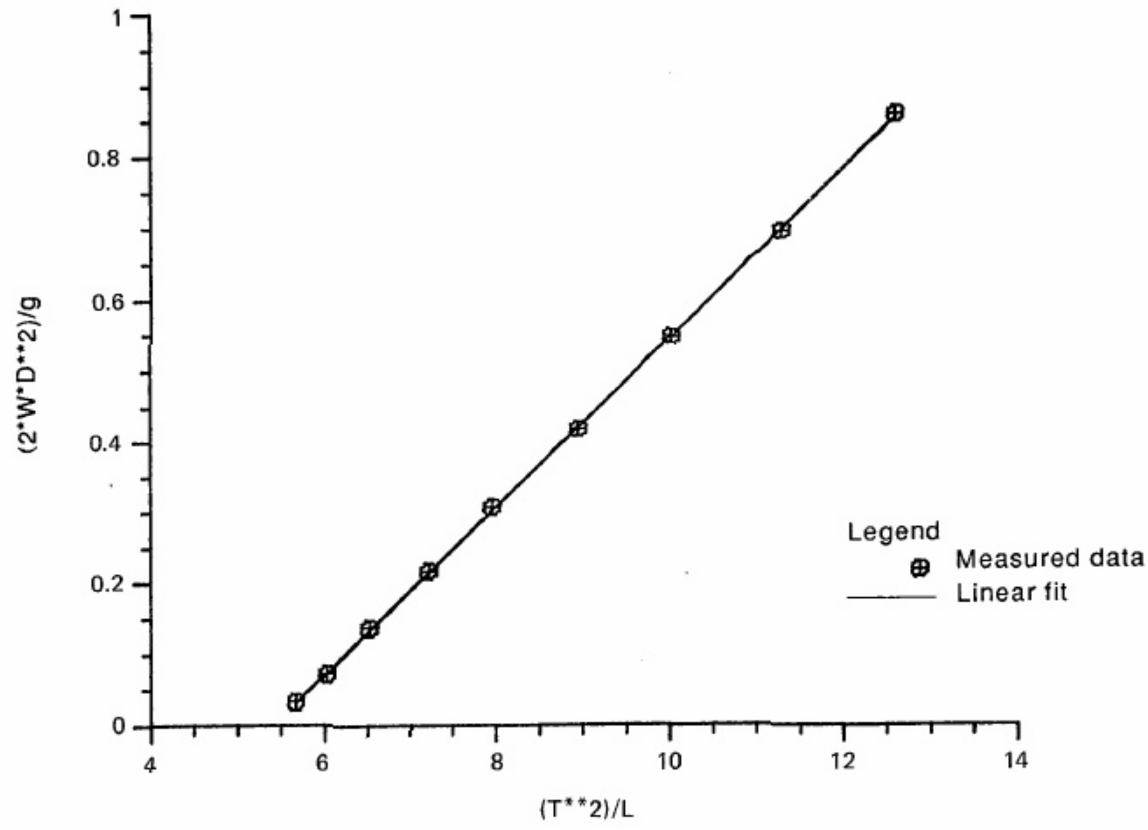


Figure D.4 – Calibration of single-wire device for measuring inertia of the chain saw

Annex E
(informative)

Kickback machine – Chain saw balancing procedure

The following is a suggested procedure for balancing of the chain saw in the kickback machine.

NOTE – The terms "horizontal" and "vertical" used in the following refer to the orientation of the cradle. The "vertical" position of the cradle should be with the legs of the cradle pointing up, and the "horizontal" position with the legs pointing forward.

a) Locate the bracket (EX 4743)[6] to achieve horizontal balance, being sure the bracket is oriented as shown in figure E.1. If horizontal balance cannot be achieved, then proceed to (b);

b) When additional mass is required to obtain balance, center the connection rod (EX 4742)[6] in the bracket and locate the bracket to achieve horizontal balance, maintaining the orientation as shown in figure E.2. Attempt to achieve vertical balance by sliding the connection rod through the bracket. If balance cannot be achieved both horizontally and vertically, go to (c);

c) When additional mass is required:

1) Add the aluminum countermass (EX 5011)[6] to the connection rod in the orientation shown in figure E.3;

2) Move the bracket to achieve horizontal balance;

3) Locate the aluminum countermass along the connection rod to achieve vertical balance.

4) If balance cannot be obtained, repeat (1) through (3) using the steel countermass (EX 4744).[6]

d) If any system cannot be balanced using this procedure, add suitable weights to achieve balance and document the added weight and its location on the data sheet. See figure J.2.

NOTE – When system balance is achieved, configuration may be recorded on Form J.2 in annex J. Documentation should include the location of the rear handle brace(s) on the cradle and notation of which countermass (aluminum or steel) was used.

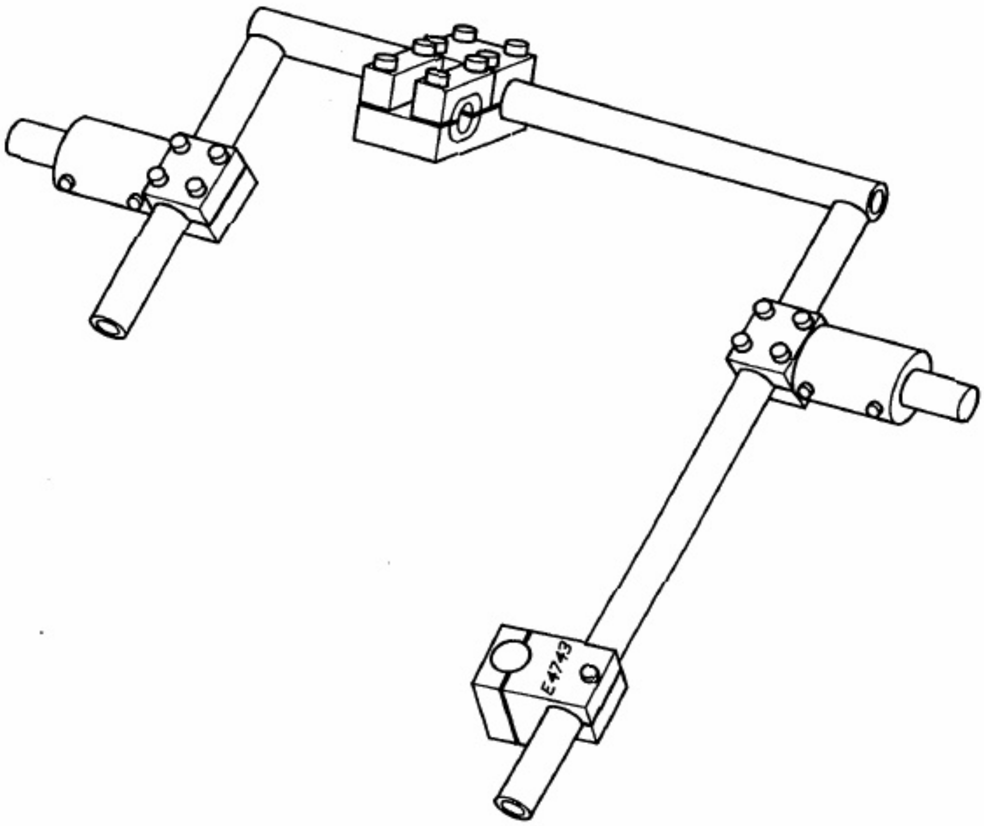


Figure E.1 – Balancing procedure – Addition of bracket

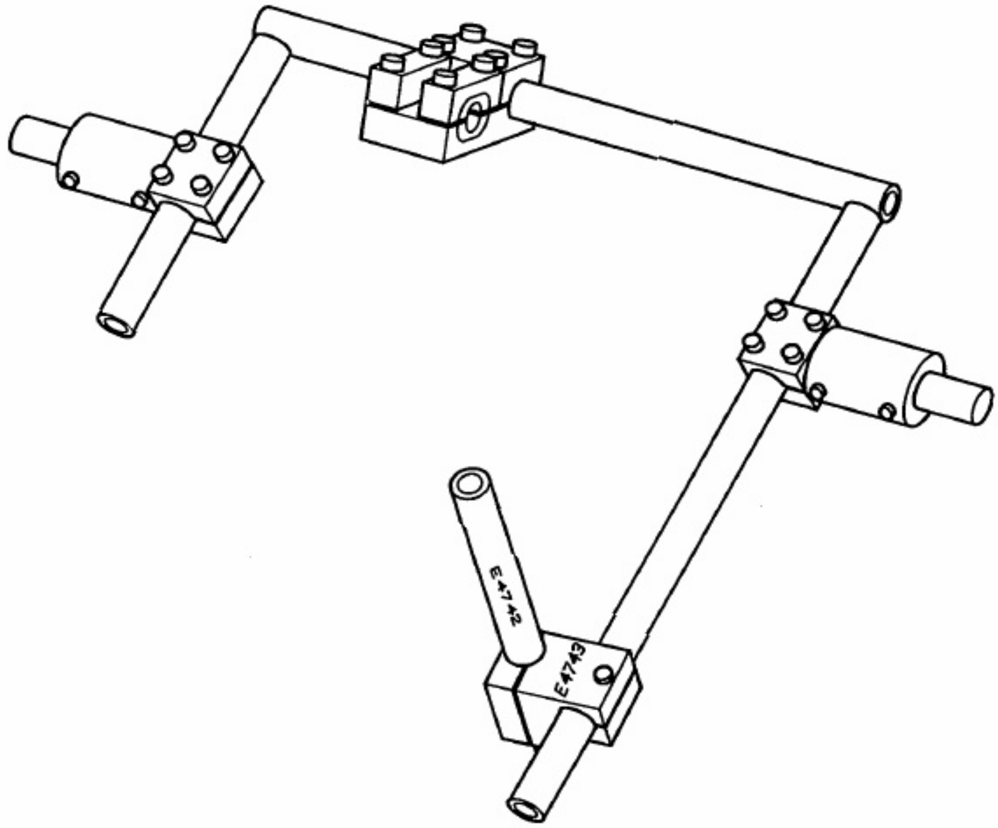


Figure E.2 – Balancing procedure – Addition of connection rod

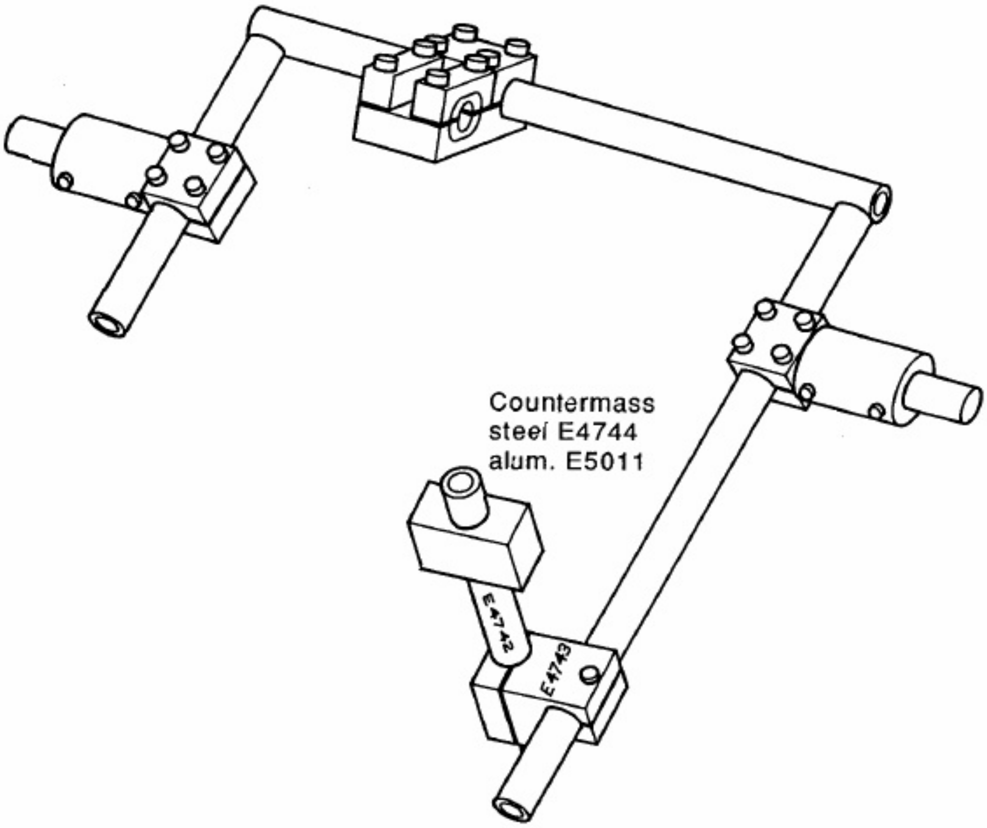


Figure E.3 – Balancing procedure – Addition of countermass

Annex F
(informative)

Kickback machine – Horizontal system

F.1 Introduction

Carriage weight is to be in accordance with Drawing EX 4201 (with Baraboard® specimen)[6]. Horizontal friction must be measured prior to and after kickback energy tests using procedures in this annex, or equivalent. Pulleys for restraining weights system must spin freely. Alignment of the carriage bearings may be accomplished in accordance with procedure F.2.

F.2 Carriage bearing alignment

The average of the horizontal friction measurements in the direction of travel away from the powerhead must not exceed 0.5 lb (0.23 kg).

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

b) Loosen the first bearing, then adjust the second;

c) When loose, each bearing should be tightened until it starts to grip the shaft. The tightening should be stopped just before an increase in the force required to move the bearing is felt;

d) The first bearing is then returned to its proper setting.

F.3 Horizontal friction test method A

F.3.1 Preparation

Attach weights to the carriage, with Baraboard® sample installed, to equal the weight of the chain saw.

F.3.2 Taking measurements

a) Connect the friction-measurement weight cup to the carriage;

b) Add sufficient weight to the cup assembly to cause the carriage to move at least 12 inches (with the ratchet in place). If friction exceeds 0.5 lb (0.23 kg), clean the bearings and adjust the machine as required to bring the friction level below 0.5 lb (0.23 kg).

F.3.3 Horizontal friction computation

Horizontal Axis Friction = $W_1 + W_2$,

where

W_1 is the weight of cup assembly (lb);

W_2 is the added weight (lb).

F.4 Horizontal friction test method B

a) Attach a 0.5-lb (0.23-kg) weight and cable assembly to the carriage;

b) If the weight causes the carriage to travel at least 12 in (30.5 cm), the friction level is within tolerance;

c) Adjust the horizontal system to reduce frictional level if necessary.

NOTE – Horizontal kickback energies are to be computed with a frictional level of 0.5 lb (0.23 kg).

Annex G
(informative)

Kickback machine – Rotary system (with saw in place)

G.1 Introduction

Rotary friction must be measured prior to and after kickback energy tests, using the procedures outlined below, or equivalent. Pulleys for restraining the weight system must spin freely. Alignment of the rotary bearings may be accomplished per procedure G.2.

G.2 Rotary bearing alignment

The average of the rotary friction measurement must not exceed 0.5 lb (0.23 kg), the rotary bearings should be checked for alignment and adjusted.

a) Remove the rotary machine parts and place a 1 inch × 44 inch (2.54 cm × 112 cm) alignment shaft through the rotary bearings;

b) Level the alignment shaft;

c) Adjust the pillow blocks and bearing plates so that the alignment passes easily through the bearings and rotates freely.

G.3 Rotary friction test method A

G.3.1 Preparation and measurement

a) Attach the friction-measurement weight cup (EX 5230)[6] to the rotary pulley with the cradle legs horizontal;

b) Add sufficient weight to the weight cup to cause a saw rotation of at least 180° with ratchet pawls in place;

c) If the rotary friction exceeds 0.5 lb (0.23 kg), clean and adjust the bearings to bring the friction level within tolerance.

G.3.2 Rotary friction computation

Rotary axis friction $= f_r = W_1 + W_2$,

where

W_1 is the weight of cup (lb);

W_2 is the weight added to cup (lb).

G.4 Rotary friction test method B

a) Attach a 0.5-lb (0.23-kg) weight and cable assembly to the rotary pulley, ratchet pawls in place.

b) If the 0.5-lb (0.23-kg) weight causes the saw cradle assembly to rotate from horizontal (0°) through at least 180°, the friction level is within tolerance.

c) In rotary kickback energy computations, use 0.5-lb (0.23-kg) rotary friction.

NOTE – In saws with soft isolator systems, the center of gravity shifts as the saw and cradle rotate. If shifting of the center of gravity of the saw prevents accurate friction measurements, a substituted saw of approximately the same weight may be used for friction measurements.

Annex H
(informative)

Velocity adjustment

H.1 Scope

This annex establishes a procedure for adjustment of the carriage velocity.

H.2 Preparation

a) Set the Baraboard® angle to 30°. Move the carriage so that the Baraboard® contacts the saw chain. Adjust the position of the rack/horizontal restraining assembly so that the cable section from the carriage to the pulleys is vertical. See Figure 15.

b) Measure and record the distance between the actuation points of the velocity probes. Be sure the probes are located in the free-travel range, that is, in the range before the restraining weight is lifted.

c) Reset the Baraboard® sample to the initial test condition.

H.3 Adjustments

Release the carriage to locate the release point for test conditions of 30 in/s ± 0.5 in/s (0.76 m/s ± 0.013 m/s).

Annex J
(informative)

Kickback fixture test record

The following test forms (figures J.1 and J.2) may be used to record the results of the kickback tests.

KICKBACK FIXTURE TEST RECORD

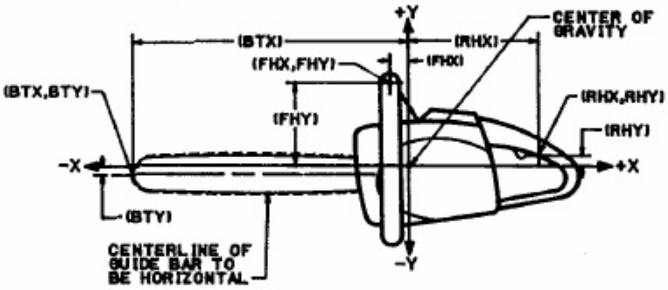
LABORATORY ____________
DATE ____________
TECHNICIAN ____________
TEST NUMBER ____________

TEST COMBINATION

SAW MODEL/MFG'R.		CHAIN TYPE/MFG'R.	D.L. COUNT
SERIAL NO.		CUTTER TYPE	
DISPLACEMENT		SEQUENCE	
SAW WEIGHT		CONDITION	D.G. SETTING
CARRIAGE WT.:	MATCHING WT.:	PITCH	GAUGE
INERTIA		GUIDE BAR	
ROTARY FRICTION		NOSE TYPE	GAUGE
HORIZONTAL FRICTION		BAR PART NO./MFG'R	
CLUTCH SLIP SPEED		DRIVE SPROCKET TYPE	TOOTH COUNT

CHAIN SAW HANDLE AND BAR TIP COORDINATES, LEFT SIDE VIEW

BTX		FHX		RHX	
BTY		FHY		RHY	



CHAIN BRAKE SUMMARY

RELEASE FORCE	LBS	R1:
LBS÷2.2 LBS	LBS	R2:
ANGLE OF ACTUATION A2	DEGREES	R3:
CHAIN STOPPING TIME T3	SEC	R4:

DATA SUMMARY

DATA SET NO.	CONTACT ANGLE (°)	RPM X 10³	AVG. HORIZONTAL ENERGY (IN-LB)	AVG. ROTARY ENERGY (IN-LB)	CKA (°)

PEAK AVG. ROTARY ENERGY ____________ IN-LBS

DATA SET NO.	CONTACT ANGLE (°)	RPM X 10³	AVG. HORIZONTAL ENERGY (IN-LB)	AVG. ROTARY ENERGY (IN-LB)	CKA (°)

AVG. ROTARY ENERGY AT PEAK CKA ____________ IN-LBS

COMPUTED KICKBACK ANGLE

CKA WITHOUT BRAKE

____________ DEGREES

ENERGY SPLITS

____________ HORIZONTAL ____________ VERTICAL ____________ ROTATIONAL

CKA WITH BRAKE

____________ DEGREES

CHAIN STOP ANGLE ____________ DEGREES

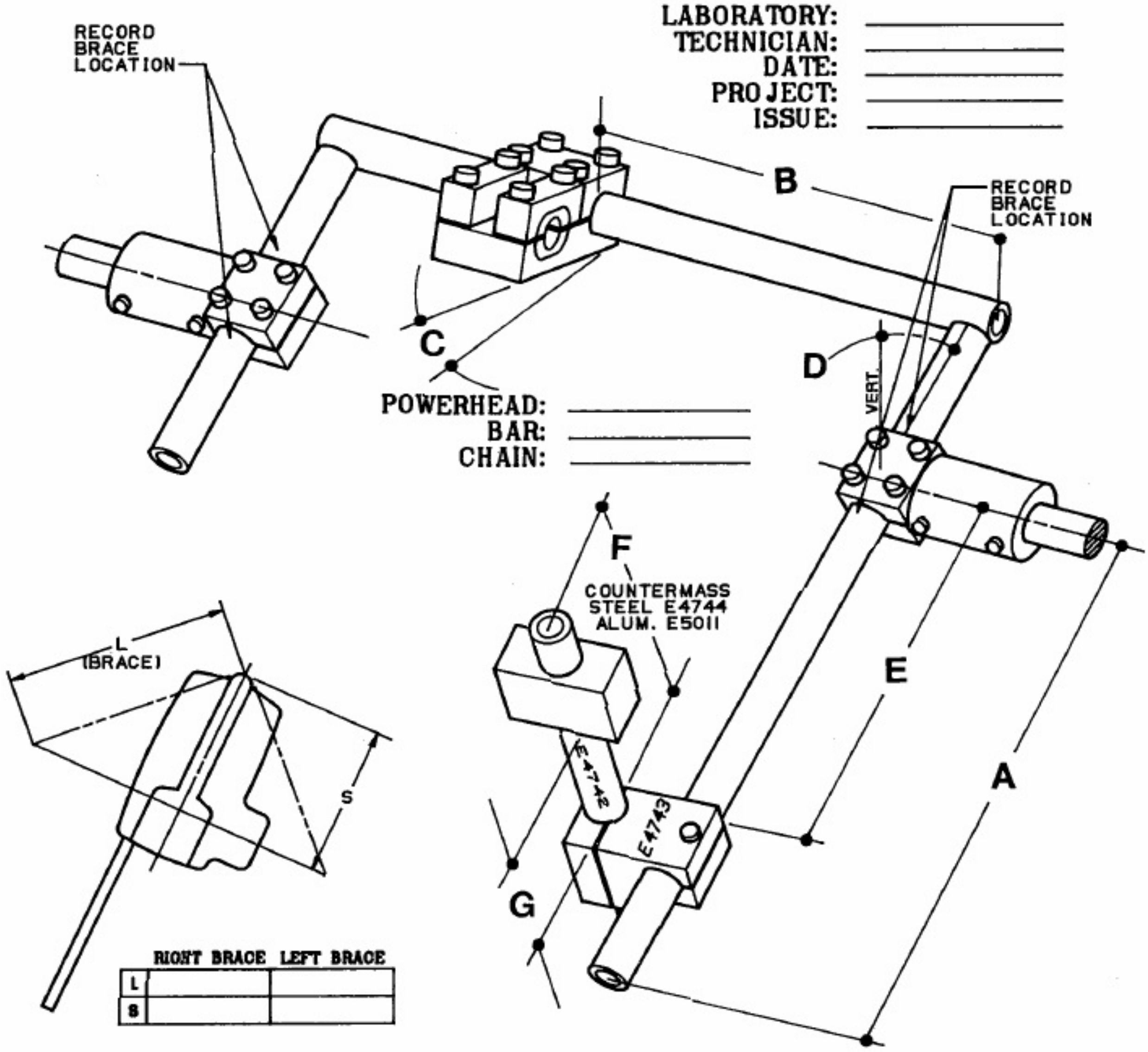
ENERGY SPLITS

____________ HORIZONTAL ____________ VERTICAL ____________ ROTATIONAL

COMMENTS ____

Figure J.1 – Kickback test record

LABORATORY: ____________
TECHNICIAN: ____________
DATE: ____________
PROJECT: ____________
ISSUE: ____________



	RIGHT BRACE	LEFT BRACE
L		
S		

CRADLE MEASUREMENTS

A: ____________ IN
B: ____________ IN
C: ____________ °
D: ____________ °

#1 COUNTERBALANCE MEASUREMENTS

E: ____________ IN
F: ____________ IN (IF NECESSARY)

#2 COUNTERBALANCE MEASUREMENTS

G: ____________ IN

COMMENTS: ____________

Figure J.2 – Chain saw installation and balancing test record

Annex K
(informative)

Procedures for control and calibration of Baraboard® test material

K.1 Scope

This annex sets forth procedures for control of the Baraboard® test material through central procurement and a method to adjust test data aimed at reducing the effects of specimen variation on test results. The goal of these procedures is to be able to relate measurements made at any laboratory to measurements at a standard laboratory with a standard lot of the test material.

K.2 Background

Baraboard®, a medium-density fiberboard, has been selected as the "wood" specimen material to be used in kickback testing on the kickback machine. Baraboard® is a wood-fiber product that is produced under generally controlled conditions. This material is more homogeneous than common species of wood, resulting in more consistent kickback energy data. Although Baraboard® is more consistent than common types of wood, variability does occur between and within lots of the Baraboard® material.

K.3 Introduction

K.3.1 Baraboard® is made in large sheets (5 ft × 18 ft × 1-1/2 in), which in turn can be cut into boards by the producer if requested. Specimens 1-1/2 in × 1-1/2 in × 10 in are cut from boards or sheets for use in the kickback machine tests. It is possible that specimens cut from different sheets will vary from each other with respect to average kickback energy levels measured on the kickback machine.

K.3.2 In order that the kickback energies determined from specimens cut from different sheets may be compared with confidence, the procedures in clauses K.4 through K.6 (or equivalent procedures) must be used to screen sheets used to form a standard lot, and to adjust for differences in individual sheets.

K.3.3 Since it will also be necessary to compare results of kickback energies obtained at different test facilities to the results that would have been obtained had the tests been conducted at a "standard" laboratory using "standard" specimens, additional adjustments as set forth in clause K.7 are to be used to relate the specific laboratory and specimens to the standard laboratory and standard lot.

K.4 Establishing the initial standard lot at the standard test facility

K.4.1 To establish the standard lot as measured at the test facility designated as the standard laboratory, a sufficiently large number, *N*, of Baraboard® sheets made during a limited production time period are obtained by that test facility.

K.4.2 To eliminate possible edge effects, a strip measuring 4 inches is cut from each edge of each sheet and discarded. The remainder of the sheets are cut into individual specimens and kept segregated by sheets.

K.4.3 A random sample of fifteen specimens is selected from each sheet.

K.4.4 One side of each specimen is tested with the Homelite SXL-AO chain saw with a Homelite PT16381GS guide bar (16-inch symmetrical sprocket nose bar) with a Homelite 38ME50-59 chain, or equivalent. The other side is tested with the same saw and type of guide bar, with a Homelite 38LE50-59 chain, or equivalent. The tests are performed on the kickback machine at an approach speed of 30 in/s, 5° contact angle, and engine speed of 9000 rpm.

K.4.5 For each sheet, the mean, $\bar{x}_i$, and standard deviation, s_i, of the rotary energy are calculated for each saw-chain combination for the fifteen specimens selected from the *i*th sheet.

K.4.6 The coefficient of variation (standard deviation divided by the mean) is computed for each saw-chain combination, for each sheet.

Only those sheets whose coefficients of variation do not exceed 0.10 for both saw-chain combinations are retained in the standard lot. If either or both coefficients of variation for a sheet exceed 0.10, the sheet is excluded from the standard lot. This eliminates sheets with too great a variability among specimens within the sheet.

K.4.7 Combining all of the sample observations for the *N'* sheets that remain in the standard lot, for each saw-chain combination, compute the overall mean, $\bar{\bar{x}}$ and standard deviation, *s*. Compute the upper and lower limits, $\bar{\bar{x}} \pm 1.96s/\sqrt{15}$, for both saw-chain combinations. Compare the means for each sheet in the standard lot to the appropriate limits for the standard lot, depending on the saw-chain combination used in the testing.

K.4.8 Exclude from the standard lot any sheets whose mean values fall outside the limits calculated above. The sheet will be excluded if either or both means are outside. The sheet will be included only if both means for the sheet fall within the respective limits. This eliminates sheets whose average energy values differ excessively from the average of the overall lot.

K.4.9 Using only those *N"* sheets whose means are within the limits, recompute the overall lot means, $\bar{\bar{x}}''$, and standard deviations for both types of chain. These values define the standard lot. Compute *B*, the midpoint between the overall means for the two chains

$$B = \frac{[\bar{\bar{x}}''(ME) + \bar{\bar{x}}''(LE)]}{2}$$

K.4.10 For each sheet in the standard lot, and for each saw-chain combination, compute the ratio of the overall mean for the standard lot to the mean value for that sheet, $\bar{\bar{x}}''/\bar{x}_i$. These ratios are designated, respectively, as $K_i(ME)$ and $K_i(LE)$, representing the values for the *i*th sheet for the 38ME5059 chain and the 38LE50-59 chain.

K.5 Kickback testing at the standard test facility

When the standard laboratory wishes to test any chain saw for kickback, it should select specimens for test from one sheet only. When the rotary and linear energies have been computed for that saw at its peak approach conditions, the rotary and linear energies should be multiplied by $K_i(ME)$ if the measured rotary energy is less than *B* inch-pounds (see K.4.9) and by $K_i(LE)$ if greater than B inch-pounds. These adjustments convert the measurements made on specimens from the *i*th sheet to standard lot measurements. Further adjustments as set forth in clause K.6 may also be required.

K.6 Perpetuation of the standard lot

K.6.1 New Baraboard® material at the standard laboratory

When specimens from the standard lot become depleted to the point where additional sheets must be obtained, repeat steps in K.4.1 through K.4.9 on the new sheets. For each saw-chain combination, compute K_i for each new sheet, the ratio of the overall mean of the new sheets, $\bar{\bar{x}}''$(new), to the mean for that sheet, $\bar{x}_i$. Compute the ratios of the overall mean of the standard (original) lot to the overall mean of the new sheets, *C*(*ME*) and *C*(*LE*), respectively, for the 38ME50-59 chain and the 38LE50-59 chain. Whenever specimens from the new sheets are used in tests, multiply the rotary and linear energies by both $K_i(ME)$ and *C*(*ME*) if the average rotary energy at peak approach conditions is less than B inch-pounds, or by $K_i(LE)$ and *C*(*LE*) if the average is greater than *B* inch-pounds.

K.6.2 New Baraboard® material at alternate laboratories

When an alternate laboratory wishes to establish a lot that is a perpetuation of the initial standard lot, the alternate laboratory must follow the procedures outlined in K.6.2.1 through K.6.3.

K.6.2.1 The alternate laboratory purchases a supply of Baraboard® in accordance with K.4.1. The sheets are trimmed in accordance with K.4.2. Random samples are cut in accordance with K.4.3. These samples are appropriately identified as to the sheet of origin, packaged, and shipped to the standard laboratory.

K.6.2.2 The standard laboratory must test and evaluate the samples in accordance with K.4.4 through K.4.10 and report the results to the alternate laboratory to permit appropriate discarding, retentions, and future use of the sheets in the lot. The standard laboratory must also establish the adjustments, *C*, in accordance with K.6.1 to be made to the mean of the sheets in this lot to relate them to the mean of the sheets in the initial standard lot.

K.6.2.3 The alternate laboratory must follow the procedures outlined in clause K.7 when using the material for testing.

K.6.3 Adjustment for new powerhead

When the powerhead of the original Homelite SXL-AO chain saw used to establish the standard lot wears or is broken to the point that it must be replaced, it should be replaced with an identical powerhead unit. To find the adjustment factor for the new powerhead, test the powerhead with both chains on fifteen specimens from each of three sheets from the standard lot at an approach speed of 30 in/s, 5° contact angle, and engine speed of 9000 rpm. See K.4.4. Compute the average rotary energy for the forty-five specimens for both chains. Compute the average value of the rotary energy for the three sheets obtained with the saw powerhead being replaced. Compute the ratio of the average of the three sheets from the prior saw test to the average of the forty-five-specimen test with the new powerhead, *S*(*ME*) and *S*(*LE*), respectively, for tests with the 38ME50-59 and 38LE50-59 chains. In qualifying new sheets for the standard lot using the new powerhead, all average measurements made from these sheets are to be multiplied by *S*(*ME*) or *S*(*LE*), as appropriate, to convert the new sheet averages to the values which would have been obtained using the original powerhead. The *K* values are computed as in K.4.10, using the adjusted averages.

NOTE – Replacement of the saw chain because of dullness or the guide bar because of wear do not require adjustments to be made to measurements.

K.7 Alternate test facilities

K.7.1 Whenever it is necessary to certify a saw at a test facility other than the standard laboratory, the following procedures must be used to adjust the results for laboratory and specimen differences.

K.7.2 The alternate test facility will be supplied with sufficient specimens from one or more sheets from the standard lot, along with the average values for each chain obtained by the standard laboratory for each of the sheets, as well as the $K_i(ME)$ and $K_i(LE)$ values for each sheet.

K.7.3 The alternate test facility must obtain a powerhead, guide bar, and chains similar to those used at the standard laboratory.

K.7.4 The alternate test facility must test fifteen specimens from one of the sheets in accordance with K.4.4 and compute the average rotary energy and standard deviation of these measurements for each type of chain. The powerhead must be considered acceptable, provided the coefficients of variation of these measurements (standard deviation divided by mean) is less than 0.10. Otherwise, additional powerheads must be tested until this condition is met.

K.7.5 Compute the ratio of the average rotary energy of the sample from the sheet obtained at the standard laboratory to the average obtained at the alternate test facility, *A*(*ME*) and *A*(*LE*), for each chain type, respectively.

K.7.6 Whenever a saw is to be certified at the alternate laboratory, the average rotary and linear energies found at peak approach conditions are to be multiplied by $A(ME)K_i(ME)$ if the average rotary energy at peak approach conditions is less than *B* inch-pounds, or by $A(LE)K_i(LE)$ if the average is greater than *B* inch-pounds.

K.8 Definitions and formulas

$n = 15$ — number of specimens selected at random for test from a sheet of Baraboard®

N — total number of sheets for possible inclusion in the standard lot

$N' \leq N$ — number of sheets that meet requirement on coefficient of variation, i.e., $CV \leq 0.10$

$N'' \leq N' \leq N$ — number of sheets that meet requirements on CV and mean value; N'' is the number of sheets in the standard lot.

x_{ij} — rotary energy measurement made on the jth specimen selected from the ith sheet; $j = 1, 2, \ldots, n$; $i = 1, 2, \ldots, N$. (The x refers to measurement made with either the 38ME50-59 or 38LE50-59 chain. The analyses are conducted separately for each chain.)

$\bar{x}_i = \sum_{1}^{15} x_{ij}/15$ — mean rotary energy for the sample from the ith sheet

$s_i = \sqrt{\dfrac{\sum_{1}^{15}(x_{ij} - \bar{x}_i)^2}{14}}$ — sample standard deviation of rotary energy for ith sheet

$CV_i = s_i/\bar{x}_i$ — coefficient of variation for ith sheet; sheet may be included in standard lot if $CV \leq 0.10$, otherwise, it is excluded.

$\bar{\bar{x}} = \sum_{1}^{N'} \bar{x}_i/N'$ — average rotary energy of all N' sheets whose $CV \leq 0.10$

$s_i = \sqrt{\dfrac{\sum_{1}^{N'}\sum_{1}^{15}(x_{ij} - \bar{\bar{x}})^2}{15\,N' - 1}}$ — sample standard deviation of individual measurements from sheets whose $CV \leq 0.10$

$\bar{\bar{x}} \pm 1.96\, s/\sqrt{15}$ — upper and lower limits on the means of sheets determined so that 95 percent of the $\bar{x}_i$ values should fall within these limits; any $\bar{x}_i$ within the limits will be included in the standard lot . . . those outside are excluded.

$\bar{\bar{x}}'' = \sum_{1}^{N''} \bar{x}_i/N''$ — average rotary energy of sheets in the standard lot, i.e., of only those sheets which meet the CV and mean requirement.

$B = \dfrac{\bar{\bar{x}}''(ME) + \bar{\bar{x}}''(LE)}{2}$ — the midpoint between the overall lot mean for the 38ME chain and the 38LE chain.

$K_i = \bar{\bar{x}}''/\bar{x}_i$ — adjustment to be made to measurements made on the ith sheet at the standard laboratory to bring the measurement in line with the standard lot; measurements made on the ith sheet are to be multiplied by K_i.

$\bar{\bar{x}}''$ (new) — average rotary energy for new sheets to be included in the standard lot; each of these sheets have been screened on CV and mean as was done for the original standard lot.

$C = \bar{\bar{x}}''/\bar{\bar{x}}''$ (new) — adjustment to be made to the means of the new sheets to bring them into line with the mean of the original standard lot.

K_i (new) $= \bar{\bar{x}}''$ (new)$/\bar{x}_i$ (new) — adjustment to be made to measurements from the new ith sheet to bring it into line with the average of all new sheets.

$C\ K_i$(new)	adjustment to be made to measurements made on new *i*th sheet to bring it into line with measurements made on original standard lot material.
$S + (\bar{x}_i + \bar{x}_j + \bar{x}_k)/(\bar{x}_i' + \bar{x}_j' + \bar{x}_k')$	adjustment to be made to all measurements made with a replacement powerhead. $\bar{x}_i$, $\bar{x}_j$, and $\bar{x}_k$ are the average values from sheets *i*, *j*, and *k* from the standard lot with the previous powerhead. $\bar{x}_i'$, $\bar{x}_j'$, and $\bar{x}_k'$ are average values obtained with the new powerhead. Measurements made on specimens from the sheets using the new powerhead are to be multiplied by S.
$A = \bar{x}_i/\bar{x}_i''$	adjustments to be made to measurements made at a test facility other than the standard laboratory. $\bar{x}_i$ is the average value for the *i*th sheet determined by the standard laboratory. $\bar{x}_i''$ is the average for the *i*th sheet determined at the other laboratory. The adjustment factor, *A*, is to be multiplied by the measurements made at the other laboratory to correct for laboratory bias. It is assumed that laboratory bias in measuring the *i*th sheet is the same for all sheets.
AK_i	adjustment to be made to measurements made by another laboratory on specimens tested from the *i*th sheet from the standard lot. Multiplying measurements by AK_i will bring measurements in line with standard lot.

Annex L
(informative)

Index to chain saw labeling requirements

Subclause

Annex M
(informative)

Bibliography

ANSI/UL 1662-1989, *Safety Standard for Electric Chain Saws*

ISO 6534: 1985, *Forestry machinery – Portable chain saws – Front-hand guard – Determination of strength* [1)]

ISO 6535: 1983, *Forestry machinery – Portable chain saws – Chain brake – Performance* [1)]

ISO 7182: 1984, *Acoustics – Measurement at the operator's position of airborne noise emitted by chain saws* [1)]

ISO 7505: 1986, *Forestry machinery – Measurement of hand-transmitted vibration* [1)]