



# Standard Test Method for Measurement of Cut Resistance to Chain Saw in Lower Body (Legs) Protective Clothing<sup>1</sup>

This standard is issued under the fixed designation F1414; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 This test method measures cut resistance of garments and devices worn to protect the lower body (legs) when operating a chain saw.

1.2 This test method may be used to test for compliance to minimum performance requirements in established safety standards.

1.2.1 By agreement between the purchaser and the supplier, or as required by established safety standards, it will be decided if this test method will be used to determine one or both of the following: (1) chainspeed 50 (CS50), and (2) success/failure (jamming/chain stop or no cut in less than 1.5 seconds) at specified chain speed.

1.3 This test method may be used to determine levels of protection for areas of coverage as stipulated in established safety standards.

1.4 The values stated in SI units are to be regarded as standard.

NOTE 1—The values stated in each system may not be exact equivalents; therefore, each system must be used independently of the other, without combining values in any way.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

## 2. Referenced Documents

2.1 The following documents, form a part of this specification to the extent referenced herein:

2.2 *ASTM Standards*:<sup>2</sup>

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee F23 on Personal Protective Clothing and Equipment and is the direct responsibility of Subcommittee F23.20 on Physical.

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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

D123 Terminology Relating to Textiles

D1056 Specification for Flexible Cellular Materials—Sponge or Expanded Rubber

D1776 Practice for Conditioning and Testing Textiles

F1494 Terminology Relating to Protective Clothing

2.3 *AATCC Test Methods*:

AATCC 96 Dimensional Changes in Laundering of Woven and Knitted Fabrics, except Wool (1988)<sup>3</sup>

AATCC 158 Dimensional Changes on Dry Cleaning in Perchloroethylene: Machine Method<sup>3</sup>

2.4 *Military Standards*:

MIL-STD-105 Sampling Procedures and Tables for Inspection by Attributes<sup>4</sup>

2.5 *Federal Standard*:

FS 5100-86 Type II, Cloth, Duck, Nylon, Polyurethane Coated<sup>4</sup>

## 3. Terminology

3.1 *Definitions*:

3.1.1 *chain saw, n*—a portable power operated tool used for cutting wood which has cutters linked in a chain.

3.1.2 *chain speed, n*—the velocity of synchronized movement of linked cutters around a guide bar and sprocket.

3.1.3 *chainspeed 50 (CS50), n*—for chain saw protection, the mean velocity at which cut through occurs.

3.1.3.1 *Discussion*—This value establishes the relationship between the probability of cutting through the protective clothing (or foot protective device) and the speed of the saw chain. For lower chain speeds, the probability of cut through approaches zero, while for higher chain speeds, the probability of cut through approaches one.

3.1.4 *chain stop, n*—the resulting action when a material clogs (jams) the drive sprocket or slows the speed sufficiently to prevent advancement of the saw chain.

3.1.5 *cut resistance, n*—in chain saw testing, the ability of a material, while in contact with the linked cutters, to resist cut

<sup>3</sup> Available from American Association of Textile Chemists and Colorists (AATCC), One Davis Dr., P.O. Box 12215, Research Triangle Park, NC 27709-2215.

<sup>4</sup> Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

through of the cutters of a moving saw chain independent of either jamming or chain stop.

3.1.6 *cut-through, n— for chain saw cut resistance*, the action of a running chain saw after complete breakthrough of either a protective garment or protective device.

3.1.6.1 *Discussion*—When a cut through is effected, speed of the saw chain must be measured.

3.1.7 *jamming, n—for chain saw cut resistance*, the clogging action manifested by a protective garment or a device that can produce a chain stop.

3.1.8 *lower body, n—that part of the human body which includes all portions between the waist and feet, not to include the feet.*

3.1.9 *protective clothing, n—an item of clothing that is specifically designed and constructed for the intended purpose of isolating all or part of the body from a potential hazard, or isolating the external environment from contamination by the clothing.*

3.1.9.1 *Discussion*—For chain saw cut resistant protective clothing, the potential hazard is exposure to a running power saw chain.

3.1.10 *saw chain, n—a closed loop of cutters linked together for use in a portable power-operated tool.*

3.2 For definitions of other textile terms used in this test method, refer to Terminology [D123](#).

3.3 For definitions of other protective clothing, terms used in this test method, refer to Terminology [F1494](#).

## 4. Summary of Test Method

4.1 Test specimens are securely mounted on a test apparatus which simulates a human leg.

4.2 A chain saw, of specific characteristic and operating at a designated speed, is brought into contact with the test specimen.

4.2.1 The cutting action of the saw chain will achieve one of the following results; (1) complete cut through with chain stop, (2) complete cut through without chain stop, (3) no cut through with a chain stop, or (4) no cut through without a chain stop.

4.3 Chain speed is measured electronically just prior to contact with test specimen. Chain speed is adjusted and reported based on these measurements.

NOTE 2—Materials may be characterized by repeated testing at different speeds, followed by a calculation of CS50. Alternatively, for quality control, results may be reported as pass or fail at one pre-selected chain speed.

## 5. Significance and Use

5.1 The purpose of this test method is to provide a measurable criterion of performance about the level of cut resistance provided by different types of protective garments and protected coverings worn by chain saw operators.

5.2 This test method is intended to show to what level a protective garment can offer resistance to the cutting action of a chain saw.

5.3 The protection which can be demonstrated by the garments and coverings tested in accordance with this test method is achieved by: (1) the cut resistance of the material to cutting when put in contact with saw chain; (2) pulling a part of the material or yarns in the material so that they are drawn into the chain and drive mechanism to block the chain movement; (3) the fibers of the materials used to demonstrate both high resistance to cutting and the capacity to absorb rotational energy, so that chain speed can be slowed down sufficiently to stop the movement of the saw chain; or (4) any combination of these.

5.4 This test method does not purport to evaluate comfort of lower body protective garments.

5.5 In case of a dispute arising from differences in reported test results when using this test method for acceptance testing of commercial shipments, the purchaser and the supplier should perform comparative tests to determine if there is a statistical bias between their laboratories. Competent statistical assistance is recommended for the investigation of bias. As a minimum, the two parties should take a group of test specimens from the same lot of components to be evaluated. The test specimens should then be randomly assigned in equal numbers to each laboratory for testing. If a bias is found, either its cause must be determined and corrected or the purchaser and the supplier must agree to interpret future test results in light of the known bias.

## 6. Apparatus<sup>5</sup>

6.1 Apparatus consists of three main components:

6.2 *Specimen Holder:*

6.2.1 A stationary wooden cylinder having a diameter of 150 mm (6 in.) and a minimum length of 350 mm (14 in.) (see [Fig. 1](#)).

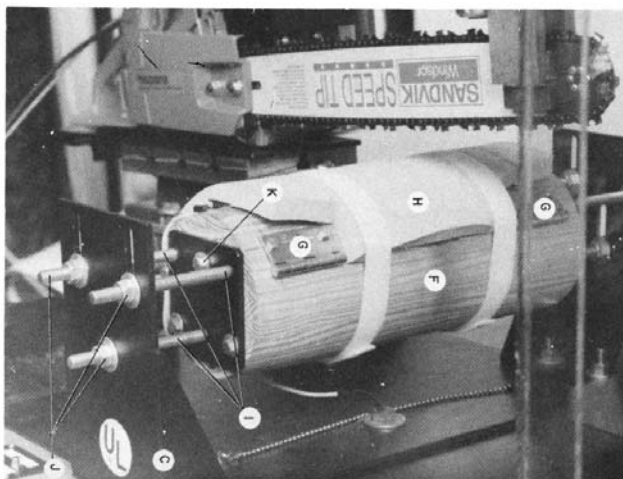
6.2.1.1 The cylinder is covered with a vinyl nitrile foam having a thickness of 18 mm (0.75 in.) (see [Fig. 1](#)). This covering shall have a density between 55 and 80 kg/m<sup>2</sup> and its resistance to a 25 % compression shall be between 10 and 20 kPa measured in accordance with the testing procedure in Specification [D1056](#).

NOTE 3—*Ensolute M*, a synthetic foam rubber made of PVC and NBR, meets the requirements stipulated in Specification [D1056](#).

6.2.1.2 Two specimen attachment plates each secured by two screws to the wooden cylinder parallel to the axis of that cylinder. Each plate is 75 by 25 mm (3 by 1 in.) (see [Fig. 1](#)).

6.2.1.3 The stationary wooden cylinder shall be attached to a swivel mechanism that allows the mandrel to be moved to an angle of either 45° or 90° to the vertical plane of the guide bar. Specimen must be securely attached to mandrel to prevent movement of specimen.

<sup>5</sup> See [Appendix X1](#) to review maintenance checklist.



| Item | Quantity | Description                                                                  |
|------|----------|------------------------------------------------------------------------------|
| A    | 1        | steel plate 0.25 by 576 by 670 mm                                            |
| B    | 2        | steel plate 0.25 by 216 by 375 mm                                            |
| C    | 2        | steel plate 0.25 by 208 by 216 mm                                            |
| D    | 1        | steel tube 0.75 by ID – 1 mm OD by 172 mm                                    |
| E    | 1        | aluminum plate 0.5 by 4 by 14.5 mm                                           |
| F    | 1        | hardwood or white pine 152 by 400 mm                                         |
| G    | 2        | hinge 3 by 3 by 1/16 in.                                                     |
| H    | 1        | foam pad 15 by 180 by 360 mm + glue                                          |
| I    | 6        | threaded rod 0.40 by 16 by 120 mm                                            |
| J    | 12       | bolt 0.40 by 16 mm                                                           |
| K    | 8        | wood screw 8 by .75 mm TR                                                    |
| L    | 1        | steel axle .75 mm diameter x 350 threaded .75 mm x 10 mm x 80 mm at each end |
| M    | 2        | pillow block VPS112 valuline browsing                                        |
| N    | 5        | bolt 0.75 by 10 mm                                                           |
| O    | 1        | hex bolt 0.75 by 10 by 70 mm                                                 |
| P    | 1        | square 30 mm x 90 mm x 3/16 x 75L                                            |
| Q    | 1        | stopping block 20 mm x 40 mm x 60L                                           |
| R    | 1        | lever support 3/16 x 80 mm x 130 mm                                          |
| S    | 1        | lever 0.25 by 60 by 120 mm                                                   |
| T    | 1        | axle 0.250                                                                   |
| U    | 1        | compression spring                                                           |
| V    | 1        | micro-switch                                                                 |
| W    | 1        | safety shield pivoting on D                                                  |

NOTE 1—Measurements are in millimetres. Arcs of a circle are measured on the circumference of the wood cylinder.

FIG. 1 Specimen Holder (Front View Facing Chain Saw)

### 6.3 Chain Saw and Related Equipment:<sup>6,7</sup>

#### 6.3.1 Saw:

6.3.1.1 A gas-powered chain saw having an idle speed of  $2250 \pm 250$  rpm, a maximum power of  $3.3 \pm 0.3$  kW at 8500 rpm that meets the following specifications: (1)  $66.7 \text{ cm}^3$  or 4.0 in.<sup>3</sup>; (2) bore 50 mm; (3) stroke 34 mm; (4) clutch engagement speed of  $3450 \pm 250$  rpm; (5) maximum no load speed of 12 500 rpm; (6) maximum no load chain speed of 27 m/s (5475 f/m); and (7) 3/8 by 7 tooth rim drive sprocket. (Figs. 3 and 4)

6.3.1.2 Throttle control mechanism is used to maintain constant saw chain speed.

<sup>6</sup> Husqvarna Model 266, XP with a seven tooth drive sprocket, available from Husqvarna, 907 W. Irving Park Road, Itasca, IL 60143, 312-773-2777.

<sup>7</sup> This is the sole source of supply known to the committee at this time. If you are aware of alternative suppliers, please provide this information to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,<sup>1</sup> which you may attend.

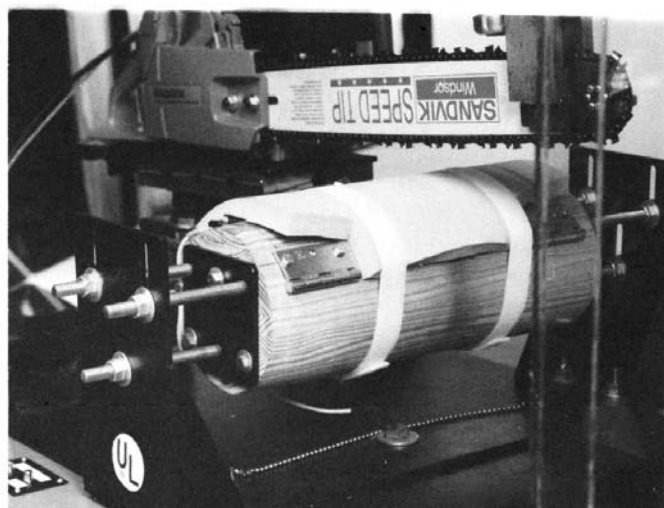


FIG. 2 Specimen Holder (Attachment and Positioning)

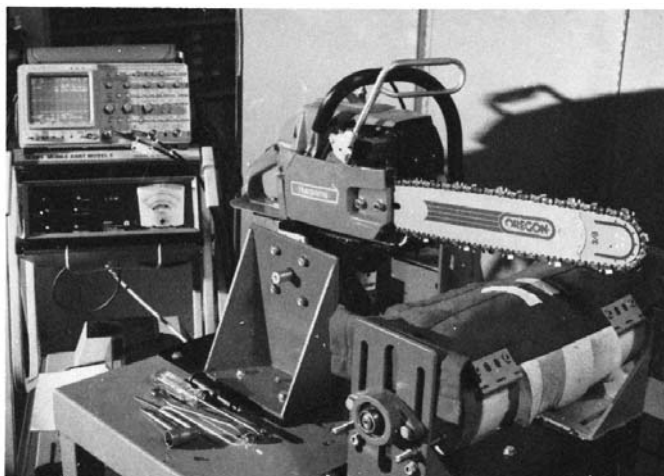


FIG. 3 Post Contact with Specimen (Front View) and Data Acquisition System

6.3.1.3 The engine of the chain saw is a two-stroke engine that uses a gasoline/oil mixture. The gasoline shall be a premium unleaded without alcohol additive and having a minimum anti-knock rating of 90. The oil shall be a high-quality two-stroke oil especially developed for chain saws. Mix ratio is 50 + 1 (2 % two-stroke oil to 98 % gasoline).

6.3.1.4 Chain saw power head shall be checked using a dynamometer after any of the following: (1) when CS50 of a calibration sample lot exceeds a range of speed greater than  $13.9 \text{ m/s} \pm 1.0 \text{ m/s}$  ( $2750 \text{ fpm} \pm 200 \text{ fpm}$ ); (2) after 120 test cuts; or (3) when chain saw has been idle for more than 30 days.

6.3.1.5 The chain saw shall be fitted with a resistive type plug to reduce interference with the chain speed electronics.

NOTE 4—When testing constraints prevent dynamometer verification, technician is responsible to check that the engine is running smoothly, starts readily, has a clean screen, if present, a good spark plug, and so forth.

NOTE 5—All requirements of the chain saw are determined in accordance with many manufacturers' published specifications.

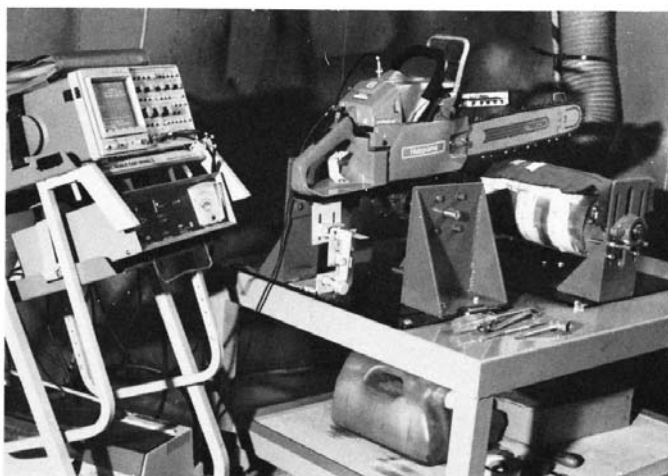


FIG. 4 Post Contact with Specimen (Rear View)

### 6.3.2 Chain:<sup>7,8</sup>

6.3.2.1 A chain with a pitch of 10 mm ( $\frac{3}{8}$  in.), a 0.058-in. gage, and a round ground full chisel cutter.

6.3.2.2 New chain may be used without sharpening or the chain must be sharpened using the sharpening procedure noted in Annex A1 before testing.

### 6.3.3 Guide Bar:

6.3.3.1 A guide bar having a length of 500 mm (20 in.) with an eleven-tooth roller-nose sprocket designed to accommodate a 10-mm ( $\frac{3}{8}$ -in.) pitch, 0.058 in. gage saw chain.

6.3.3.2 The roller nose on the guide bar will need to be cleaned at periodic intervals. To facilitate repeated cleanings, the rivets attaching the roller nose to the bar should be replaced. Modification requires that rivets be removed and holes be enlarged by drilling, so that aircraft quality bolts and locking nuts can be used.

### 6.3.4 Chain Guidance and Lubrication:

6.3.4.1 The saw chain shall be able to turn freely around the drive sprocket and roller nose. The system shall be adequately lubricated. Chain tension shall be adjustable so that application of a force of 15 N on the middle of the guide bar causes a chain deflection of  $6 \pm 0.5$  mm.

### 6.4 Chain Saw Support Bracket:

6.4.1 The saw is attached to a metal plate that rotates freely around the axle (see Fig. 5 and Fig. 7).

6.4.2 The horizontal distance between the pivot of the saw and the central axis of the specimen support is  $365 \pm 1$  mm ( $14.2 \pm 0.125$  in.) (see Figs. 5 and 6).

6.4.2.1 The vertical distance between the pivot of the saw and the center of the drive sprocket cannot exceed 130 mm (5 in.).

6.4.3 The mounting mechanism of the chain saw to the bracket shall be fixed.

6.4.4 The guide bar falls perpendicular to the support axis and exerts a static force of 15 N at the point of contact.

6.4.5 The vertical dropping distance to the point of contact with foam is 50 mm (2 in.). The longitudinal axis of the guide bar is virtually horizontal at the moment of contact (see Figs. 3 and 4).

6.4.6 A trigger release mechanism allows free fall without initial acceleration (see Figs. 4 and 6).

### 6.5 Interfaced Data Acquisition System:

6.5.1 The cutting time between wires placed on the top and bottom of the specimen is measured to  $\pm 0.001$  s.

6.5.1.1 These wires are connected to the circuitry.

6.5.2 The speed of the saw chain may be measured in metres per second or feet per minute ( $\pm 3$  %) by means of a magnetic pickup which reads data from a pickup band that is pressed onto the clutch housing. This data is then read by a tachometer which is calibrated to read this information. Some other effective means may be used to determine chain speed with equivalent precision (see Fig. 3).

## 7. Hazards

7.1 **Warning**—The chain saw equipment used in this test method can pose a potential danger to the technician if specific safety cautions are not followed.

7.2 As a minimum safety precaution, it is suggested that the spark plug wire be disengaged until engine needs to be started.

7.3 As a further safety precaution, it is suggested that the spark plug wire be grounded by circuitry after cutting the lower wire of the data collection system. If the chain stops before this wire is cut, or if the chain slides over the specimen, a timer should limit the test and stop the engine by grounding the electric circuitry of the chain saw.

7.4 The technician performing this test method should use ear protection to avoid potential hearing injury.

7.5 The technician performing this test method should use eye protection to avoid potential eye injury.

7.6 The chain saw motor should be vented to prevent potential danger posed by carbon monoxide gas.

## 8. Sampling

8.1 **Lot Sample**—As a lot sample for acceptance testing, take at random the number of shipping containers directed in an applicable material specification or other agreement between the purchaser and the supplier. Consider shipping containers to be the primary sampling units.

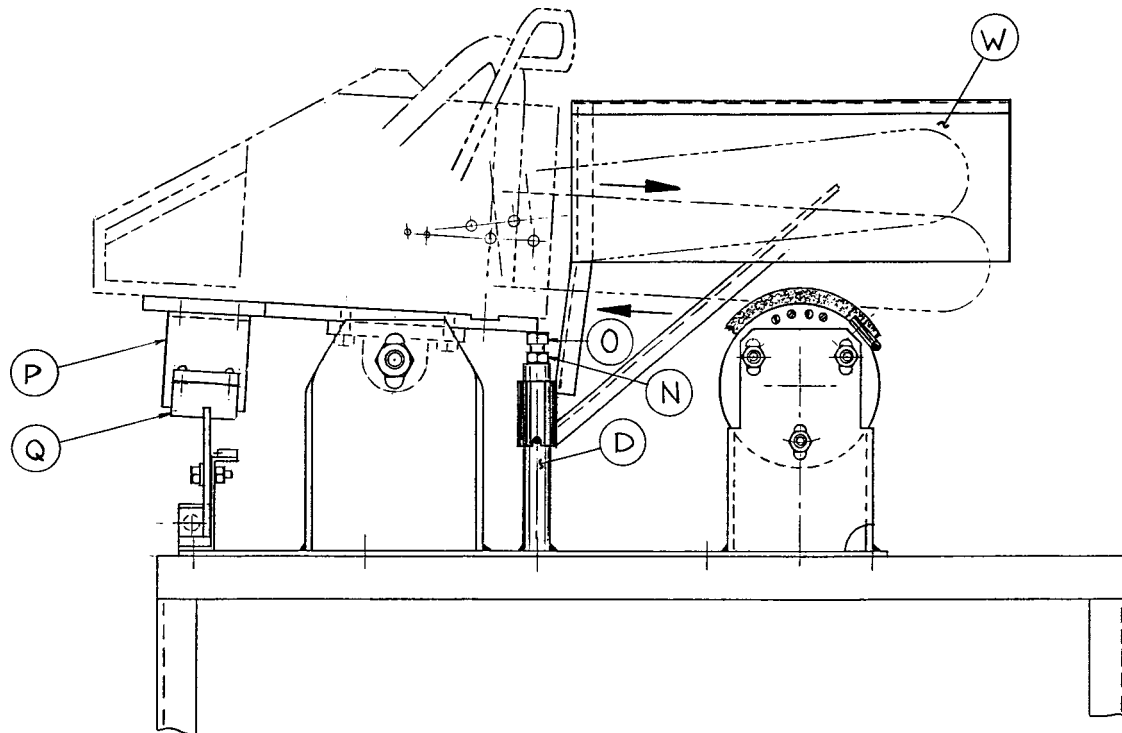
NOTE 6—An adequate specification or other agreement between the purchaser and the supplier requires taking into account the variability between shipping containers, between laboratory samples within a shipping container, and between test specimens within a laboratory sample to provide a sampling plan with a meaningful producer's risk, consumer's risk, acceptable quality level, and limiting quality level.

### 8.2 Specimen Preparation:

8.2.1 The specimen shall be of the same fabric assembly as that used in protective garment. Its technical description (number of layers, fabric used, etc.) shall be supplied.

8.2.2 Four holes, 6 mm (0.25 in.) in diameter, shall be punched into the specimen at the laboratory, at the places

<sup>8</sup> The sole source of supply of the saw chain with a pitch of 10 mm (0.40 in.),  $\frac{3}{8}$ , 72LP (73LP) Oregon Type, known to the committee at this time is Blount, Inc., 4909 S.E. International Way, PO Box 22127, Portland, OR 97222. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters.



| Item | Quantity | Description                                                                  |
|------|----------|------------------------------------------------------------------------------|
| A    | 1        | steel plate 0.25 by 576 by 670 mm                                            |
| B    | 2        | steel plate 0.25 by 216 by 375 mm                                            |
| C    | 2        | steel plate 0.25 by 208 by 216 mm                                            |
| D    | 1        | steel tube 0.75 by ID – 1 mm OD by 172 mm                                    |
| E    | 1        | aluminum plate 0.5 by 4 by 14.5 mm                                           |
| F    | 1        | hardwood or white pine 152 by 400 mm                                         |
| G    | 2        | hinge 3 by 3 by 1/16 in.                                                     |
| H    | 1        | foam pad 15 by 180 by 360 mm + glue                                          |
| I    | 6        | threaded rod 0.40 by 16 by 120 mm                                            |
| J    | 12       | bolt 0.40 by 16 mm                                                           |
| K    | 8        | wood screw 8 by .75 mm TR                                                    |
| L    | 1        | steel axle .75 mm diameter x 350 threaded .75 mm x 10 mm x 80 mm at each end |
| M    | 2        | pillow block VPS112 valuline browng                                          |
| N    | 5        | bolt 0.75 by 10 mm                                                           |
| O    | 1        | hex bolt 0.75 by 10 by 70 mm                                                 |
| P    | 1        | square 30 mm x 90 mm x 3/16 x 75L                                            |
| Q    | 1        | stopping block 20 mm x 40 mm x 60L                                           |
| R    | 1        | lever support 3/16 x 80 mm x 130 mm                                          |
| S    | 1        | lever 0.25 by 60 by 120 mm                                                   |
| T    | 1        | axle 0.250                                                                   |
| U    | 1        | compression spring                                                           |
| V    | 1        | micro-switch                                                                 |
| W    | 1        | safety shield pivoting on D                                                  |

NOTE 1—Measurements are in millimetres. Arcs of a circle are measured on the circumference of the wood cylinder.

**FIG. 5 Chain Saw Support Bracket (Side View)**

specified. Use these holes to position and to fasten the specimen to the test apparatus. Construct a template for consistency among specimens (Fig. 8).

### 8.3 Number of Specimens:

8.3.1 Use each specimen only once. Each leg of a paired item can be considered a specimen.

8.3.2 Use at least three unconditioned specimens to determine CS50 of calibration pads.

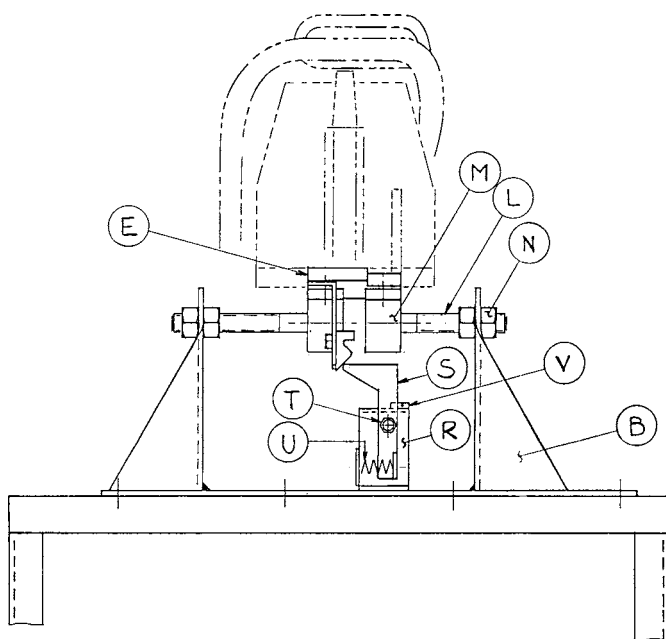
8.3.3 Use at least twelve unconditioned specimens and twelve conditioned specimens if this test method is used to determine the CS50 of performance pads.

8.3.4 Use five unconditioned specimens and five conditioned specimens if this test method is used to determine “success/failure” (jamming/chain stop). All specimens must pass.

## 9. Calibration

9.1 Calibration pads shall be composed of six layers of Lincoln fabric ID# 1060.071.02.000 fabric with a top cover of at least 400 denier nylon and a bottom layer of 70 denier Tricot.

9.1.1 Pads will measure a minimum of 200 by 700 mm (8 by 28 in.).



| Item | Quantity | Description                                                                  |
|------|----------|------------------------------------------------------------------------------|
| A    | 1        | steel plate 0.25 by 576 by 670 mm                                            |
| B    | 2        | steel plate 0.25 by 216 by 375 mm                                            |
| C    | 2        | steel plate 0.25 by 208 by 216 mm                                            |
| D    | 1        | steel tube 0.75 by ID – 1 mm OD by 172 mm                                    |
| E    | 1        | aluminum plate 0.5 by 4 by 14.5 mm                                           |
| F    | 1        | hardwood or white pine 152 by 400 mm                                         |
| G    | 2        | hinge 3 by 3 by 1/16 in.                                                     |
| H    | 1        | foam pad 15 by 180 by 360 mm + glue                                          |
| I    | 6        | threaded rod 0.40 by 16 by 120 mm                                            |
| J    | 12       | bolt 0.40 by 16 mm                                                           |
| K    | 8        | wood screw 8 by .75 mm TR                                                    |
| L    | 1        | steel axle .75 mm diameter x 350 threaded .75 mm x 10 mm x 80 mm at each end |
| M    | 2        | pillow block VPS112 valuline browng                                          |
| N    | 5        | bolt 0.75 by 10 mm                                                           |
| O    | 1        | hex bolt 0.75 by 10 by 70 mm                                                 |
| P    | 1        | square 30 mm x 90 mm x 3/16 x 75L                                            |
| Q    | 1        | stopping block 20 mm x 40 mm x 60L                                           |
| R    | 1        | lever support 3/16 x 80 mm x 130 mm                                          |
| S    | 1        | lever 0.25 by 60 by 120 mm                                                   |
| T    | 1        | axle 0.250                                                                   |
| U    | 1        | compression spring                                                           |
| V    | 1        | micro-switch                                                                 |
| W    | 1        | safety shield pivoting on D                                                  |

NOTE 1—Measurements are in millimetres. Arcs of a circle are measured on the circumference of the wood cylinder.

FIG. 6 Chain Saw Support Bracket (Rear View from Motor)

9.1.2 Stitch the inner pad material to the outer cover 25 mm (1 in.) from the edge on all four sides.

9.2 Determine the accuracy of the test apparatus, before and after each test lot, by verifying that the CS50 calibration specimen is 13.9 m/s (2750 f/m) at 90°.

9.2.1 If CS50 deviates more than  $\pm 1.0$  m/s (200 f/m) the saw chain must be resharpened to meet the specifications in accordance with 6.3.2.

9.2.1.1 Any deviation in CS50 of  $\pm 1.0$  m/s (200 f/m) requires that the problem be rectified and the test lot be redone with the proper number of specimens.

## 10. Conditioning

10.1 The manufacturer's care and maintenance guidelines, as required in Section 9, are used to determine the pretreatment method.

10.2 *Protective Garments or Protective Devices Intended for Machine Wash Only:*

10.2.1 The test specimen shall be subjected to five complete laundering cycles in accordance with AATCC Test Method 96-1988 Washing IIC and Drying A.

10.2.2 The test specimens shall then be brought from the dry side to approximate moisture equilibrium in accordance with Practice D1776.

NOTE 7—Equilibrium is considered to have been reached when the increase in mass of the specimen in successive weighings, made at intervals of not less than 2 h, does not exceed 0.1 % of the mass of the specimen.

10.3 *Protective Garments or Protective Devices Intended for Dry Cleaning Only:*

10.3.1 The test specimen shall be subjected to three dry cleaning cycles in accordance with AATCC Test Method 158-1985.

10.3.2 The test specimens shall then be brought from the dry side to approximate moisture equilibrium in accordance with Practice D1776 (see Note 7).

10.4 *Protective Garments or Protective Devices Intended for Both Machine Wash and Dry Cleaning:*

10.4.1 The test specimen shall be subjected to five complete laundering cycles in accordance with AATCC Test Method 96-1988 Washing IIC and Drying A.

10.4.2 The test specimen shall then be subjected to three dry cleaning cycles in accordance with AATCC Test Method 158-1985.

10.4.3 The test specimen shall then be brought from the dry side to approximate moisture equilibrium in accordance with Practice D1776.

10.5 *Protective Garments or Protective Devices Not Intended to be Laundered or Dry Cleaned:*

10.5.1 The chain saw shall be fitted with a resistive type plug to reduce interference with the chain speed. The test specimen shall be subjected to five complete laundering cycles in accordance with AATCC Test Method 96-1988 Washing IIC and Drying A, with the following modifications: without the use of soap or detergent, washing temperature 20°C (68°F), rinse temperature 20°C (68°F), and dry temperature 40°C (105°F) for 30 min. or until dry.

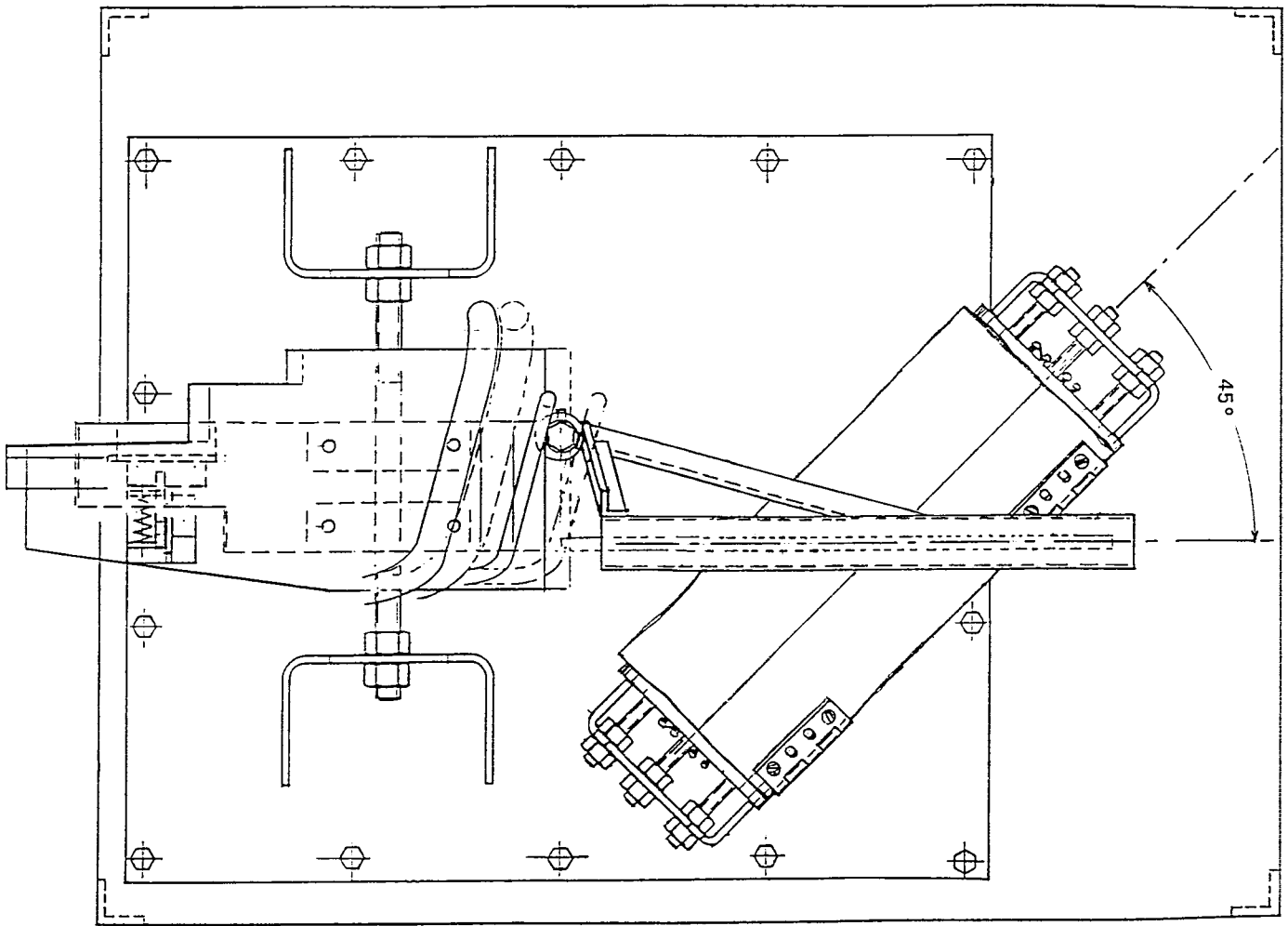
10.5.2 These protective garments or protective devices shall be brought to moisture equilibrium in accordance with Practice D1776 (see Note 7).

## 11. Procedure

11.1 *Placement of Specimen:*

11.1.1 Position the bottom timing wire from the interfaced data acquisition system beneath the specimen to be tested.

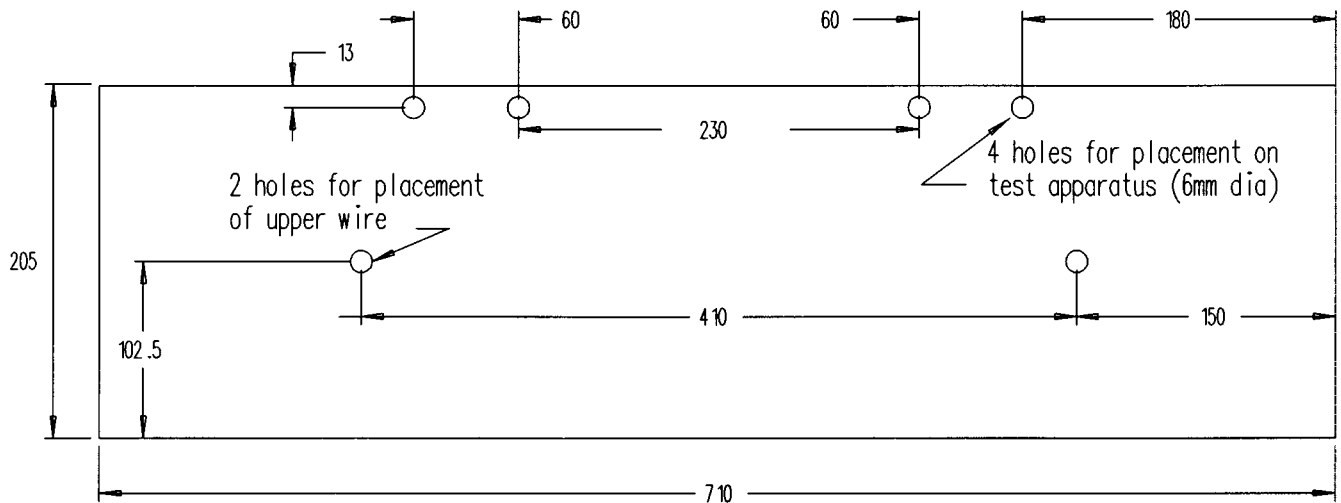
11.1.1.1 This wire should be taut against the foam pad at a constant force, directly on the foam pad at the point of contact with the saw chain and perpendicular to the axis of the guide bar.



| Item | Quantity | Description                                                                  |
|------|----------|------------------------------------------------------------------------------|
| A    | 1        | steel plate 0.25 by 576 by 670 mm                                            |
| B    | 2        | steel plate 0.25 by 216 by 375 mm                                            |
| C    | 2        | steel plate 0.25 by 208 by 216 mm                                            |
| D    | 1        | steel tube 0.75 by ID – 1 mm OD by 172 mm                                    |
| E    | 1        | aluminum plate 0.5 by 4 by 14.5 mm                                           |
| F    | 1        | hardwood or white pine 152 by 400 mm                                         |
| G    | 2        | hinge 3 by 3 by 1/16 in.                                                     |
| H    | 1        | foam pad 15 by 180 by 360 mm + glue                                          |
| I    | 6        | threaded rod 0.40 by 16 by 120 mm                                            |
| J    | 12       | bolt 0.40 by 16 mm                                                           |
| K    | 8        | wood screw 8 by .75 mm TR                                                    |
| L    | 1        | steel axle .75 mm diameter x 350 threaded .75 mm x 10 mm x 80 mm at each end |
| M    | 2        | pillow block VPS112 valuline browng                                          |
| N    | 5        | bolt 0.75 by 10 mm                                                           |
| O    | 1        | hex bolt 0.75 by 10 by 70 mm                                                 |
| P    | 1        | square 30 mm x 90 mm x 3/16 x 75L                                            |
| Q    | 1        | stopping block 20 mm x 40 mm x 60L                                           |
| R    | 1        | lever support 3/16 x 80 mm x 130 mm                                          |
| S    | 1        | lever 0.25 by 60 by 120 mm                                                   |
| T    | 1        | axle 0.250                                                                   |
| U    | 1        | compression spring                                                           |
| V    | 1        | micro-switch                                                                 |
| W    | 1        | safety shield pivoting on D                                                  |

NOTE 1—Measurements are in millimetres. Arcs of a circle are measured on the circumference of the wood cylinder.

**FIG. 7 Chain Saw Bracket (Top View)**



\* All measurements in mm  
FIG. 8 (Specimen)

11.1.2 Carefully position the specimen and securely mount to the holder so that the holes can be aligned for the attachment. The position of these holes is shown in Fig. 8.

11.1.2.1 Lock the specimen holder into place at the appropriate angle of either 45° or 90°.

11.1.2.2 Reposition any hooks, buckles, closures, or other devices that make up part of the protective garment or covering so as not to inhibit the specimen from being placed flat against the cylinder. When unable to reposition the hooks, buckles, closures, or other devices, remove them either in part or completely.

NOTE 8—If it has been shown that the performance pads under test either jam the saw or are cut through in less than 0.2 seconds then the timing wires may be omitted and Pass/Fail will be based only on cut through.

NOTE 9—Each leg of a paired item can be considered a specimen.

11.2 Use each specimen for only one test.

11.3 Put the upper timer wire through the two center holes of the specimen. Attach each end of wire to a terminal of the interfaced circuitry.

11.3.1 Place this wire taut against the specimen without exerting any tension stress.

11.3.2 Verify the continuity of all circuits prior to starting chain saw procedures.

#### 11.4 Chain Saw:

11.4.1 Clean and visually check the chain saw after every test cutting. Correct any abnormality.

11.4.2 Refuel and oil after every ten test cuts.

NOTE 10—Refueling avoids significant variations in mass.

11.4.3 Start the chain saw and warm up for approximately two min. Adjust the chain saw to the specific speed for the trial in progress.

11.4.4 Before the test, turn on the recording circuitry so that a record can be made of the chain speed and cut through.

11.4.5 Release the chain saw to make contact with the specimen holder so that the saw chain cuts the top wire and starts the timer.

#### 11.5 Chainspeed (CS50):

11.5.1 Determine the measurement of the mean velocity at which a cut through can occur. The operator must do a sufficient number of tests in order to obtain at least three results that are failures - a cut through of all layers and three results that are passes - no cut through of all layers. To limit the range as much as practical, the failures should yield cut throughs up to 25 mm (1 in.) long. The passes should show a cut through of all layers except the last layer of the pad.

11.5.1.1 Start the engine of the chain saw and set the speed at an initial speed of 13 m/s (2650 fpm) or a speed at which the probability of cut through is approximately 50 %.

11.5.1.2 Trigger the saw release mechanism.

11.5.1.3 Note the results either of the cut through or chain stop.

11.5.2 Repeat the test on a new specimen after setting the speed of the saw at 1.0 m/s (200 fpm) slower than the initial test if the first specimen resulted in a cut through, or at a speed of 1.0 m/s (200 fpm) faster if a chain stop was the result of the first test.

11.5.2.1 Note the results and continue to test in this manner using the chain speeds specified in Fig. 9 for each trial.

11.5.2.2 To achieve the six speeds used for the calculation of CS50, the test results must be listed by chain speed order. The three highest chain speeds which are passes and the three lowest which are failures are selected for the calculation of (1) the CS50, (2) standard deviation, and (3) range.

(a) The CS50 reported is the average of the six chain speeds selected.

(b) The standard deviation reported is calculated using all six samples selected using normal statistical techniques.

(c) The range reported is calculated by taking the difference between the highest chain speed of the six samples minus the lowest chain speed of the six samples.

A minimum of three “pass” and three “fail” results is required for calibration pads. Performance characterization requires a minimum of twelve unconditioned and twelve conditioned specimens to be tested.

| 1st Trial                   | 2nd Trial<br>+/- 1.0 m/s<br>(+/- 200 fpm) | 3rd Trial<br>+/- .50 m/s<br>(+/- 100 fpm) | 4th Trial<br>+/- .25 m/s<br>(+/- 50 fpm) | 5th Trial<br>+/- .25 m/s<br>(+/- 50 fpm) |
|-----------------------------|-------------------------------------------|-------------------------------------------|------------------------------------------|------------------------------------------|
| 13.5 m/s Fail<br>(2650 fpm) | 12.4 m/s Fail<br>(2450 fpm)               | 12.0 m/s Fail<br>(2350 fpm)               | 11.5 m/s Fail<br>(2300 fpm)              | 11.4 m/s<br>2250                         |
|                             |                                           |                                           | 11.5 m/s Pass<br>(2300 fpm)              | 12.0 m/s<br>2350                         |
|                             |                                           | 12.0 m/s Pass<br>(2350 fpm)               | 12.0 m/s Fail<br>(2400 fpm)              | 12.0 m/s<br>2350                         |
|                             |                                           |                                           | 12.0 m/s Pass<br>(2400 fpm)              | 12.4 m/s<br>2450                         |
|                             | 12.4 m/s Pass<br>(2450 fpm)               | 13.5 m/s Fail<br>(2550 fpm)               | 12.7 m/s Fail<br>(2500 fpm)              | 12.4 m/s<br>2450                         |
|                             |                                           |                                           | 12.7 m/s Pass<br>(2500 fpm)              | 13.0 m/s<br>2550                         |
|                             |                                           | 13.5 m/s Fail<br>(2550 fpm)               | 13.0 m/s Fail<br>(2600 fpm)              | 13.0 m/s<br>2550                         |
|                             |                                           |                                           | 13.0 m/s Pass<br>(2600 fpm)              | 13.5 m/s<br>2650                         |
| 13.5 m/s Pass<br>(2650 fpm) | 14.5 m/s Fail<br>(2850 fpm)               | 14.0 m/s Fail<br>(2750 fpm)               | 13.7 m/s Fail<br>(2700 fpm)              | 13.5 m/s<br>2650                         |
|                             |                                           |                                           | 13.7 m/s Pass<br>(2700 fpm)              | 14.0 m/s<br>2750                         |
|                             |                                           | 14.0 m/s Pass<br>(2750 fpm)               | 14.0 m/s Fail<br>(2800 fpm)              | 14.0 m/s<br>2750                         |
|                             |                                           |                                           | 14.0 m/s Pass<br>(2800 fpm)              | 14.5 m/s<br>2850                         |
|                             | 14.5 m/s Pass<br>(2850 fpm)               | 15.0 m/s Fail<br>(2950 fpm)               | 15.0 m/s Fail<br>(2900 fpm)              | 14.5 m/s<br>2850                         |
|                             |                                           |                                           | 15.0 m/s Pass<br>(2900 fpm)              | 15.0 m/s<br>2950                         |
|                             |                                           | 15.0 m/s Pass<br>(2950 fpm)               | 15.0 m/s Fail<br>(3000 fpm)              | 15.0 m/s<br>2950                         |
|                             |                                           |                                           | 15.0 m/s Pass<br>(3000 fpm)              | 15.5 m/s<br>3050                         |

**FIG. 9 Determination of CS50**

## 12. Interpretation of Results

12.1 When the chain speed is higher than the CS50 of the protective garment, the likelihood that the specimen is cut through is greater than 50 %.

12.1.1 Jamming can stop the rotation of the chain before a cut through.

12.1.2 In most tests, the chain saw engine may continue to run despite the saw chain being stopped. The structure of the protective component slowed the motor sufficiently for the centrifugal clutch to stop driving the chain.

12.2 When this test method is used to determine success/failure (jamming/chain stop) at a specified saw chain speed, all specimens must pass the specified saw chain speed.

12.2.1 Failure of a single specimen results in failure of the specimen lot.

## 13. Report

13.1 Report the following information:

13.1.1 Angle of cutting by the chain saw to the mandrel.

13.1.2 Quantity and description of specimens.

13.1.3 Statement of preconditioning treatment.

13.1.4 Table showing specimen number, chain speed, and CS50 for both calibration pads and performance pads.

## 14. Precision and Bias

14.1 An interlaboratory test program was conducted to obtain precision data.

14.1.1 The standard calibration material was used in this interlaboratory program, and was tested in three laboratories. Thirty calibration pads of dimension 400 mm (16 in.) by 225 mm (9 in.) were sent to each laboratory for cut testing. The test pads were used to obtain as many CS50 estimates as possible, following the test methodology in this test method.

14.1.2 The results of the precision calculations for repeatability and reproducibility are given in Table 1.

TABLE 1 Precision of the Test Method<sup>A</sup>

| Note— $s_r$ = repeatability standard deviation (pooled within-laboratory standard deviation),<br>$r$ = repeatability = 2.80 $s_r$ ,<br>$s_R$ = reproducibility standard deviation (total standard deviation), and<br>$R$ = reproducibility = 2.80 $s_R$ . |               |       |     |       |     |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|-------|-----|-------|-----|
| Material                                                                                                                                                                                                                                                  | Average (fpm) | $S_R$ | $r$ | $S_R$ | $R$ |
| six-layer<br>Barrday                                                                                                                                                                                                                                      | 2235          | 95.0  | 266 | 95.0  | 266 |

<sup>A</sup>Estimates are based on twelve CS50 estimates (four from each laboratory), and were calculated using a variance components analysis. Laboratory means were not statistically different; 99.99 % of total variance was within-laboratory.

14.1.3 *Repeatability*—The repeatability,  $r$ , of this test method has been established as the value tabulated in Table 1. Two single test results, obtained in the same laboratory under normal test method procedures that differ by more than this tabulated  $r$  must be considered as derived from different or non-identical sample populations.

14.1.4 *Reproducibility*—The reproducibility,  $R$ , of this test method has been established as the value tabulated in Table 1. Two single test results, obtained in two different laboratories under normal test method procedures that differ by more than this tabulated  $R$  must be considered to have come from different or non-identical sample populations.

14.2 *Bias*—In test method terminology, bias is the difference between an average test value and the reference (or true) test property value. Reference values do not exist for this test method since value (of the test property) is exclusively defined by the test method. Bias, therefore, cannot be determined.

## 15. Keywords

15.1 chain saw; cut resistance; lower body; protective clothing

## ANNEX

### (Mandatory Information)

#### A1. SHARPENING PROCEDURE

##### A1.1 Equipment :

A1.1.1 The saw chain shall be sharpened using two identical grinders, one permanently set up for left hand cutters and the other for right hand cutters. The grinders shall be securely mounted at chest height in a well lit area, clear of all flammable materials. (Figs. A1.1-A1.13)

A1.1.2 The grinding wheel shall meet the specifications of the grinder manufacturer and be designed to sharpen the chain specified in this test method.

A1.2 *Hazards*: The chain sharpening equipment used in this procedure can pose a potential danger to the technician if specific cautions are not followed. To avoid injury, make sure that all assembly instructions have been followed. Be certain anyone who uses the grinder has been instructed in its proper use.

A1.3 *Warnings*: An electric grinder operates at a high speed; misuse or mechanical failure can result in serious injury to the operator or others nearby. In normal operation, the grinder

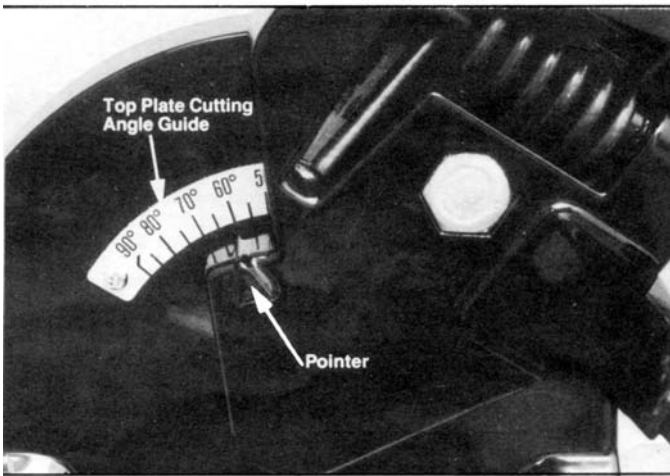


FIG. A1.1 Knob-rear of Grinder

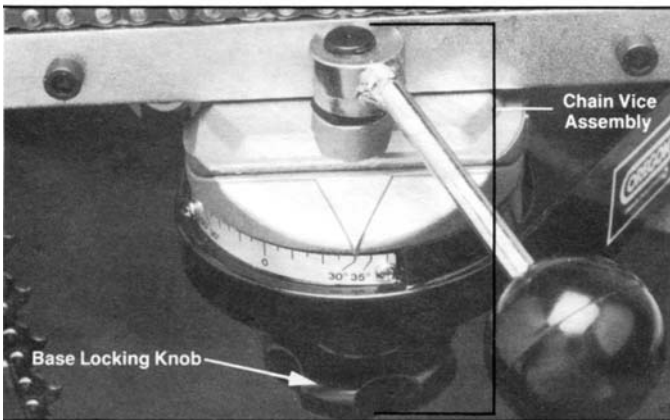


FIG. A1.2 Base Locking Knob

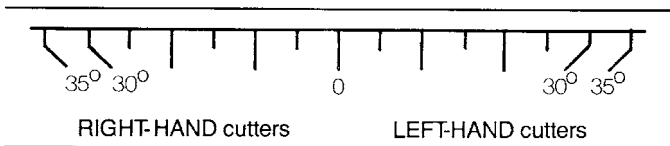


FIG. A1.3 Angle Jig

expels grinding debris and sparks at high rates of speed. This material can cause serious injury. In the event of a mechanical failure of the grinding wheel, large fragments may be ejected at very high velocity. Always wear eye protection when operating the grinder. To avoid injury, never use the grinder without the safety shields properly installed and in place.

#### A1.4 Safety Precautions:

A1.4.1 Do not force a wheel onto the machine or alter the size of the mounting hole. If a wheel does not fit exactly, use another.

A1.4.2 Do not use a wheel that has been dropped. A damaged wheel is likely to disintegrate in use.

A1.4.3 To avoid injury always *ring test* the grinding wheel and inspect visually for cracks. A good wheel will sound a clear musical note when tapped gently with a screw driver handle.

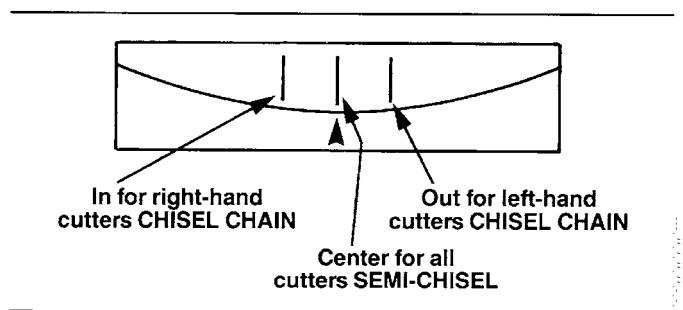


FIG. A1.4 Angle Jig

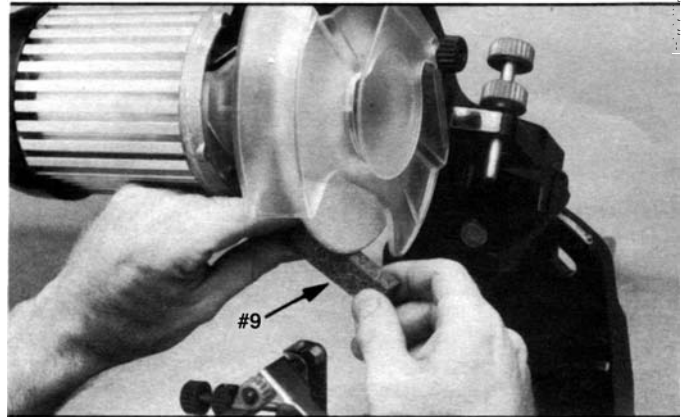


FIG. A1.5 Dressing Brick

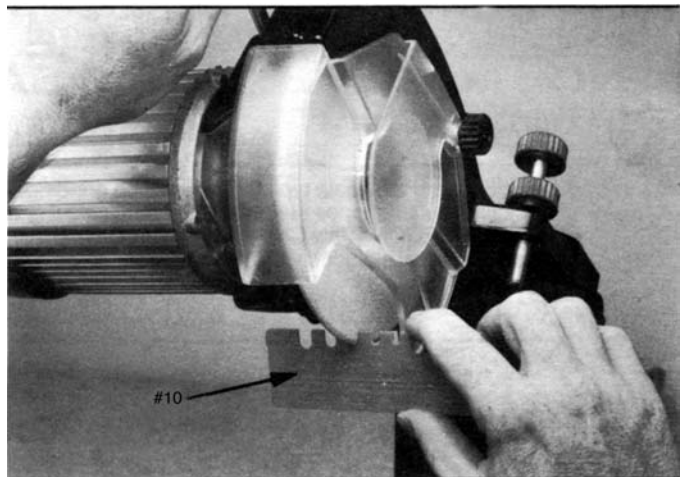


FIG. A1.6 Grinding Wheel Template

A1.4.4 Do not over tighten the wheel mounting nut.

A1.4.5 Never stand directly in front of the grinding wheel when you are starting the motor.

A1.4.6 Do not start the grinder if the wheel guards are not in place.

A1.4.7 Use only wheel mounting flanges that are clean and flat. In the event of any vibration when the motor is started or running, remove and inspect the surfaces of the flanges and the wheel.

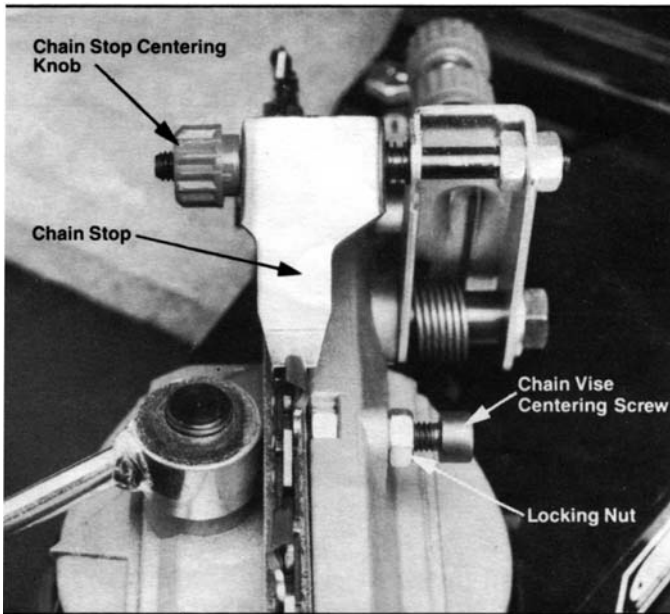


FIG. A1.7 Chain Stop Centering Knob

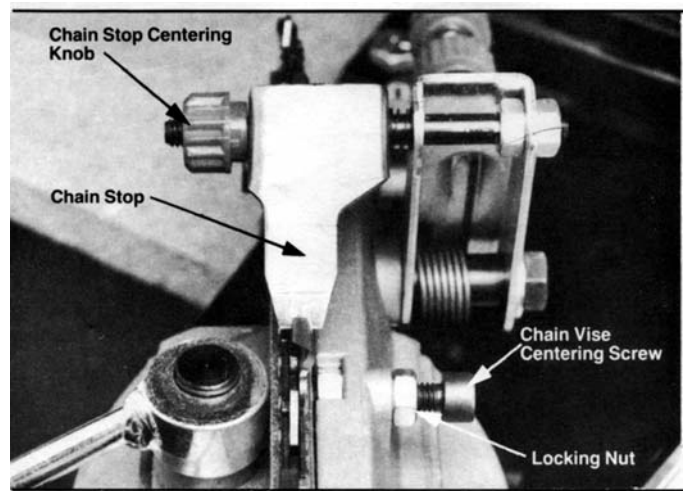


FIG. A1.9 Chain Stop Centering

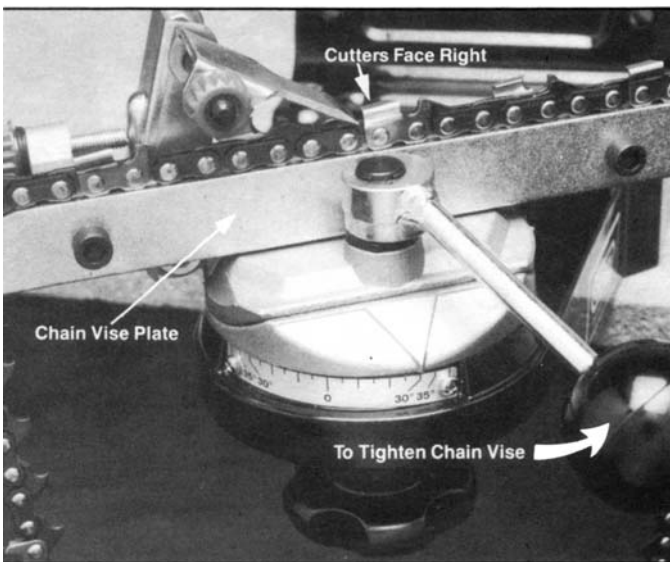


FIG. A1.8 Chain Vise Locking Knob

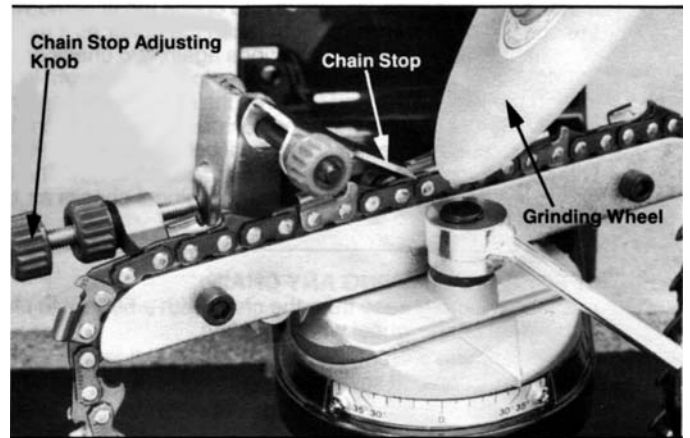


FIG. A1.10 Cutter Positioning

Parts of a cutter.

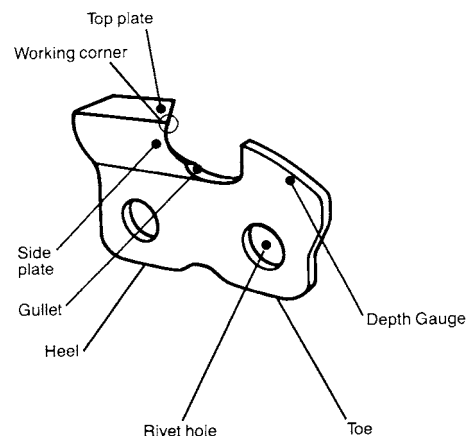


FIG. A1.11 Cutter Depth

A1.4.8 Do not exceed the maximum operating speed established for the grinding wheel.

A1.4.9 Do not grind on the side of the wheel.

A1.4.10 Do not grind material for which the wheel was not designed.

A1.4.11 Do not jam the work into the wheel, use a light touch, let the abrasive do the work.

A1.4.12 Always wear approved eye protection when operating the grinder.

A1.4.13 Do not operate the grinder with damaged or cracked safety shields.

A1.5 *Set Up: Right Hand Cutters*—These procedures should be followed for both the left and right hand cutter grinders.

A1.5.1 Loosen the large knob at the rear of the grinder so that the pointer can be set to the 60° mark on the top plate angle cutting guide. This will ensure that the top plate angle of the cutter is 60°. Use angle jig to confirm that this 60° cutting angle is exact.

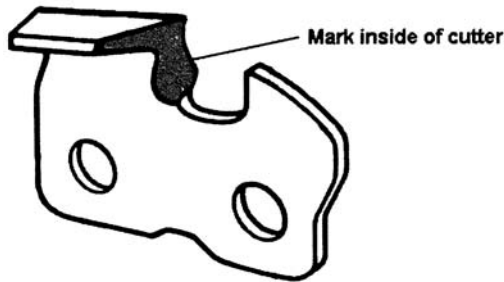


FIG. A1.12 Cutter Marking

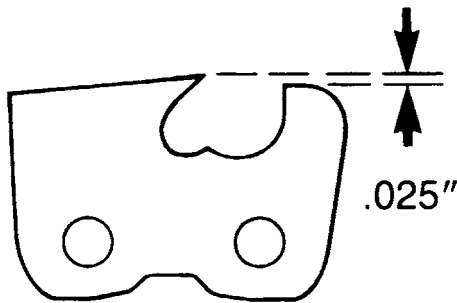


FIG. A1.13 Depth Gage

surface of the jig. Loosen the vise and change the setting of the chain vise centering screw until the mark made on the jig is on the center line. Tighten the locking nut after the wheel is centered.

#### A1.6 Inspection and Procedure:

A1.6.1 Examine the grinding wheel to assess for accumulated metal. This is evidenced by black or dark marks on the wheel cutting edge. The wheel should be free from marks and of the proper shape as determined by the appropriate profile on the wheel shape template. If necessary, dress the grinding wheel as directed above.

A1.6.2 The chain to be sharpened shall be mounted in the slot of the chain vise with the cutters facing right as they would be if mounted on a saw. Use the chain vise locking knob to secure the chain in position. The chain stop centering knob should be adjusted to center the chain stop behind the cutter.

A1.6.3 Lower the cutting head with the grinder turned off to position the cutter under the grinding wheel. When the cutter is properly positioned under the grinding wheel, use the chain stop adjusting knob to bring the chain stop to a position lightly touching the back of the cutter.

A1.6.4 Identify the first cutter sharpened using a mark on the top or side plate. Also mark the inside of the cutter face with a black felt marker to provide a witness mark left by the grinder. Set the depth of cut stop adjustment screw so that the grinding wheel lightly touches the back of the cutter.

A1.6.5 Quick short advances of the wheel into the cutter surface will prevent heat build up. Heat build up in the cutter can change the hardness of the cutter by destroying its temper. Watch for cutters that are darkened by the grinding process as this is evidence of heat build up. Metal accumulation in the grinding wheel can cause burning. Chains are best sharpened by using single quick advances of cutter wheel into cutter surface. This removes small amounts of metal with each pass. Sequentially repeat this action for each cutter as many times as necessary until desired sharpness is achieved.

A1.6.6 Check the depth gage. If it is less than .023 in., discard the chain and select a new one.

A1.6.7 After sharpening all right hand cutters, move chain to grinder set up for left hand cutters and repeat steps 1 through 6.

A1.5.2 Loosen the base locking knob below the chain vise and set the pointer to the 25° angle mark on the vise assembly. This will ensure that the top plate angle of the cutter is 25°. Use angle jig to confirm that this 25° angle is exact.

A1.5.3 Loosen the base locking knob and move the tilt feature to the center 90° position. This will set the file angle of the cutter to 90°.

A1.5.4 To shape the grinding wheel to the cutter's profile, use the grinding wheel template and dressing brick supplied by the grinder or wheel manufacturer. Use only quick, light strokes of the dressing brick against the wheel. This will make the wheel sharpen the cutter properly.

A1.5.5 Mount the angle jig in the chain vise, locking it securely, with the grinder in the off position. Bring the wheel in contact with the jig. Rotate the wheel by hand to mark the

## APPENDIXES

### (Nonmandatory Information)

#### X1. CHAIN SAW MAINTENANCE CHECKLIST

##### X1.1 Check:

- X1.1.1 Sprocket,
- X1.1.2 Spark plug and ignition system,
- X1.1.3 Anti-vibration system, and
- X1.1.4 Compression pressure.

##### X1.2 Change:

- X1.2.1 Air filter, and
- X1.2.2 Centrifugal cloth.

##### X1.3 Perform:

- X1.3.1 General lubrication.

#### X2. VELOCITY CONVERSION

X2.1 **Table X2.1** shows the conversion from velocity indicated as revolution per minute (rpm) to velocity indicated as feet per minute (fpm) for a seven tooth sprocket.

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**TABLE X2.1 Velocity Conversion**

| ENGINE RPM | ENGINE RPM X 4.38 = FPM |          |
|------------|-------------------------|----------|
|            | FPM                     | m/s      |
| 2000       | 876                     | 4.5 m/s  |
| 2500       | 1095                    | 5.5 m/s  |
| 3000       | 1314                    | 6.6 m/s  |
| 3500       | 1533                    | 7.8 m/s  |
| 4000       | 1752                    | 8.9 m/s  |
| 4500       | 1971                    | 10.0 m/s |
| 5000       | 2190                    | 11.0 m/s |
| 5500       | 2409                    | 12.0 m/s |
| 6000       | 2628                    | 13.3 m/s |
| 6500       | 2847                    | 14.5 m/s |
| 7000       | 3066                    | 15.5 m/s |
| 7500       | 3285                    | 16.7 m/s |
| 8000       | 3504                    | 17.8 m/s |
| 8500       | 3723                    | 18.9 m/s |
| 9000       | 3942                    | 20.0 m/s |
| 9500       | 4161                    | 21.0 m/s |
| 10 000     | 4380                    | 22.0 m/s |
| 11 000     | 4818                    | 24.5 m/s |
| 12 000     | 5256                    | 26.7 m/s |
| 13 000     | 5694                    | 28.9 m/s |
| 14 000     | 6132                    | 31.0 m/s |
| 15 000     | 6570                    | 33.0 m/s |

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