Safe design and use of chain saws

ILO Codes of Practice

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Preface

At its 191st Session, late in 1973, the Governing Body of the International Labour Office adopted various conclusions and resolutions of the Second Tripartite Technical Meeting for the Timber Industry (Forestry).

In particular, it approved the recommendation of its Industrial Activities Committee that the Director-General should give effect to the Meeting's wish that the ILO should, inter alia, gather and disseminate "exhaustive information concerning new machines (especially power saws) and their effects on workers' health and safety". The present code of practice forms part of the action taken by the ILO to meet this request.

The code was prepared in close collaboration with an ad hoc group of experts on noise and vibration in chain saws established by the FAO/ECE/ILO Joint Committee on Forest Working Techniques and Training of Forest Workers. Following several meetings of this group in Czechoslovakia, the Federal Republic of Germany, Sweden, the USSR, the United Kingdom and the United States, a final draft version of the code was produced. This draft was then circulated by the ILO to a representative group of independent experts for comment. These experts were selected from employer and worker circles concerned with chain saws. The present version of the code is the result of these consultations.

Although couched in the language of a set of rules, this code has no binding force and is not intended to supersede national laws or regulations or accepted standards; it is merely a body of practical advice for the use of all persons, whether in the public or private sector, who have responsibility for safety and health as affected by the design or use of chain saws, and who may be framing provisions on the subject.

Its value lies in the fact that, like all ILO codes of practice, it embodies the knowledge and experience of many countries.

Contents

1. Scope of the code

1.1. This code describes safety requirements for the design of chain saws, and includes recommendations pertaining to their safe and easy operation. Its provisions apply to portable hand-held fuel and electrically powered portable chain saws which are so designed that the operator's left hand holds the front handle and his right hand holds the rear handle.

1.2. Chain saws which comply with these requirements should not be acceptable under this code if, when examined and tested, they are found to have additional features which reduce the degree of protection contemplated by the code.

1.3 Chain saws made from materials or using forms of construction that differ from those contemplated by this code should be subjected to special examination to determine whether they comply with the intent of the code; if found to be substantially equivalent, they may be given recognition.

2. Definitions

2.1. For the purposes of this code—

(a) "bucking" means the process of cross-cutting a felled tree or a log into lengths;

(b) "choke control" means a control which is used to enrich the fuel/air mixture in the carburettor;

(c) "clutch" means a mechanism for connecting and disconnecting a driven member to and from a rotating source of power;

(d) "drive sprocket" means the toothed part that drives the saw chain;

(e) "engine displacement" means the volume swept by the piston in one-half of a revolution. It is measured in cubic centimetres, and can be calculated as follows:

$$\text{displacement} = \frac{\pi\ (\text{bore})^2}{4} \times (\text{twice crankshaft throw}).$$

(f) "front handle" means the support handle located at or towards the front of the chain saw;

(g) "guide bar" means the part which supports and guides the saw chain;

(h) "kickback" means the upward and/or backward motion of the guide bar which may occur when the saw chain, near the nose or the top area of the guide bar, comes into contact with an object such as a log or branch, or when the wood closes in and pinches the saw chain in the cut;

(i) "muffler" means a device to reduce engine exhaust noise and direct the exhaust gases;

(j) "normal cutting position" means one of the positions adopted in performing the felling and cross-cutting cuts;

(k) "oiler control" means a system for oiling the guide bar and saw chain;

(l) "on/off control" means a control which allows the engine to be started or stopped;

(m) "primer control" or "choke" means a control for supplying extra fuel for starting the engine;

(n) "rear handle" means the support handle located at or towards the rear of the chain saw;

(o) "saw chain" means a loop of chain having cutting teeth which is driven by the engine and is supported by the guide bar;

(p) "spiked bumper (spike)" means the pointed tooth or teeth located between the guide bar and engine for use when felling or bucking, in order to pivot the saw and maintain position while sawing;

(q) "starter" means the mechanism that rotates the engine to start it;

(r) "throttle control latch" means a device which temporarily sets the throttle control valve in a partially open position in order to help the operator to start the engine;

(s) "throttle control linkage" means the mechanism which transmits motion from the throttle control trigger to the throttle control valve;

(t) "throttle control lockout" means a movable stop which, until manually released, prevents the accidental opening of the throttle control valve;

(u) "throttle control system" means the complete system, including the throttle control trigger, the throttle control linkage and, in some cases, a throttle control latch and/or a throttle control lockout;

(v) "throttle control trigger" means the part of the saw (usually a lever, activated by the operator's hand or finger) which controls the throttle control valve; and

(w) "throttle control valve" means the control which regulates the volume of the fuel/air mixture delivered to the combustion chamber of an internal combustion engine.

A. Manufacturing requirements

3. Technical requirements

3.1. General provisions

3.1.1. (1) All chain saws should be designed, constructed and tested in accordance with the relevant national requirements concerning exhaust fumes, noise and vibration levels, marking, durability and other safety factors.

(2) Where there are no relevant national requirements in a particular area of interest, the provisions of this code of practice and the information in its appendices should be observed.

3.2. Design and balance

3.2.1. Chain saws should be of compact design, with smooth surfaces and no hampering details, and should be appropriately balanced to make them safe and easy to handle in the various working positions, i.e. for felling, debranching and cross-cutting.

3.3. Handles, general provisions

3.3.1. Chain saws should be designed and constructed with a front handle and a rear handle that enable the operator to operate the chain saw with two hands.

3.3.2. The position, shape and surface of both handles should enable the operator to take a firm grip of them, even when gloves are worn, in order that the chain saw may be safely controlled in all working conditions and positions, including starting.

3.3.3. The strength of both handles should be adequate. Typical specifications are given in Appendix A.

3.3.4. The clearance and size of both handles should be adequate. Typical specifications are given in Appendix B.

3.3.5. Both handles should either be covered with a non-slip material or their design should be such as to provide a non-slip surface.

3.4. Handles, front

3.4.1. The front handle should be so placed that the chain saw, equipped with a standard guide bar of the length recommended by the manufacturer, remains in a horizontal position when it is being carried by this handle with one hand. Typical specifications are given in Appendix C.

3.4.2. The shape of the front handle should allow the operator easily to change grip and to move his hand along the full length of the handle.

3.4.3. The front handle should be so constructed that no bracket or obstruction will be in the working area of the handle as defined by the arc HJ in Appendix B, figure 2*(c)*. This should not apply to saws with an engine displacement over 82 cm^3.

3.5. Handles, rear

3.5.1. The rear handle should be so placed, in relation to the guide bar, that the chain saw can be easily turned along its longitudinal axis.

3.5.2. The rear handle should be so designed as to give ample room behind the throttle control trigger for a hand, even when wearing gloves. Typical specifications are given in Appendix B.

3.6. Weight

3.6.1. Chain saws should be so designed and constructed that the total weight of the saw in relation to the engine displacement is kept as low as possible.

3.7. Noise

3.7.1. (1) Whenever technically feasible, chain saws should be so designed and constructed that the operator is not exposed to harmful noise.[1]

(2) Chain saw noise levels should be measured in accordance with appropriate national standards.

(3) Where such standards do not exist, the methods of measurement given in Appendix D, Part II, may be used.

(4) Typical values for safe noise levels related to exposure time based on equal energy criteria are contained in Appendix D.

3.7.2. (1) When operators are exposed to noise levels in excess of established levels, or their eight-hour equivalent, either the duration of their exposure to the harmful noise should be reduced or they should be provided with personal hearing protection.[2]

(2) This reduction in exposure time or the use of the hearing protection should reduce the exposure of the operator to a level equal to or lower than the equivalent eight-hour continuous sound level of the established safe noise exposure level.

3.7.3. (1) Attenuation of noise as a result of ear protection should be measured in accordance with appropriate national standards.

(2) Where such standards do not exist, the methods of measurement given in Appendix D, Part III, may be used.

3.7.4. (1) Chain saws should be marked in a visible place with a clear and durable text along the following lines, or its equivalent in the language(s) required by government regulations: "Use hearing protectors at all times when operating this machine."

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[1] See ILO: *Protection of workers against noise and vibration in the working environment* (Geneva, 1977).

[2] See Appendix paragraph D.I.3.3 and table 4.

(2) An approved warning sign[1] may replace or accompany the above text.

3.8. Exhaust fumes

3.8.1. (1) Chain saws should be so designed and constructed (as regards fuel/oil mixture, direction of muffler outlet, carburettor, fuel/air mixture, reduction of fumes, etc.) that the operator is not exposed to harmful levels of exhaust fumes under normal working conditions.

(2) The exhaust flow should be away from the chain saw, and away from the operator when in the normal cutting position.

3.8.2. The maximum concentration of harmful gases at the level of the operator's head should not exceed the established threshold limit values for the relevant chemical substances under normal environmental conditions, including work with the chain saw in deep snow or under a thick network of branches in calm, windless weather.

3.9. Handle vibration isolation

3.9.1. (1) Chain saws should be so designed and constructed that the operator is not exposed to harmful vibration under normal working conditions.

(2) The vibration level in the handles of the saw should not exceed the established national vibration threshold limit value for a daily exposure of eight hours.

(3) Typical methods of measurement of vibration in chain saws are given in Appendix E.

3.9.2. The vibration isolation system should be of durable construction, and the vibration damping capacity should not deteriorate during normal use of the chain saw or as a result of climatic conditions.

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[1] See ILO: *Protection of workers against noise and vibration in the working environment*, op. cit., Appendix 5, figure 2.

3.9.3. Anti-vibration devices such as vibration isolators and dampers should be so constructed that a failure of one or more of the isolators does not result in a loss of ability by the operator to control the chain saw.

3.9.4. (1) Vibration isolators and dampers should be replaceable.

(2) The manufacturer should indicate in the maintenance instructions[1] the recommended intervals for the inspection, maintenance and replacement of vibration isolators and dampers.

3.9.5. The anti-vibration devices should be so constructed that the relative motion between the body of the saw and the handles resulting from the softness of the isolators does not make the chain saw difficult to guide or adversely influence the throttle control system.[2]

3.10. Heating of handles

3.10.1. (1) Where required, chain saws should be equipped with heating facilities for both handles.

(2) The heating device should be so designed that it is easy to turn on, adjust, turn off and service.

3.11. Starting devices

3.11.1. (1) Chain saws should be so designed and constructed as to prevent the chain from moving during starting operations, or should be equipped with a device to serve this purpose.

(2) A chain brake may fulfil this requirement.

3.11.2. The handle of an automatically rewinding starter rope should be so designed that it cannot cause hand injuries, for example when an engine backfires.

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[1] See section 4.4.

[2] See also paragraph 3.16.2.

3.11.3. Chain saws, if equipped with a rope or rewind starter, should not require a cranking effort exceeding the established levels. Typical values are given in Appendix F.

3.12. Clutch devices

3.12.1. Chain saws should be so designed and constructed (for instance, with a clutch device) that the saw chain will automatically become disengaged when the engine speed is reduced below a certain level.

3.12.2. The relationship between the engine idling speed (throttle control trigger not activated) and the engine speed for chain engagement (i.e. when the saw chain becomes powered) should be at least 1 : 1.25.

3.13. Throttle control system

3.13.1. Chain saws should be equipped with a constant pressure throttle control system that will automatically shut off the power to the saw chain when pressure on the throttle is released.

3.14. Throttle control trigger

3.14.1. The throttle control trigger should be located in such a position that it can be actuated and released by the operator only while his hand is gripping the rear handle.

3.14.2. There should be a guard completely surrounding the trigger in the plane of the trigger motion.[1]

3.15. Throttle control lockout

3.15.1. (1) Chain saws should be equipped with a throttle control lockout for locking the throttle control trigger in the idling position only, in order to prevent the accidental engagement of the throttle.

[1] A continuous loop formed by the rear handle and the body of the chain saw will satisfy this requirement.

(2) The throttle control lockout should be so constructed that it must be activated before the throttle control valve can be opened.

3.15.2. The throttle control lockout should not prevent the engine from returning to idling speed.

3.15.3. The throttle control lockout should be located on the rear handle, and be so designed that the operator must maintain a steady handhold in the various working positions.

3.16. Throttle control linkage

3.16.1. The throttle control linkage should be adequately protected by enclosure.

3.16.2. The throttle control linkage should be so constructed that a force of three times the empty weight of the chain saw (without guide bar and saw chain), applied to the rear handle in any direction, will not cause engagement of the saw chain.

3.17. Carburettor

3.17.1. The throttle control valve on the carburettor should return to the idling position if the throttle control linkage becomes disconnected, regardless of the position of the chain saw.

3.18. Throttle control latch

3.18.1. If a throttle control latch is provided, it should be self-releasing when the throttle control trigger is depressed.

3.18.2. The throttle control latch should be so constructed that two or more independent motions are required to engage the latch. A single-motion throttle control latch is acceptable provided that it does not cause the chain to become powered when it is engaged.

3.18.3. Chain saws should have no devices for locking the trigger other than the throttle control lockout and the throttle control latch.

3.19. On-off control switch

3.19.1. (1) Chain saws should be equipped with a reliable device for switching off the engine.

(2) The device should be placed in such a position that it is accessible to the hand operating the throttle control, so that the operator can stop the engine without releasing his grip on the saw.

(3) The device should be designed as a switch (not as a button) with distinct "on" and "off" positions.

(4) The device should require deliberate activation before the engine can be restarted.

(5) The device should be so designed that it may be placed in the "off" position even when the operator is wearing gloves or mittens.

3.19.2. The "off" position of the device should be visibly and durably marked with the word STOP.

3.20. Front handle guard

3.20.1. (1) Chain saws should be equipped with a front handle guard, placed forward of the handle.

(2) The front handle guard should be designed to stop the operator's hand from contacting the moving chain if his hand slips from the front handle.

(3) The front handle guard should be of durable construction, firmly and permanently attached to the chain saw, and should be so designed that it will not hamper the operator when he changes his grip or moves his hand along the front handle.

(4) The front handle guard may also be a means of activating the chain brake.[1]

3.20.2. The dimensions and clearances of the front handle guard should be adequate. Typical specifications are given in Appendix G.

[1] See section 3.21.

3.20.3. The front handle guard should be designed to withstand a blow from a 0.70 kg pendulum having a length of 0.70 m and a drop height of 0.20 m.[1]

3.21. Chain brake

3.21.1. Chain saws should be equipped with a chain brake.

3.21.2. The front handle guard may be combined with the chain brake mechanism and serve as a lever to actuate the chain brake when any part of the operator's body comes into contact with the front handle guard.

3.21.3. (1) The brake should stop the chain within 0.1 s after its engagement, when tested in accordance with the procedure indicated in Appendix H.

(2) A typical method of testing chain brakes which are combined with front handle guards is given in Appendix H.

3.21.4. The force required to operate the brake should not exceed 80 N.

3.21.5. (1) The chain brake should be designed to withstand a blow from a 0.70 kg pendulum having a length of 0.70 m and a drop height of 0.20 m.[2]

(2) These measurements should be made and the test conducted at temperatures of *(a)* + 30°C; and *(b)* −30°C.

3.22. Rear handle guard

3.22.1. The bottom part of the rear handle should be designed as a guard so as to protect the operator's hand from injury if the chain breaks.

3.23. Chain catcher

3.23.1. Chain saws should be equipped with a chain catcher, placed under the saw chain as far to the front of the body of the

[1] See also paragraph 3.21.5 (1).

[2] See also paragraph 3.20.3.

chain saw as practically possible, and designed to restrict the whip backwards of the saw chain if it breaks.

3.24. Underside

3.24.1. The underside of the body of the chain saw should be smooth, in order to allow the chain saw to slide easily along the tree trunk, particularly during debranching.

3.25. Other guards

3.25.1. Chain saws should be so designed and constructed that no part of the clutch, starter or pulleys will be thrown towards the operator in the event of failure of these parts.

3.25.2. (1) All power-driven shafts, gears, flywheels and starter pulleys should be totally enclosed by guards or should be protected, by other non-moving parts of the chain saw or saw housing, from contact by any part of the operator's body.

(2) The top, sides and rear of the clutch and sprocket should be guarded to prevent contact by a probe having a 13 mm hemispherical end.

(3) When the chain saw is equipped with a wrap-around front handle, the sprocket guard should extend at least 13 mm below the saw chain cutter teeth.

3.25.3. Where perforated material is used for guards, the holes should be of such a size or design as not to admit a test probe having a 13 mm hemispherical end.

3.25.4. The engine and the silencer should be so located or guarded that the operator may not inadvertently contact any hot surface when starting or operating the chain saw in the normal working positions.

3.26. Chip discharge

3.26.1. Chain saws should be so designed that the main stream of wood chips and sawdust will not be directed above the operator's waist when cutting in the normal cross-cutting position.

3.27. Fuel and oil tanks

3.27.1. (1) The filler openings of the fuel and oil tanks should be so located that the operation of filling the tanks is not obstructed by the chain saw components.

(2) The filler caps or openings should be clearly and durably identified.

(3) If only the filler caps are identified, they should not be interchangeable.

(4) The filler caps should be attached to the chain saw with chains or other adequate means.

3.27.2. The minimum diameter of the filler opening of the fuel tank should be 20 mm.

3.27.3. The minimum diameter of the filler opening of the oil tank should be 15 mm.

3.27.4. The chain saw should not require additional support to maintain a stable position for filling the tanks.

3.27.5. The oil tank should be large enough not to run out of oil before the fuel tank empties under normal usage.

3.28. Choke control

3.28.1. Where a manual choke control is provided, it should be clearly and durably identified.

3.29. Spiked bumper

3.29.1. (1) On all chain saws provision should be made for mounting a spiked bumper.

(2) A spiked bumper should be mounted when the work requires it.

3.30. Sprocket

3.30.1. The size and dimensions of the sprocket should match the guide bar and chain pitch being used, in accordance with the chain saw manufacturer's recommendations.

3.31. Guide bar

3.31.1. The size and dimensions of the guide bar should match the chain pitch being used, in accordance with the chain saw manufacturer's recommendations.

3.31.2. All guide bars should be permanently marked with the gauge of the saw chain as well as the gauge of the sprocket of the bar.

3.31.3. Except for the mounting slot, no opening (hole) with a dimension greater than 10 mm should be in the cutting area of the guide bar.

3.32. Saw chain tensioning

3.32.1. (1) On all chain saws provision should be made for adjusting the guide bar to obtain the proper saw chain tension, as recommended by the saw chain manufacturer.

(2) Tensioning should be carried out according to the chain saw manufacturer's instructions.

3.33. Saw chains

3.33.1. The size, dimension, mechanical strength and durability of saw chains should comply with the chain saw manufacturer's recommendations.

3.33.2. The saw chain should be so designed that the kickback tendency is reduced.

3.34. Safety warning markings

3.34.1. Chain saws should be clearly and permanently marked in a readily visible and protected location with the following instructions or their equivalent in the language(s) required by government regulations: "For safe operation follow all prescribed safety precautions."

3.35. Marking/identification

3.35.1. (1) The marking of chain saws should form a durable bond with the base material, and should show no appreciable loss of adhesion due to exposure to weather.

(2) The marking should be weather resistant and, following normal cleaning procedures, should show no appreciable fading, discoloration, cracking, crazing, blistering or dimensional change.

(3) The marking should not be affected by spilled fuel or oil.

(4) The marking should be located on a permanent part of the equipment or on a separate name-plate which should be permanently attached to the chain saw.

(5) The marking should be anographed, die-stamped or indented, cast, embossed or suitably lithographed, or should be a durable label.

3.35.2. (1) Chain saws should be provided with markings regarding—

(a) hearing protectors (see paragraph 3.7.4);

(b) on-off control switch (see paragraph 3.19.2);

(c) filler openings of the fuel and oil tanks (see paragraph 3.27.1);

(d) choke control (see paragraph 3.28.1);

(e) safety warnings (see paragraph 3.34.1);

(f) manufacturer's name and location, trade name, or other recognised symbol of manufacture; and

(g) model number of the complete equipment.

(2) These basic markings should:

(a) be located in a readily visible place on the unit;

(b) be on a permanent part of the equipment that is not normally removed for servicing; and

(c) when concerned with the operation of equipment, be located where they are readily visible to the operator when performing the operation.

3.36. Guide bar cover

3.36.1. Chain saws should be provided with a transportation sheath to cover the guide bar and saw chain during transportation of the chain saw. The cover should be durable, and should be easy to attach and remove.

3.37. Fire hazards

3.37.1. The fuel tank should be so constructed that, when the saw is tested in accordance with the procedure indicated in Appendix J, no liquid fuel will boil over or spill from the filler opening.

3.38. Muffler design and construction

3.38.1. (1) When the muffler is equipped with a spark arrester screen, this should be made of chromium alphatised mild steel, 410 stainless steel, inconel or an equivalent grade of steel.

(2) No opening in the spark arrester screen should be greater than 6 mm in the largest dimension.

3.38.2. When the muffler is provided with a spark arrester screen, this should be so designed that it may be readily inspected and cleaned.

3.38.3. (1) The exhaust system for the chain saw should be so designed that the exhaust gas temperature does not exceed 260°C when measured at a distance of 150 mm from the point of the muffler outlet nearest to the point where the gas would strike forest fuel.

(2) This test should be conducted when the ambient temperature is between 26°C and 29°C.

3.39. Oiler control

3.39.1. If a chain saw is equipped with a manual saw chain oiler control, this should be so located that it can be operated while both the operator's hands maintain a grip on the handles.

3.40. Tools

3.40.1. Chain saws should be provided with a screwdriver, a sparking-plug wrench and a tool to remove the saw chain and guide bar and allow for the proper adjustment of the saw chain. Tools may be of the combination type.

3.41. Electrically powered chain saws

3.41.1. Operators of electrically powered chain saws should be protected against electric shocks by one of the following means:

(a) the use of an electric chain saw which is properly earthed;

(b) the use of a double-insulated electric chain saw; or

(c) the use of an earth fault circuit interrupter in the power circuit supplying the electric chain saw.

3.41.2. The attachment cable for an electric chain saw should be properly insulated, and should be provided with a strain relief device at the point of entry into the body of the chain saw.

3.41.3. The attachment cable should be provided with a plug consistent with the shock protection provided under paragraph 3.41.1.

3.41.4. The cable supplying power to the electric chain saw should be—

(a) fitted with a properly installed outlet which is approved as weather-proof and is consistent with the type of plug on the chain saw attachment cable;

(b) approved for use in outdoor damp locations; and

(c) of a heavy duty type.

3.41.5. Only qualified persons should—

(a) rigidly connect power supply cables to power sources;

(b) repair damaged power supply or attachment cables; or

(c) repair the electrical parts of electric chain saws.

3.41.6. The power switch on electric chain saws should be—

(a) of a moisture-proof type properly installed and insulated from the body of the chain saw;

(b) of such a type that the power will be automatically shut off in all cases whenever the operator releases it; and

(c) so located or protected as to minimise the possibility of its accidental operation.

4. Instructions

4.1. General provisions

4.1. Each chain saw should be provided with the following items:

(a) operator's manual;

(b) technical specifications;

(c) maintenance instructions; and

(d) parts list.

4.2. Operator's manual

4.2.1. The operator's manual should provide instructions for the correct installation and adjustment of the guide bar and saw chain.

4.2.2. The operator's manual should provide basic instructions for starting and stopping the chain saw safely.

4.2.3. The operator's manual should explain the correct techniques for making felling, debranching and cross-cutting cuts with the chain saw.

4.2.4. The operator's manual should list at least the following safety considerations:

(a) Fatigue causes carelessness. Take sufficient rest periods and breaks when operating a chain saw.

(b) Safety clothing as required by your safety organisation, government regulations or employer should be worn. Otherwise snug-fitting clothing, gloves, safety footwear and head and ear protection should be worn.

(c) Before fuelling, servicing or transporting your chain saw, switch off the engine. To help to prevent fire, restart the chain saw at least 3 m from the fuelling area. Never smoke when fuelling the chain saw or handling fuel.

(d) Under conditions favouring the outbreak of forest fires, it is recommended that a fire extinguisher be provided.

(e) Follow the instructions in your operator's manual for starting the chain saw, and control it with a firm grip on both handles when it is in operation. Keep handles dry, clean and free from oil. Carry a chain saw with its engine running (idling) over short distances only. Otherwise cut off the engine or activate the chain brake and carry the chain saw with the guide bar pointing to the rear and with the muffler preferably away from the body.

(f) Keep a sufficient distance (at least two tree lengths) between yourself and your fellow workers when felling.

(g) Plan your work; ensure that you have an obstacle-free work area and, in the case of felling, an escape path from the falling tree.

(h) When you are starting a chain saw or cutting with a chain saw, other persons must keep a distance at least 2 m away from the chain saw.

(i) Appropriate transportation covers for the guide bar and saw chain should be provided.

(j) Never 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. Never adjust the guide bar or saw chain when the engine is operating.

(k) Beware of carbon monoxide poisoning. Operate the chain saw in well ventilated areas only.

(l) Do not attempt a pruning or debranching operation on a standing tree unless you are specifically trained to do so.

(m) Guard against kickback, which can lead to a dangerous loss of control of the chain saw.

To avoid kickback—

(i) take a firm grip of the chain saw, with thumbs and fingers encircling the handles;

(ii) avoid reaching out too far with the chain saw;

(iii) avoid cutting above shoulder height; and

(iv) follow the manufacturer's instructions for sharpening and maintaining the saw chain.

(n) In the case of electrically powered chain saws—

(i) do not make any adjustment to your electric chain saw without disconnecting it from the power source;

(ii) make sure your power supply cable is in good condition; and

(iii) do not use poorly insulated or defective cables.

4.3. Technical specifications

4.3.1. Full technical specifications should be provided with each chain saw, concerning the following items:

(a) engine displacement;

(b) r.p.s. at maximum no-load engine speed;

(c) r.p.s. at idling speed;

(d) r.p.s. at saw chain engagement speed;

(e) weight, fully equipped for use and filled with fuel and oil;

(f) internal clearances of rear handle (see Appendix B);

(g) noise level (see Appendix D);

(h) exhaust fumes;

(i) vibration level (see Appendix E);

(j) chain brake efficiency (see Appendix H);

(k) heating of handles;
(l) throttle control system;
(m) throttle control lockout;
(n) on-off control switch;
(o) front handle guard;
(p) rear handle guard;
(q) chain catcher;

} Description and method of operation

(r) appropriate fuel/oil mixture;
(s) saw chain—
(i) type;
(ii) pitch;
(iii) durability; and
(iv) kickback tendency (see Appendix I); and
(t) saw chain lubrication oil specifications for various climatic conditions.

4.4. Maintenance instructions

4.4.1. The maintenance instructions should include basic instructions for the proper inspection and maintenance of the chain saw, particularly as regards the following items:

(a) guide bar;
(b) saw chain tensioning device;
(c) sprocket and sprocket guard;
(d) chain lubricating device;
(e) front handle guard;
(f) chain brake;
(g) throttle control lockout;
(h) rear handle guard and chain catcher;
(i) starting and stopping devices;
(j) clutch and engine idling speed (r.p.s.);
(k) silencer;

(l) cap of fuel tank;
(m) handle vibration isolation devices;
(n) saw chains: filing, exchange, discarding;
(o) running in of sprocket, guide bar and saw chains; and
(p) lubrication and greasing.

B. Preventive maintenance

5. Operator's regular maintenance

5.1. General provisions

5.1.1. Maintenance of the chain saw should be carried out by the operator as—

(a) pre-operating measures;

(b) daily measures; and

(c) weekly measures.

5.1.2. The maintenance should follow the manufacturer's recommendations.

5.1.3. Broken or defective items should be replaced immediately.

5.2. Pre-operating measures

5.2.1. The following measures should be taken after each refuelling of the chain saw:

(a) inspect the chain saw generally, and in particular the front and rear handles, the throttle controls and the attachment of the guide bar;

(b) check the condition of the saw chain cutters. Replace damaged cutters, or change the entire saw chain (see section 7.2). The cutters may also be sharpened at the same time;

(c) check the saw chain tension and adjust if necessary, according to the manufacturer's instructions;

(d) lubricate the roller or sprocket nose of the guide bar according to the manufacturer's instructions; and

(e) inspect and test the automatic saw chain lubrication system.

5.3. Daily measures

5.3.1. The following measures should be taken daily or after every six to eight operating hours:

(a) inspect the chain brake and test its effectiveness. Start the engine and at full throttle apply the chain brake. Adjust the brake according to the manufacturer's instructions;

(b) inspect and test the front handle guard. Adjust as necessary to ensure that it is in its correct position and that it is tight;

(c) inspect and test the saw chain disengagement system;

(d) clean the guide bar groove and saw chain oil lubricating hole;

(e) inspect the guide bar for alignment. Turn it before mounting, if necessary;

(f) inspect the condition of the saw chain, replacing if necessary. Sharpen the saw chain; and

(g) check that all nuts, bolts and screws are properly tightened.

5.4. Weekly measures

5.4.1. The following measures should be taken weekly or after every 30 to 40 operating hours:

(a) inspect and clean the starting device, paying particular attention to the condition of the starter rope and the tension on the rewinding spring;

(b) inspect, and replace if necessary, the guide bar roller or sprocket nose;

(c) remove any burrs on guide bar edges, using a flat file;

(d) inspect the sprocket or drive rim for wear. Replace the sprocket or drive rim when the tops of the teeth have worn excessively or more than 1.0 mm;

(e) inspect the saw chain, in particular the wear on the rivet heads or drive links; and

(f) file and sharpen the saw chains thoroughly according to the manufacturer's instructions.

6. Sprocket/drive rim and guide bar

6.1. General provisions

6.1.1. To reduce the possibility of damage to the guide bar and saw chain, the following measures should be taken:[1]

(a) check regularly the teeth of the sprocket or drive rim for damage and abnormal wear. Change the sprocket or drive rim when the tops of the teeth have been worn excessively or more than 1.0 mm;

(b) use only saw chains and sprockets of the same pitch;

(c) never use saw chains with damaged drive links;

(d) check regularly that the saw chain is properly tensioned; and

(e) use two saw chains alternately with the same guide bar and sprocket in order to keep the total wear to a minimum.

7. Saw chain

7.1. Running in

7.1.1. The durability of the saw chain depends to a great extent on the first hours of use. The careful running in of a new saw chain is therefore essential.

7.1.2. The following steps are recommended when running in a new saw chain:

(a) before mounting the saw chain, check that the guide bar and the sprocket are undamaged, and that the saw chain and the sprocket have the same pitch;

[1] The sprocket or drive rim, guide bar and saw chain should be considered as one unit and should therefore be inspected simultaneously. A worn sprocket or rim will, in a short period of time, cause excessive damage to the saw chain and will subsequently damage the guide bar. In the same way, a damaged saw chain or guide bar may cause damage to the sprocket or rim.

(b) mount the saw chain and adjust the tension correctly. It should be possible to move the saw chain along the guide bar easily with the fingers, and to lift it up approximately 5 mm at the middle of the guide bar;

(c) start the engine, and let the saw chain move at an engine speed just above that for saw chain engagement. The saw chain should be moving without load and be abundantly lubricated. Let it move for approximately five minutes;

(d) stop the engine and check the saw chain tensioning. Tension the saw chain if necessary;

(e) start the engine and repeat the above procedure two or more times;

(f) make some light cuts with the saw chain, without imposing a heavy load on the engine. Check that the saw chain is being properly lubricated. Stop the engine and let the saw chain and the guide bar cool. Adjust the saw chain tensioning if necessary; and

(g) during the first hours of operation with the new saw chain, observe in particular the saw chain tensioning and lubrication.

7.2. Discarding

7.2.1. Saw chains should be discarded in accordance with the manufacturer's instructions or the following guidelines:

(a) when the toe, head of a cutter or tie strap is worn down to the level of the rivet heads;

(b) when a cutter has been filed back to the top plate length of 4 mm; or

(c) when the saw chain becomes unusually stiff as a result of seizing in the rivets.

7.3. Repair

7.3.1. (1) Saw chains should be repaired only in accordance with the manufacturer's instructions.

(2) The correct tools should be used when replacing broken or damaged links.

(3) Saw chains should be repaired when a cutter is broken or when any part is broken off from any link or rivet head.

C. General safety precautions

8. Employers' duties and responsibilities

8.1. Medical examination

8.1.1. All personnel recruited for professional work with chain saws should pass a medical health examination in accordance with national requirements.

8.1.2. Attention should be given to the chain saw operator's physical qualifications and fitness for the job and in particular to possible hearing impairment or vibration diseases.

8.1.3. Medical examinations of chain saw operators should be repeated at regular intervals in accordance with national requirements.

8.2. Age limit

8.2.1. No person under 18 years of age should be employed as a chain saw operator.

8.3. Training

8.3.1. (1) All workers using chain saws should be adequately trained for the work.

(2) The basic training should include instruction regarding the hazards of the work and the precautions necessary to prevent accidents and injuries to health.

(3) Chain saw operators should also be trained in chain saw preventive maintenance, including cases when the chain saw needs to be repaired for safety reasons, and when parts such as the saw chain, guide bar or sprocket need to be replaced.

8.3.2. (1) Selected workers should be trained in first-aid procedures.

(2) Workers' safety representatives should be given additional training in the identification of hazards and the procedures for accident prevention.

8.4. Personal safety equipment

8.4.1. (1) The employer should provide each chain saw operator with adequate personal safety equipment in accordance with national requirements.

(2) Protective equipment should conform at least with any national standards or (where national standards do not exist) with international standards.

8.4.2. Such safety equipment may consist of—

(a) safety helmet;
(b) hearing protection devices (ear protectors);
(c) safety footwear;
(d) protective gloves;
(e) eye protectors;
(f) leg protectors;
(g) helmet neck-guard (against rain, snow, etc.);
(h) helmet hood; and
(i) adequate working clothes.

8.5. First-aid kit

8.5.1. The employer should provide each chain saw operator with a suitable individual first-aid kit.

8.6. Working tools

8.6.1. The employer should ensure that each chain saw operator is equipped with adequate tools and equipment for safe work, such as felling levers, wedges, lifting devices (hooks, tongues), and so on.

8.7. Safety regulations

8.7.1. The employer should issue safety regulations for work with chain saws in logging operations.

8.7.2. Particular attention should be paid to—

(a) the division and distribution of working areas between chain saw operators;

(b) the safety distance between chain saw operators felling trees;

(c) felling techniques, particularly for controlling directional felling;

(d) the taking down of lodged (hung-up) trees; and

(e) the interruption of work in recognition of hazards, such as high winds, crown snow-load or overhead cables.

8.8. Safety distance

8.8.1. The safety distance between individual fellers or felling teams should be at least twice the length of the tallest tree being felled at the worksite.

8.8.2. If for any reason the safety distance cannot be observed, supervisory staff should give detailed instructions.

8.9. Planning and supervision

8.9.1. All felling operations should be planned by a competent person.

8.9.2. The work in the felling area should be supervised by a competent person.

8.9.3. In planning and supervision, care should be taken to ensure that particular attention is paid to the following:

(a) all items listed in sections 8.6 and 8.7;

(b) accident preparedness (communications, transport, first-aid equipment, stretchers, and so on, in case of accidents or sickness);

(c) assignment of first-aid men (at least one man per felling area);

(d) assignment of workers' safety representatives (one safety representative per worksite); and

(e) provision of suitable huts (for instance, workers' cabins) for resting and meal-breaks, with separate space for drying clothes and for chain saw maintenance.

8.9.4. (1) Areas in which felling is in progress should be indicated by notices or warning signs prominently displayed on recognised approaches.

(2) Unauthorised persons should not enter the area thus indicated.

8.10. Working alone

8.10.1. Chain saw operators should always work within hearing distance of other workers.

8.11. Lodged (hung-up) trees

8.11.1. The employer should ensure that adequate aids for taking down lodged trees are available at the felling site.

8.12. Miscellaneous provisions

8.12.1. No felling operation should be carried on in high winds, thunderstorms or bad visibility.

8.12.2. No tree should be felled that is liable to endanger road or rail traffic as it falls, unless adequate precautions have been taken to protect the traffic.

8.12.3. Felling and associated operations in the vicinity of high voltage and other electrical lines should not be undertaken unless:

(a) arrangements have been made with the competent authority for taking such precautions as may be necessary to prevent danger; and

(b) the work is done under competent supervision.

9. Operators' duties and responsibilities

9.1. General provisions

9.1.1. Operators should take good care of and make proper use of all safeguards, protective equipment and safety devices provided by themselves or the employer for their own protection or the protection of others.

9.1.2. Safety rules or regulations and safe working procedures should be observed.

9.1.3. Any defect noticed in tools or protective equipment should be reported to a responsible person and corrective action taken.

9.1.4. Operators should not engage in any work for which they do not have the proper training or experience.

9.1.5. Chain saws should be inspected before work is begun, to ensure their safe and proper operation.

9.1.6. An adequate type and number of working tools (such as felling levers and wedges) should be used in all operations.

9.1.7. Operators should never work alone and should always have an individual-type first-aid kit.

9.2. Starting up

9.2.1. (1) Chain saws should be started up only when the following requirements have been met:

(a) they have been placed on firm ground where they cannot easily slip;

(b) the saw chain cannot accidentally catch in any obstruction; and

(c) no person other than the operator is within 2 m of the chain saw.

(2) Chain saws should be started up on the ground and not in the cuts.

9.3. Refuelling

9.3.1. When refuelling, chain saw operators should—

(a) not fill the tank while the engine is running;

(b) place the saw on bare ground;

(c) if the saw is hot, wait until it has cooled down sufficiently;

(d) remove any fuel oil, lubricating oil or dirt from the surface;

(e) move the saw to another place before restarting; and

(f) not smoke, strike matches or have any open flame near the saw.

9.4. Cleaning of chain saws

9.4.1. Chain saws should not be cleaned, oiled or adjusted with the engine running.

9.4.2. Operators should—

(a) keep the chain saw as free of sawdust and oil as possible;

(b) keep the exhaust ports free of carbon; and

(c) keep flammable material away from the cut.

9.5. Cutting

9.5.1. When sawing, operators should—

(a) secure a good footing;

(b) remove all obstructions from the path of the saw; and

(c) communicate by signal and take such additional precautions as are made necessary by the noise.

9.6. Kickbacks

9.6.1. (1) To prevent kickbacks when cutting with the forward-running part of the saw chain, especially when starting the cut, the engine should be run at full speed before cutting.

(2) To prevent kickbacks when cutting with the backward-running part of the saw chain, care should be taken that the forward-running part does not jam.

9.7. Wedges

9.7.1. When cutting with chain saws, wooden, plastic or soft metal wedges should be used.

9.8. Transportation

9.8.1. (1) When petrol-driven chain saws are being transported, the motor should be stopped, except for short distances from cut to cut (for example during debranching or cross-cutting operations).

(2) During storage and transport over longer distances, the saw chain should be protected by a sheath.

9.9. Exhaust gases

9.9.1. Chain saws should not be run inside buildings unless these are adequately ventilated, because of the danger represented by the exhaust gases.

9.9.2. When working outdoors in deep snow, thick undergrowth or in other areas where exhaust fumes are not quickly dispersed, the operator should pay particular attention to the dangers of carbon monoxide poisoning.

A. Handle strength

Chain saw handles should not break when tested in accordance with the procedure indicated in this appendix.

Chain saw handles should be subjected to the static test loads separately applied, at the handle grip, midpoint, in each of six directions as specified in table 1, and illustrated in figure 1. The chain saw should be supported at the guide bar mounting pad when the test loads are applied.

Table 1. Chain saw handle test loads

Engine displacement (cm^3)	Minimum loads (N)		
	Front and rear X_1 and X_2	Up and down Y_1 and Y_2	Right and left Z_1 and Z_2
Up to 49	900	900	450
50-81	1 300	1 300	700
82 and above	1 800	1 800	900

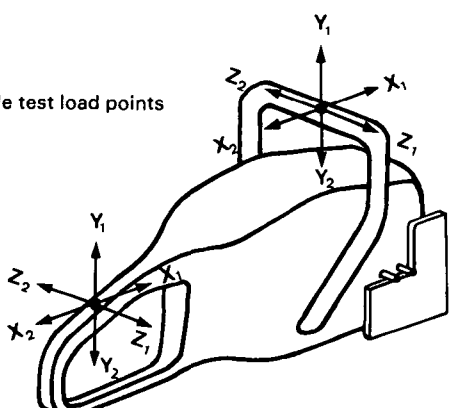


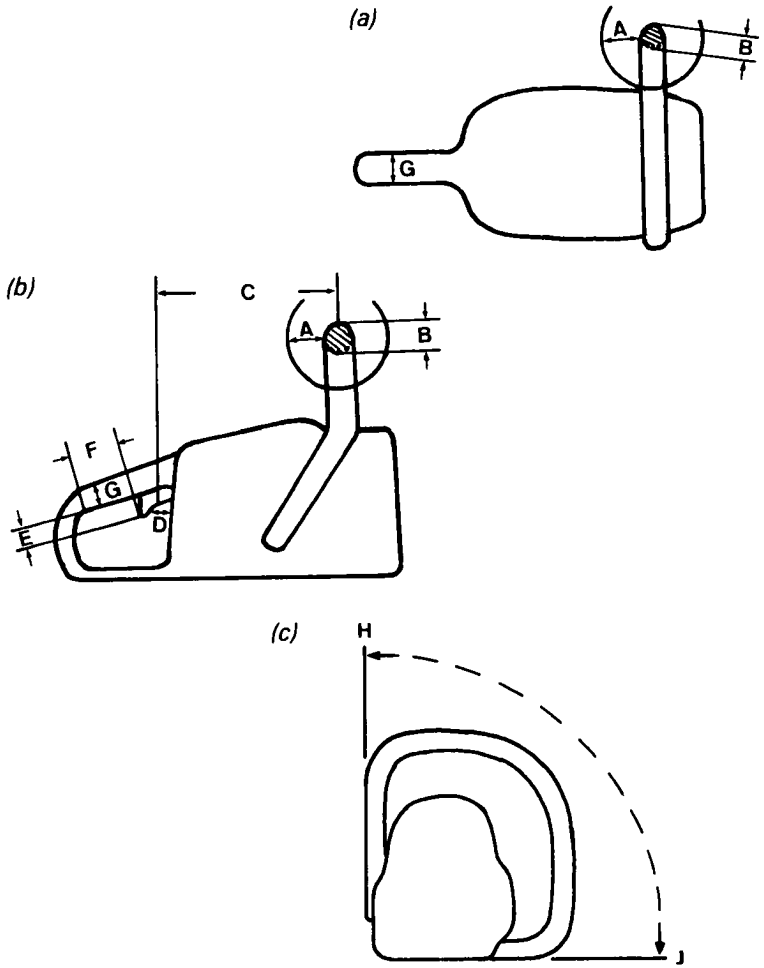
Figure 1.
Chain saw handle test load points

B. Minimum handle clearances and sizes

Table 2. Minimum handle clearances and sizes

Handle	Description	Dimension in figure 2*(a)* and *(b)*	Minimum size (mm)
Front	Finger clearance in the handle grip area	A	35
	Projected thickness	B	11
	Handle perimeter		60
	Clearance between finger on throttle trigger and centre line on front handle (measured parallel to centre line of guide bar)	C	180
Rear	Finger clearance at the released throttle control trigger	D	35
	Finger clearance behind the throttle control trigger	E	32
	Hand width clearance	F	76
	Projected thickness	G	19
	Handle perimeter		89

Figure 2. Finger and hand clearances



C. Balance

With the oil and fuel tanks of the chain saw at least half full, and with the length of the guide bar as specified in table 3, the following criteria should apply:

(a) the centre line of the guide bar should not be at an angle greater than 15° above or below the horizontal when the chain saw is held by the front handle gripping area with the crankshaft in the horizontal plane; and

(b) for chain saws with an engine displacement of up to 100 cm^3, the guide bar should not touch the horizontal plane at the base of the chain saw when the chain saw is resting on a flat plane.

Table 3. Length of guide bar

Engine displacement (cm^3)	Length of guide bar[1] (cm)
Up to 49	33
50-64	40
65-79	50
80-99	60
100 and above	80

[1] Tolerance ± 3 cm.

D. Noise

D.I. Safe sound tolerance levels related to exposure time

D.I.1. Introduction

D.I.1.1. This appendix is based on the equal energy concept for hearing conservation which accumulates each exposure to noise into a daily dosage; it also indicates a possible allowance for the intermittent nature of the exposure of chain saw operators to noise. It indicates how much daily exposure to noise can be tolerated with a minimum risk of permanent hearing loss, and recommends the use of ear protectors where this exposure will be exceeded.

D.I.2. Methods of determining exposure time of chain saw operators to noise

D.I.2.1. Time studies, production results and fuel consumption tests indicate that regular chain saw operators are exposed to sound levels in excess of 85 dB(A) for between two and five hours per eight-hour day. The shorter duration occurs when, for example, large trees are being felled or the operation includes the measuring of timber and the stacking of pulpwood by hand. The longer duration is exceptional and is unlikely to occur day after day; examples include continuous cross-cutting, or felling and debranching medium-sized trees with deep crowns.

D.I.3. Tolerance of the human ear to noise

D.I.3.1. Once a person has been trained to use a chain saw, it is likely that he will continue to be a machine operator for the rest of his working life. There is consequently a risk of noise-induced hearing loss. Some operators have already suffered some permanent hearing loss from medical causes or from exposure to noise in other work; such operators are particularly susceptible to further noise-induced hearing loss and should not be exposed to damaging noise at work.

D.I.3.2. National standards for safe equivalent continuous noise levels vary. Some standards are based on the equal energy concept, which assumes that the exposure time is halved for each doubling of the energy or for each 3 dB(A) increase. Other national standards hold that intermittent noise is less damaging and that in this case exposure times can be

Table 4. Exposure times

dB(A)	Equal energy in 3 dB(A) steps				Intermittent energy in 5 dB(A) steps			
	85 dB(A)		90 dB(A)		85 dB(A)		90 dB(A)	
	Hours	Minutes	Hours	Minutes	Hours	Minutes	Hours	Minutes
85	8				8			
86	6	30			7			
87	5				6	10		
88	4				5	20		
89	3				4	40		
90	2	30	8		4		8	
91	2		6	30	3	30	7	
92	1	30	5		3		6	10
93	1	15	4		2	40	5	20
94	1		3		2	20	4	40
95			2	30	2		4	
96			2		1	45	3	30
97			1	30	1	30	3	
98			1	15	1	20	2	40
99			1		1	10	2	20
100					1		2	
101							1	45
102							1	30
103							1	20
104							1	10
105							1	

increased. The safe equivalent continuous noise level in most countries is either 85 dB(A) or 90 dB(A).

D.I.3.3. Table 4 gives the time exposure and sound level in dB(A) which are equivalent to a continuous sound level for eight hours of 85 dB(A) and 90 dB(A), using equal energy criteria and the intermittent noise variation on equal energy.

D.I.4. The need for hearing protection

D.I.4.1. The average noise level for chain saw operators is the noise measured in dB(A) at the operator's ear when cross-cutting timber at the manufacturer's recommended speed of maximum engine power. Details of the method of measurement are given in Appendix D, Part II.

D.I.4.2. Since the noise level of most, if not all, chain saws used by regular operators exceeds 100 dB(A), it is strongly recommended that all regular chain saw operators wear ear protectors at all times when the chain saw is in use. For example, using equal energy criteria, the use of ear protectors should lead to a reduction in the noise level of the chain saw at the operator's ear to below 87 dB(A) (85 dB(A) equivalent for five hours per day). For types of ear protectors recommended and a testing procedure, see Appendix D, Part III.

D.II. Measurement of noise

D.II.1. Introduction

D.II.1.1. This part describes a method of measuring the noise emitted by chain saws powered by internal combustion engines and including the saw chain. The method of measurement corresponds as far as possible to normal working conditions in the forest.

D.II.2. Definitions

D.II.2.1. Sound pressure level (L_p)—

$$L_p = 20 \log_{10} \frac{p_n}{p_o};$$

p_n = sound pressure in Pa;

p_o = 20 μ Pa (reference sound pressure);

L_p is expressed in dB relative to 20 μ Pa.

D.II.2.2. Sound level (L_p(A))—

weighted value of sound pressure level expressed in dB(A) measured in accordance with the provisions of IEC Publication 179[1] by means of a sound level meter with "A" filter.

[1] International Electrotechnical Commission: *Precision sound level meters*, IEC Publication 179 (Geneva, 2nd ed., 1973).

D.II.2.3. Octave level (L_N)—

sound pressure level in dB (20 μPa = reference sound pressure) for a frequency band embracing one octave having the mean geometric frequency N of the limit frequencies.

D.II.3. Measuring equipment

D.II.3.1. Acoustic equipment

D.II.3.1.1. Sound levels should be determined with aid of a precision sound level meter observing the provisions of IEC Publication 179. Octave band filters should observe the provisions of IEC Publication 225.[1]

D.II.3.1.2. In accordance with the provisions of International Standard ISO 266-1975, octave bands with mean frequencies of 63, 125, 250, 500, 1,000, 2,000, 4,000 and 8,000 Hz should be used for frequency analysis.[2]

D.II.3.1.3. If other equipment (such as a tape recorder) is used, it should have characteristics such that it observes the provisions of IEC Publication 179.

D.II.3.1.4. The microphone of the sound level meter should be connected to the measuring instrument by a cable in order to ensure that there is a sufficient distance between the microphone and the observer. The microphone should not have a direction-sensitive characteristic. If a wind screen is used for the microphone, it must not affect the measuring results.

D.II.3.1.5. The measuring equipment should be calibrated before and after each measurement. The calibrator must be accurate to within ±0.5 dB(A). In extreme temperature conditions, time should be allowed for the equipment to reach the ambient temperature before calibrating.

D.II.3.1.6. The instructions of the instrument manufacturer should be strictly followed.

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[1] International Electrotechnical Commission: *Octave, half-octave and third octave band filters intended for the analysis of sounds and vibrations*, IEC Publication 225 (Geneva, 1966).

[2] International Organization for Standardization: *Acoustics—Preferred frequencies for measurements*, International Standard ISO 266-1975 (Geneva, 1975).

D.II.3.2. Revolution indicator

D.II.3.2.1. An easy-to-read revolution indicator is needed to check the speed of the engine. It should be accurate to within ± 3 per cent. The revolution indicator must not affect the sawing work during the test.

D.II.4. Acoustic environment

D.II.4.1. Open space

D.II.4.1.1. The test site should be an open space having a radius of at least 10 m. It must be completely free from obstructions (including trees) which might influence the measurements obtained. Neither the observer nor any other person may come nearer than 2 m to the chain saw operator. There should be no reflecting surface, such as a fence or wall, within a radius of 20 m. The ground at the centre part of the site should have good sound absorbent properties and may be forest ground, grass or the like. The ground may be snow covered but should not be uneven. Ambient air temperature should be between – 10°C and + 30°C.

D.II.4.1.2. The level of background noise, including wind noise, should be at least 10 dB(A) lower than the sound levels and 10 dB lower than the sound pressure levels in the respective octave levels measured in the test. Wind velocity should be less than 5 m.p.s.

D.II.4.2. Enclosed space

D.II.4.2.1. Measuring may also be carried out in a large building, provided that readings can be proved to correspond with those taken as in subsection D.II.4.1 for third octave bands of noise in the frequency range 50 Hz to 10 kHz to within ± 0.5 dB.

D.II.5. Measuring object

D.II.5.1. Measurements should be carried out on three different chain saws of the same standard model with the saw chain provided by the manufacturer. The engine should have been run in and warmed up before the test is commenced, the carburettor and ignition should have been timed according to the manufacturer's instructions and the chain should have been sharpened.

Table 5. Recommended log or cross-section diameters

Engine displacement (cm^3)	Effective length of guide bar (cm)	Recommended diameter of log or cross-section of timber (cm)
Up to 44	25-35	15-20
45-69	30-40	20-25
70-89	40-50	25-40
90 and above	50-70	40-60

D.II.5.2. A log or rectangular baulk of timber should be placed on a saw horse so that its centre is some 60 cm above the ground and so that slices can be cut from it.

D.II.5.3. The ratio between the diameter of the log, the engine power and the length of the guide bar of the chain saw to be tested should be as shown in table 5.

D.II.5.4. For guide bars longer than 70 cm, the log diameter cross-section should be about 10 cm less than the guide bar length.

D.II.6. Test procedure

D.II.6.1. Preparation

D.II.6.1.1. Each chain saw should be measured on four different occasions, which must not be in immediate succession. A complete testing cycle as described below should be performed on each occasion.

D.II.6.1.2. Measuring equipment should be calibrated in accordance with the requirements of IEC Publications 179 and 225.

D.II.6.1.3. The sound level meter should be set to "slow".

D.II.6.1.4. The microphone should be fixed at a distance of 5 cm perpendicular to the right-hand temple of the operator and at the same levels as his eyebrows and should be aimed at the saw. The operator should wear a cap or a helmet. If he is wearing a helmet, the microphone should be placed at least 3 cm outside the lower edge of the helmet.

D.II.6.1.5. The revolution indicator should be connected to the chain saw in such a manner that the operator can conveniently check the engine speed without interfering with the work of sawing.

D.II.6.1.6. The following procedure should be followed both for sound level measurement and for octave band measurement.

D.II.6.1.7. The chain saw should be held in the natural manner for normal cross-cutting. The shortest distance from an imaginary line drawn through the upper horizontal part of the front handle to the microphone should be as close to 70 cm as possible.

D.II.6.1.8. Only one measurement should be recorded for each cross-cut, at a moment when the guide bar is horizontal and in the middle third of the log.

D.II.6.1.9. If the noise is to be recorded on tape, the sawing should be performed as many times on each measuring occasion as are necessary to ensure that sufficient records are available for the evaluation of the results.

D.II.6.2. Idling

D.II.6.2.1. Measurements should be made in dB(A) at the engine idling speed stated by the manufacturer; the saw chain must not move.

D.II.6.2.2. This test is necessary as a complement to those in Appendix subsections D.II.6.3 and D.II.6.4 in order to calculate the equivalent continuous sound level, for example during a typical working day.

D.II.6.3. Full load

D.II.6.3.1. Slices should be cut from the log or baulk of timber, from the side that gives the highest sound level. Measurements in dB(A) should be made during cross-cutting with the throttle fully open. The guide bar of the chain saw should be fed into the log so that the engine speed for maximum engine power ($\pm$ 3.5 r.p.s.) is kept constant.

D.II.6.4. Racing

D.II.6.4.1. Measurements should be made in dB(A) at the manufacturer's rated speed for maximum engine power plus 33 per cent. If the engine has a revolution limit which is below that speed, the measurements should be made at the stipulated maximum revolution speed.

D.II.6.5. Frequency analysis

D.II.6.5.1. An octave band frequency analysis for the eight bands 63 to 8,000 Hz should follow the above tests. Before and after each analysis, the sound level in dB(A) should be measured.

Figure 3. Specimen test report for the three chain saws tested

Operating condition	r.p.s.	Sound level in dB(A)														
		Machine 1 Number of machine or series ... Test					Machine 2 Number of machine or series ... Test					Machine 3 Number of machine or series ... Test				
		I	II	III	IV	Arith. mean	I	II	III	IV	Arith. mean	I	II	III	IV	Arith. mean
Idling																
Full load																
Racing																

D.II.7. Test report

D.II.7.1. The test report should include the following information: name, address and country of the institution carrying out the measuring; date of measurement; place of measurement; observer and operator; originator of request for report; description of chain saw (manufacturer, model (type), serial number, type and length of guide bar, sprocket (number of teeth), chain (type and pitch)); measuring equipment; microphone location (cap or helmet); diameter or cross-section of sawn log and type of wood; environment (air temperature (°C), air humidity (percentage)); type of ground; background noise; and measurement values and mean values for each saw in accordance with figure 3.

D.II.7.2. The difference between the highest and the lowest value noted for each chain saw must not be more than 3 dB(A) on the four different occasions. If it is, the test must be repeated.

D.II.7.3. Highest and lowest octave band levels in the eight octave bands 63 to 8,000 Hz for the three chain saws are as shown in the example in figure 4.

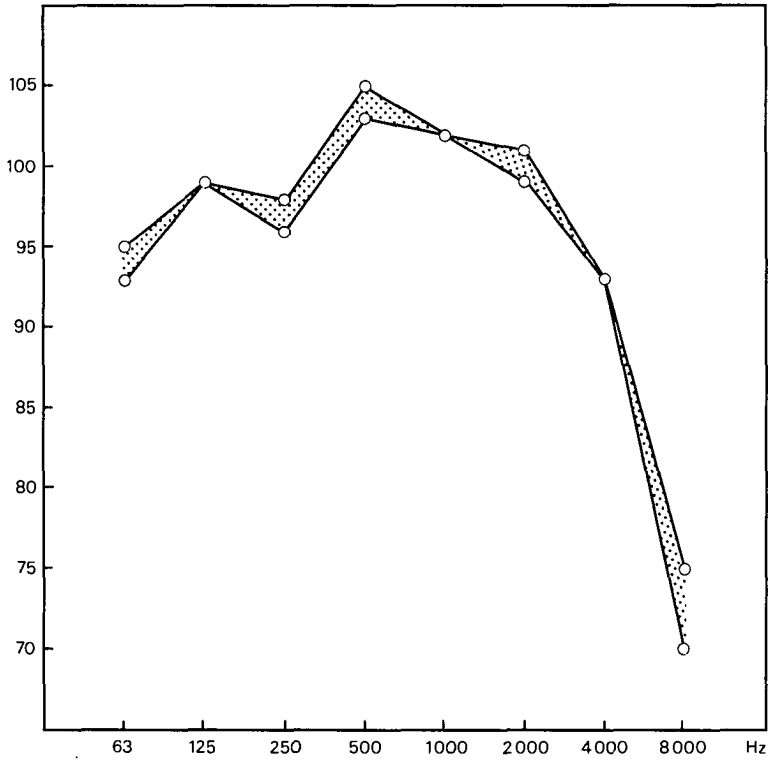
D.III. Testing of ear protectors for chain saw operators

D.III.1. Introduction

This part describes a method of checking that the attenuation qualities of each ear protector will reduce the dB(A) weighted equivalent continuous

Figure 4. Specimen test report graph

dB ref. 20 μ Pa octave level



sound level for eight hours for each model of chain saw at the operator's ear to below 85 dB(A) (87 dB(A) for five hours per day). The sound levels of the chain saw will be those recorded by octave band frequency analysis when cross-cutting under full load in accordance with the test procedure.[1]

[1] See Appendix paragraph D.II.6.3.1.

D.III.2. Type of ear protector

D.III.2.1. Ear plugs or valves of the reusable plastic type or of disposable mineral down (or acoustic wool) are not generally recommended for chain saw operators because it is difficult to ensure that the plugs will remain clean in a forest work environment. When anything is inserted into the ear canal it is essential to avoid the risk of ear infection, which can do more damage to hearing than noise alone. Ear muffs with soft plastic foam pads are recommended in preference to liquid seal pads, which are liable to puncture during forest work. The ear muffs can be held by a head-band (if this will fit under a hard hat), by a neck-band or by attachment to the hard hat.

D.III.2.2. Where climatic conditions make ear muffs intolerable, ear plugs may be the only practical alternative. In this case the following points are suggested:

(1) A medical inspection of the operator's ears is recommended before he starts to use ear plugs.

(2) The operator should have enough sets of ear plugs to ensure that a clean pair can be inserted on each occasion; the plugs and the container should be cleaned in accordance with the manufacturer's instructions.

(3) The operator should report for a medical examination if any irritation of the ear is experienced.

D.III.3. Method of testing the performance of ear protectors[1]

D.III.3.1. The attenuation of each type of ear protector is obtained from the manufacturer, who will have a testing station report showing the mean attenuation for each octave band and the standard deviation at each frequency.[2] The mean attenuation less the standard deviation for each octave band gives the assumed protection provided by the ear protector.

[1] See table 6 for a worked example.

[2] There is no international standard test procedure for ear protectors. However, several countries use the following method: a person is seated in a quiet room and his threshold sound level for each octave band is recorded; he then puts on the ear protectors, and the increase in sound level needed before he again hears the sound is taken as the measure of attentuation provided by the protector. This procedure is repeated several times for each octave band and again for several people. The mean value and the standard deviation are reported. (It is assumed that 50 per cent of the tests will be worse than the mean value, 16 per cent will be worse than the mean value minus the standard deviation and 3 per cent will be worse than the mean value minus twice the standard deviation.)

D.III.3.2. This assumed protection for each octave band is deducted from the measured octave band sound pressure level for the model of chain saw to be used by the operator; this gives the assumed band sound pressure level at the operator's ear in dB for each frequency.

D.III.3.3. The dB(A) weighted sound level correction is then applied to each assumed band sound pressure level by adding or subtracting arithmetically.

D.III.3.4. The final value for each octave band is converted into arbitrary intensity units (table 7). These units are added together arithmetically to give the intensity unit value for the dB(A) (0.1737, in the worked example in table 6).

D.III.3.5. The resultant dB(A), as read off in table 7, is the assumed A-weighted sound level at the operator's ear. The ear protector tested in table 6 is thus suitable for regular use with the chain saw in question.

D.III.4. Maximum sound level in dB(A) at the operator's ear

D.III.4.1. Chain saw operators are likely to have a working life of many years of exposure to noise from chain saws or other machines. To give them a reasonable chance of avoiding injury to their hearing, it is desirable to reduce the sound level at their ears to the equivalent continuous sound level specified by national standards.

D.III.4.2. If the sound level at the operator's ear exceeds 90 dB(A) with the best ear protectors, it is recommended that the chain saw should not be used for regular operations.

D.III.4.3. The above procedure will determine which ear protectors have adequate attenuation qualities. However, for most operators it is important that they should be able to hear as much background noise as possible, for other safety reasons. Operators should be encouraged to try out the various suitable ear protectors during normal work so that they can select the one which gives them the most background information.

Table 6. Testing the performance of ear protectors: example, showing sound level for each octave band

Step	Octave band centre frequency (Hz)								dB(A)
	63	125	250	500	1 000	2 000	4 000	8 000	
1. Mean attenuation of ear protector	6	11	14	26	34	36	44	36	
2. Less lower quartile or standard deviation	−6	−6	−6	−6	−6	−7	−8	−8	
3. Assumed protection (1−2)	0	5	8	20	28	29	36	28	
4. Sound level of chain saw at full load	70	101	92	93	98	100	100	93	103
5. Assumed sound level at operator's ear (4−3)	70	96	84	73	70	71	64	65	
6. Less or plus dB(A) correction	−26	−16	−9	−3	0	+1	+1	−1	
7. Assumed (A) weighted sound level at operator's ear (5 + 6)	44	80	75	70	70	72	65	64	
8. Convert 7 to arbitrary intensity units (table 7)		0.1	+ 0.032	+ 0.01	+ 0.01	+ 0.016	+ 0.0032	+ 0.0025	= 0.1737
9. dB(A) at operator's ear									83

Note: The regular work situations in which the equivalent continuous sound level will be 85 dB(A) or less are as follows (see also table 4):

Sound level at operator's ear (inside ear protector) (dB(A))	Length of exposure time
87	Any practical saw usage
88	Up to four hours per day of cumulative very high output usage
89	Up to three hours per day of cumulative average output usage
90	Up to two-and-a-half hours per day of cumulative usage

Table 7. Value of arbitrary intensity units corresponding to sound pressure levels from 60 dB to 110 dB

dB	0	1	2	3	4	5	6	7	8	9
60	0.0010	0.0013	0.0016	0.002	0.0025	0.0032	0.004	0.005	0.0063	0.0079
70	0.01	0.013	0.016	0.02	0.025	0.032	0.04	0.05	0.063	0.079
80	0.1	0.126	0.158	0.2	0.251	0.316	0.398	0.501	0.631	0.794
90	1	1.26	1.58	2	2.51	3.16	3.98	5.01	6.31	7.94
100	10	12.6	15.8	20	25.1	31.6	39.8	50.1	63.1	79.4
110	100	126	158	200	251	316	398	501	631	794

E. Vibration

E.I. Vibration diseases and exposure time

E.I.1. Introduction

E.I.1.1. This appendix outlines the present stage of knowledge of factors which appear to cause vibration diseases, and the vibration exposure criteria to be observed if such diseases are to be prevented. It indicates the need for more medical knowledge about the problem.

E.I.2. Vibration diseases

E.I.2.1. Many chain saw operators using chain saws not fitted with anti-vibration mountings[1] have been affected by diseases caused by vibration.

E.I.2.2. It is understood that energy with vibration frequencies above 100 Hz is mainly absorbed by the tissues of the hand and the wrist and is therefore likely to be the principal cause of vibration diseases.

E.I.2.3. The medical evidence to date indicates that the effect of the vibration is to disturb the blood supply to the tissues of the hand and wrist and to cause a deterioration in skin sensitivity, which might result in attacks of blanching of the fingers in response to cold stimuli.

E.I.3. Medical examinations

E.I.3.1. Competent medical authorities should establish examination methods with respect to vibration diseases, due regard being had to local and national conditions and possibilities.

E.I.3.2. Workers who regularly use chain saws in their work, and especially those whose protection against vibration diseases is ensured through the use of AV-saws and/or by a reduction in exposure time, should be subject to appropriate health supervision.

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[1] Chain saws which are fitted with anti-vibration mountings are referred to as AV-saws.

E.I.3.3. Principles for the organisation and aims of medical examinations and health supervision are given in the relevant ILO code of practice.[1]

E.I.4. Vibration exposure criteria to prevent vibration diseases

E.I.4.1. The fundamental principle for the prevention of vibration diseases is that of the elimination of vibration at source. To achieve this, appropriate measures must be taken when chain saws are being designed.

E.I.4.2. As a first step, manufacturers should be required to provide, with each chain saw, a data sheet giving all the necessary information about the level of vibration emitted. For this purpose, an operator-held measurement method has been designed, pending the development of an internationally acceptable vibration testing machine for chain saws.[2]

E.I.4.3. Subsequently, maximum vibration levels should be established in accordance with local and national regulations and standards.

E.I.4.4. Only when the above principle cannot be applied should regulations concerning the reduction of exposure time be adopted.

E.I.4.5. When such regulations are applied, the actual exposure time per eight-hour day should be monitored. By using any of the following three methods for the measurement of time exposure, it is possible to obtain a specific or broad classification of exposure time for typical work processes and typical tree sizes or species with each model or size class of chain saw.

(1) *Fuel consumption method.* The chain saw is used to cross-cut discs of timber continuously. The time taken to use one or more full tanks of fuel is recorded. The ratio between the diameter of the log, the engine power and the length of the guide bar should be determined from Appendix paragraph D.II.5.3. The average daily fuel consumption for the particular model of chain saw appropriate for the job, multiplied by the time taken to use one tank of fuel divided by the tank capacity, will give the average time exposure per day.

(2) *Work study method.* The normal cycle of work is repeated whilst a number of full tanks of fuel are used and the time taken is recorded. This time is compared with the length of a normal working day. Using the first part of method (1) above, the exposure time for one full tank of

[1] ILO: *Protection of workers against noise and vibration in the working environment*, op. cit.

[2] See Part E.II below.

fuel can be converted into full tanks per day and therefore into exposure time per day for the particular model of chain saw.

(3) *Noise recording method.* Record the length of time the chain saw is generating noise, including idling noise, when processing one or more trees of a particular size class. The cumulative time for noise for an average tree can then be multiplied by the typical output per day for this size class to obtain the exposure time for the particular chain saw and work processes.

E.I.5. Personal precautions for the prevention of vibration diseases

E.I.5.1. It is thought that good blood circulation to the hands will help to protect them from vibration diseases. The first essential is therefore to maintain the central body temperature at the right level. The correct clothing for the climatic conditions at the worksite, and dry gloves in colder weather, are clearly important. In a cold climate it is also wise to achieve a good level of body warmth before starting to use the saw.

E.I.5.2. Smoking reduces the circulation of blood to the extremities. It is therefore recommended that smoking before and during working hours be kept to a minimum.

E.II. Operator-held measurement method

E.II.1. Introduction

E.II.1.1. This method covers the measurement of the vibration of chain saws of the type indicated in figure 5, when the vibration is transmitted to the operator's hands. The method simulates the measurement of chain saw vibration in normal operating conditions in the forest.

E.II.1.2. The method follows as closely as possible the procedures for noise measurement, which are defined in detail in Appendix D.

E.II.2. Parameters

E.II.2.1. Measurements should be made of RMS acceleration in ms^{-2} or RMS velocity in ms^{-1} in the six octave bands with centre frequencies of 31.5, 63, 125, 250, 500 and 1,000 Hz. Results of measurement of acceleration should be presented.

E.II.2.2. (1) Measurements should be made on the front handle in the following three directions:

(a) sideways (S) (perpendicular to the plane of the guide bar);

(b) vertical (V) (parallel to the plane of the guide bar but perpendicular to the saw chain); and

(c) fore and aft (F) (parallel to the plane of the guide bar and parallel to the saw chain).

(2) On the rear handle the directions of measurement will be governed by the orientation of the handle. They should, however, be as close as possible to those specified for the front handle.

E.II.2.3. The transducer mound should be firmly attached (for example, cemented or screwed) to the handle of the chain saw. The surface to which it is attached must be flat. If the handle is covered with resilient material, this must be removed for the purpose of mounting.

E.II.2.4. The transducer must be mounted on the top of the front handle 25 mm from the plane of the guide bar, as shown in figure *5(b)*. On the rear handle the preferred position should be 120 mm (with a tolerance of ± 10 mm if necessary) from the most forward position of the hand (compatible with the correct operation of the controls) measured along the underpart of the handle as shown in figure *5(a)*. If this is not possible because of the design of the handles, the transducer should be mounted in a position as close as possible to that described above. Any deviation should be noted in the test report.

E.II.2.5. Engine speed in r.p.s. must be noted.

E.II.2.6. Gripping force in N should be noted for both hands.

E.II.3. Equipment

E.II.3.1. A transducer measuring acceleration (such as a piezo electric device) should be used in conjunction with a suitable preamplifier. The use of IEC Publication 184[1] is recommended for specifying the transducer and IEC Publication 222[2] for specifying the auxiliary equipment, including the amplifier.

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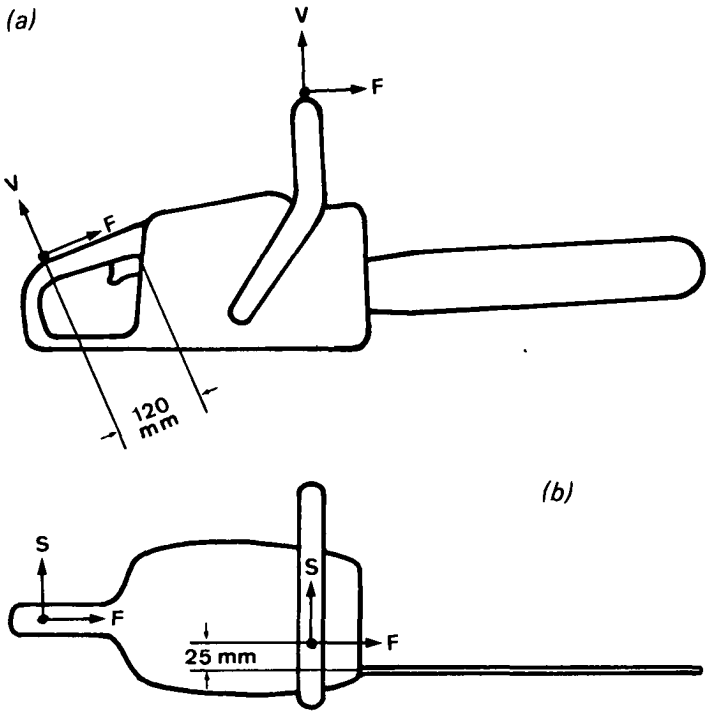
[1] International Electrotechnical Commission: *Methods for specifying the characteristics of electromechanical transducers for shock and vibration measurements*, IEC Publication 184 (Geneva, 1965).

[2] idem: *Methods for specifying the characteristics of auxiliary equipment for shock and vibration measurement*, IEC Publication 222 (Geneva, 1966).

Figure 5. Vibration measuring points



E.II.3.2. Octave band analyses should be performed by means of octave band filters as specified by IEC Publication 225.[1] Octave band analyses may also be calculated from one-third octave band measurements.

E.II.3.3. The measuring system should either have a time constant equivalent to that of the slow mode of a sound level meter or offer energy integration to obtain the RMS value over the cutting period.

[1] op. cit.

E.II.3.4. A multichannel tape recorder may be used, as simultaneous measurements of vibration in the three directions on one or both handles are preferable.

E.II.3.5. The whole system as described above should be accurate in the frequency range of 20 to 2,000 Hz.

E.II.3.6. An easy-to-read revolution counter with a range up to 270 r.p.s. and accurate to within ± 3 per cent should be used. The time constant of the device should be about 0.4 s. The counter should not affect the working of the chain saw during the test.

E.II.3.7. The total mass of the transducer and its mounting system should be as small as possible and in any case should not exceed 100 g.

E.II.3.8. Measuring and analysing instruments should be tested at suitable intervals. A qualified person should draw up a certificate of calibration to be kept with the instrument.

E.II.4. Measuring object

E.II.4.1. Measurements should be carried out using a chain saw with standard equipment and with a saw chain provided by the manufacturer. The engine should have been run in and warmed up before the test is commenced and the carburettor and ignition should be timed according to the manufacturer's instructions. The saw chain should also have been sharpened according to the manufacturer's instructions. The oil and fuel tanks should be between one-half and three-quarters full.

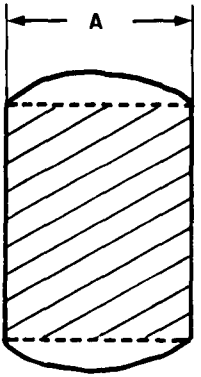
E.II.4.2. The log should be taken from freshly felled timber of the two most important species of wood in the investigator's country. If possible, one species of wood should be soft and the other hard. Wood specifications must be given.[1] Any cut with knots must not be used for the measurement of vibration.

E.II.4.3. The log must be shaped as in figure 6 and must be horizontally and rigidly mounted on a stiff support, so that its axis is about 60 cm above the ground.

E.II.4.4. The cut should be perpendicular to the longitudinal axis of the log and the bark grip must not be in contact with the log. Measurements must be taken only when cutting the section marked by hatching in figure 6.

[1] See below, Appendix paragraph E.II.6.1.

Figure 6. Test log shape and dimensions



The most stable results are obtained when the guide bar is buried in the wood to a depth equal to one-half of the width of the guide bar. The distance A should be 75 ± 5 per cent of the effective length of the guide bar. The relationship between engine power, effective length of guide bar and the distance A should be as shown in table 8.

Table 8. Minimum test log dimensions

Engine displacement (cm^3)	Effective length of guide bar (L) (cm)	Distance A = (0.75 ± 0.05) L (cm)
Up to 44	25-35	17.5-28
45-69	30-40	21-32
70-89	40-50	28-40
90 and above	50-70	35-56

E.II.5. Measurement

E.II.5.1. The measuring equipment should preferably be calibrated in accordance with the manufacturer's instructions before the measurement. Afterwards, the calibration should be checked.

E.II.5.2. To avoid electrical interference from the ignition system, the preamplifier system should be placed as far from the saw as possible.

E.II.5.3. Pending results of further research on vibration, vibration should be measured in the three cases described below. In each case the saw should be held in a natural manner for normal cross-cutting. The engine speed must be kept as constant as possible, within a range no greater than ± 5 per cent. These conditions must be maintained for a continuous period of at least 3 s. The measured engine speed must be noted in each case.

(1) *Idling.* Measurements should be made at the engine idling speed as recommended by the manufacturer, and the saw chain must not move.

(2) *Cutting.* Slices should be cut from the log with the throttle fully open, and the guide bar of the chain saw should be fed into the log so that the engine speed for maximum power, as recommended by the manufacturer, is achieved. It is recommended that the final RMS value in each octave band be obtained by averaging the results from a statistically sufficient number of saw cuts.

(3) *Racing.* Measurements should be made at the manufacturer's rated speed for maximum engine power plus 33 per cent, when the chain saw is not cutting. If the engine has a maximum revolution limit below this speed, the measurements should be made at the maximum obtainable speed. It is not necessary to apply this test to a chain saw which is used only for felling. Chain saws with an engine displacement greater than 80 cm^3 would fall into this category.

E.II.6. Test report

E.II.6.1. The test report should include the following information: name, address and country of the institution carrying out the measuring; date of measurement; place of measurement; observer and operator; originator of request for report; description of chain saw (manufacturer, model (type), serial number, type and length of guide bar, sprocket (number of teeth), chain (type and pitch)); measuring equipment (type and manufacturer of transducers, amplifier, octave filter, tape recorder, revolution indicator); environment (air temperature (°C), air humidity (percentage)); length of cut (A)[1] (cm); specifications of log (wood species (Latin name), water content (percentage), density (g/cm^3)); and details of how the gripping force was measured and monitored during the tests.

E.II.6.2. The recommended presentation of the measurements is indicated in figure 7.

[1] See figure 6 and table 8.

Figure 7. Vibration values ms^{-2}

Engine speed	Direction of measure-ment	Front (left) handle									Rear (right) handle								
		Hz						GF	r.p.s.	Cut. eff.	Hz						GF	r.p.s.	Cut. eff.
		31.5	63	125	250	500	1 000				31.5	63	125	250	500	1 000			
Idling	S																		
	V																		
	F																		
Cutting	S																		
	V																		
	F																		
Racing	S																		
	V																		
	F																		

Notes: S = sideways; V = vertical; F = fore and aft; GF = gripping force in N; Cut. eff. = cutting effect in $cm^2 s^{-1}$.

F. Starting devices: cranking effort

The chain saw should require no more cranking effort than that specified in the table below. When the chain saw has a compression release valve, this test should be conducted with the compression release in the open (or starting) position.

The test mass specified in the table should be attached to the starter rope as shown in figure 8 and allowed to drop. The drop distance should be no more than 61 cm.

The chain saw tested should be new as shipped, should previously have been run for less than one hour, and should be tested for cranking effort with the room and engine temperatures between 16°C and 27°C.

The minimum cranking r.p.m. must be reached each time on three consecutive tries.

Table 9. Minimum required test mass

Engine displacement (cm^3)	Test mass (kg)	Minimum cranking (r.p.m.)
Up to 49	14	600
50-81	32	600
82 and above	55	600

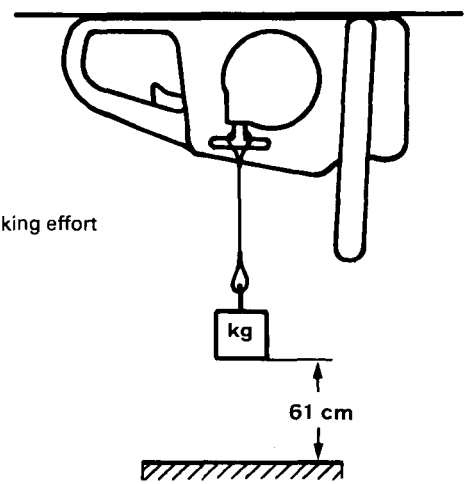


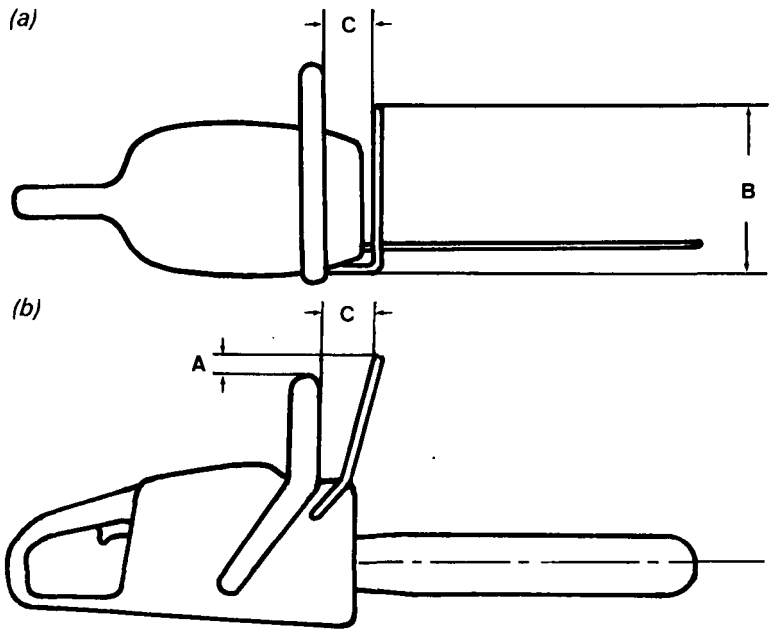
Figure 8.
Testing for cranking effort

G. Front handle guard dimensions and clearances

Table 10. Front handle guard dimensions and clearances

Dimension in figure 9	Description	Dimension (mm)
A	Minimum guard height (measured perpendicular to centre line of guide bar)	20
B	Minimum guard length	150
C	Handle clearance	35–70

Figure 9. Front handle guard dimensions and clearances



H. Chain brake

H.1. Measuring of braking time

H.1.1. The braking time should be measured according to the following procedure. The brake should be released with a pendulum, with the throttle kept in the adjusted position during the braking. The time from the release until the saw chain has stopped should be recorded. No samples should be excepted.

(1) Maintain the saw chain speed at the manufacturer's rated speed for maximum engine power plus 33 per cent.

(2) Operate the brake 25 times at intervals of 10-20 s before taking any readings.

(3) Actuate the brake and record the instant the brake arm starts to move and the instant the saw chain ceases to move.

(4) Average three operations and calculate the stopping time.

(5) Operate each chain saw for five minutes at the manufacturer's rated speed for maximum engine power.

(6) Average three operations after performing item (5) and calculate the stopping time.

(7) The braking time for all operations described in items (1) and (5) should not exceed an average of 0.10 s and a maximum of 0.15 s.

(8) No brake adjustment of any kind is allowed during the above test.

(9) Only new brakes should be tested.

I. Kickback tendency

Methods for the measurement of kickback tendency in saw chains are under development. Reference is made to the methods used by the National Swedish Testing Institute for Agricultural Machinery (90005 Umeå 5, Sweden) and by Omark Industries (Portland, Oregon 97222, United States).

J. Fuel tank: excessive heating

J.1. Test conditions

J.1.1. The following test conditions should apply.

(1) The ambient temperature for the test should be 26-29°C.

(2) The fuel should be summer grade (Reid vapour pressure at 11 p.s.i.).

(3) The carburettor should be adjusted to the manufacturer's recommended setting.

(4) The fuel/oil mixture recommended by the manufacturer should be used.

J.2. Procedure

J.2.1. The test procedure should be as follows.

(1) Run the chain saw under steady cutting conditions using one full tank of fuel.

(2) Record the time taken to use one complete tank of fuel.

(3) Immediately refill the tank and continue cutting under steady cutting conditions for half the time taken in item (2).

(4) Stop the chain saw and immediately remove the fuel cap. No liquid fuel should spill from the tank.