SAE International™

SURFACE VEHICLE STANDARD

SAE J232

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Superseding J232 APR1994

Submitted for recognition as an American National Standard

Industrial Rotary Mowers

1. Scope—This SAE Standard establishes performance criteria for towed, semi-mounted, or mounted and arm type rotary mowers with one or more blade assemblies of 77.5 cm blade tip circle diameter or over, mounted on a propelling tractor or machine of at least 15 kW, intended for marketing as industrial mowing equipment and designed for cutting grass and other growth in public use areas such as parks, cemeteries, and along roadways and highways.

The use of the word “industrial” is not to be confused with “in-plant industrial equipment.”

This document does not apply to:

a. Turf care equipment primarily designed for personal use, consumption, or enjoyment of a consumer in or around a permanent or temporary household or residence.
b. Equipment designed primarily for agricultural purposes but which may be used for industrial use.
c. Self-powered or self-propelled mowers or mowing machines.

2. References

2.1 Applicable Publications—The following publications form a part of the specification to the extent specified herein. Unless otherwise indicated, the latest revision of SAE publications shall apply.

2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J115 FEB1995—Safety Signs—(ASAE S441.1)
SAE J517 APR2001—Hydraulic Hoses
SAE J920 SEP1985—Technical Publications for Agricultural Equipment—(ASAE EP363.1 DEC97)
SAE J1150 JUL1997—Terminology for Agricultural Equipment—(ASAE S390.1)
SAE J1170 JUN91—Rear Power Take-off for Agricultural Tractors

2.1.2 ASAE PUBLICATIONS—Available from 2950 Niles Road, Saint Joseph, MI 49085-9601.

ASAE S203.13—Front and Rear Power Take-Off for Agricultural Tractors
ASAE S217.11—Three-Point Free-Link Hitch Attachment of Implements to Agricultural Wheeled Tractors
ASAE S278.6 JAN2001—Three-Point Hitch, Implement Quick-Attaching Coupler, Agricultural Tractors
ANSI/ASAE S318.14 SEP99—Safety for Agricultural Field Equipment
ASAE S483—Rotary Mower Blade Ductility Test

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2.1.3 ASTM PUBLICATIONS—Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM D 2529-74—Test for Bursting Strength of Paperboard and Linerboard
ASTM D 2738-71—Test for Bursting Strength of Corrugated and Solid Fiberboard

3. Definitions—(See also SAE J1150 JUL1997)

3.1 Arm Type Mower—Mowers which are intended to be used frequently with the cutter portion not adjacent or parallel to the ground.

3.2 Functional Component—A working mechanism of an attachment or implement designed to perform a specific task such as the cutting blade of a rotary mower.

3.3 Guarded by Location—A potential hazard is so guarded when it is covered by other parts or components of the machine, or because of its remote location, inadvertent contact is minimized during normal operation or servicing.

3.4 Hit—Rupture of the front layer but not the back layer of the thrown object target material by a test projectile.

3.5 Inadvertent Contact—Contact between a person and a moving machinery part hazard, or other type of hazard, resulting from the person's unintentional actions during normal operation.

3.6 Moving Machinery Part Hazard—A source of potential injury created by moving machinery parts which can cause serious injury upon contact or by entanglement of personal apparel. This includes, but is not limited to, the pinch points of power driven gears, run-on points of belts and chains, and projections on rotating parts.

3.7 Normal Operating Position—The space within operator zone occupied by the operator while operating mower. The operator is sitting on the seat with hands on the steering controls and feet on controls or areas provided for foot placement. For Operator zone, see Figures 1, 2, and 3.

3.8 Power Take-Off (PTO)—An external shaft on the rear of a tractor to provide rotational power to implements (ASAE S203.13).

3.9 Implement Input Driveline (IID)—Two universal joints and their connecting member(s) and fastening means for transmitting rotational power from the tractor PTO to the implement input connection. A double Cardan, constant velocity joint is considered a single joint. The IID also includes integral shielding where provided. Reference ASAE S318.14 SEP99).

3.10 Propelling Machine—A tractor or self-propelled machine.

3.11 Puncture—The rupture of all layers of the thrown object target material by a test projectile.

3.12 Rotary Mower—A power mower in which one or more functional components cut or shear by impact and rotate about an axis perpendicular to the cutting plane.

3.13 Standard Test Operator—A person weighing 95 kg ± 5 kg and standing 188 cm ± 5 cm.

3.14 Shield (or Guard)—A barrier which minimizes inadvertent personal contact with hazards created by moving machinery parts.

3.15 Target Material—160 kg uncoated corrugated board, specification paper weight 41 kg-12 kg-41 kg B flute per ASTM D 2738 and D 2529 (see Figure 4):

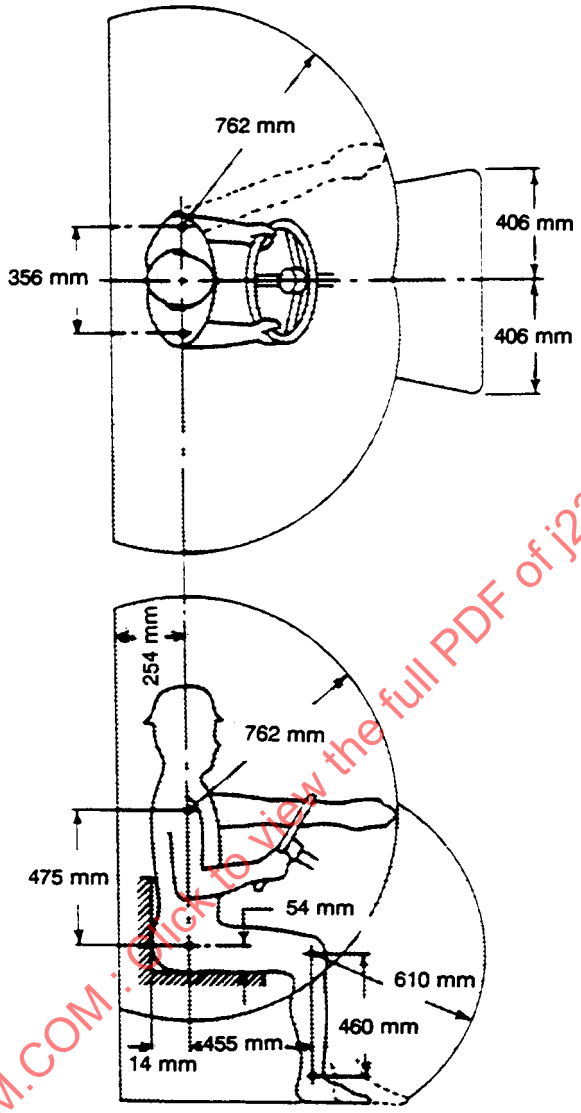
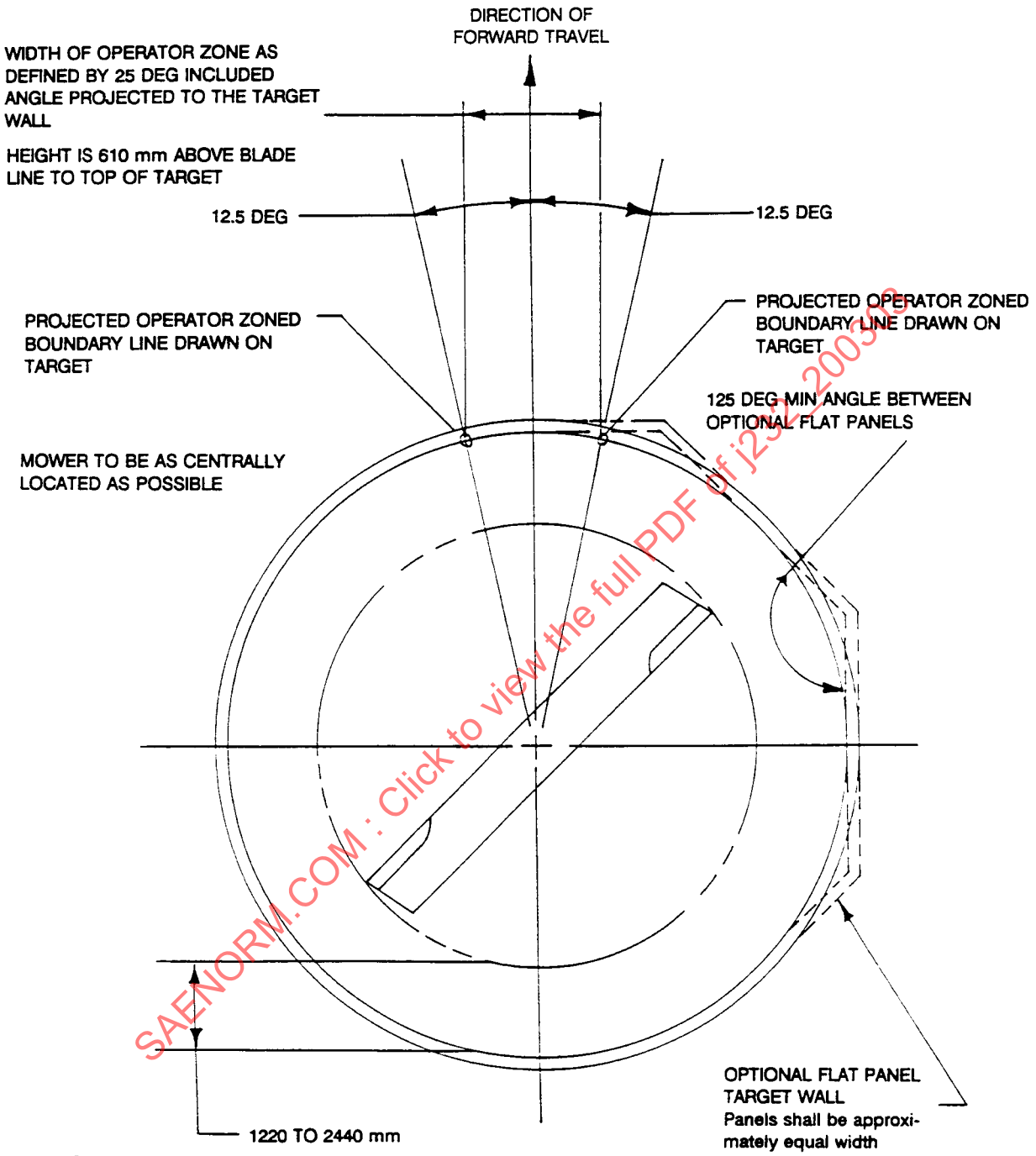


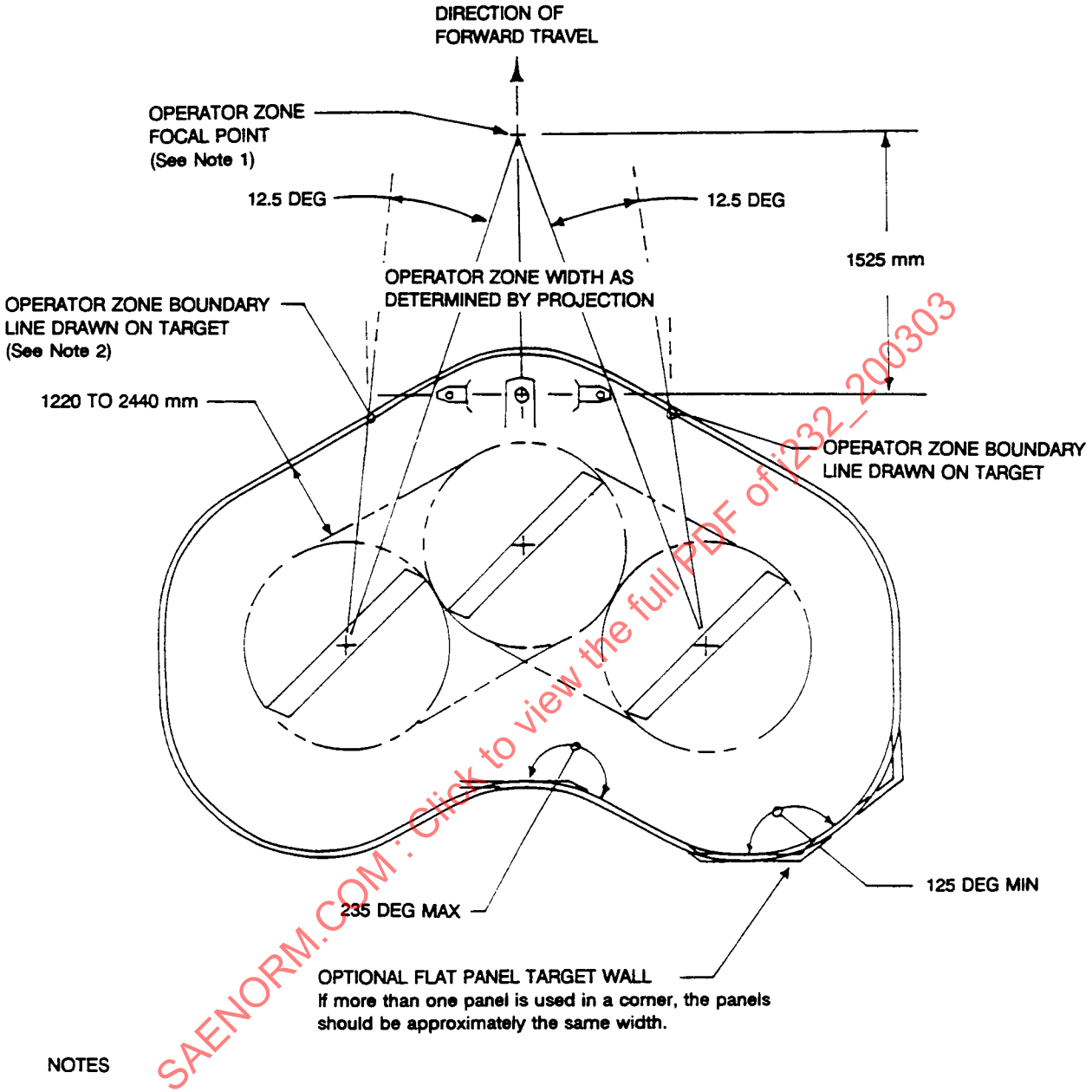
FIGURE 1—OPERATOR ZONE



NOTES

(1) The operator zone focal point shall be on a line in the forward direction of travel midway between the hitch pins or on the centerline of the tongue hole.
(2) Operator zone height is 610 mm above the blade line to the top of the target wall.
(3) The mower position shall be as symmetrical as possible within the target enclosure.

FIGURE 2—TARGET CONFIGURATION AND OPERATOR ZONE FOR SINGLE-BLADE MOWERS



NOTES

(1) The operator zone focal point shall be on a line in the forward direction of travel midway between the hitch pins or on the centerline of the tongue hole.
(2) Operator zone height is 610 mm above the blade line to the top of the target wall.
(3) The mower position shall be as symmetrical as possible within the target enclosure.

FIGURE 3—TARGET CONFIGURATION AND OPERATOR ZONE FOR MULTI-BLADE MOWERS

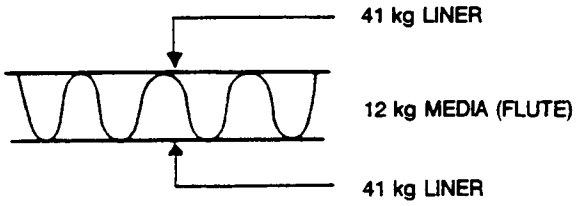


FIGURE 4—SINGLE WALL

3.16 Test Projectile—An uncoated six penny steel box nail or common nail with the following approximate dimensional limits (see Figure 5):

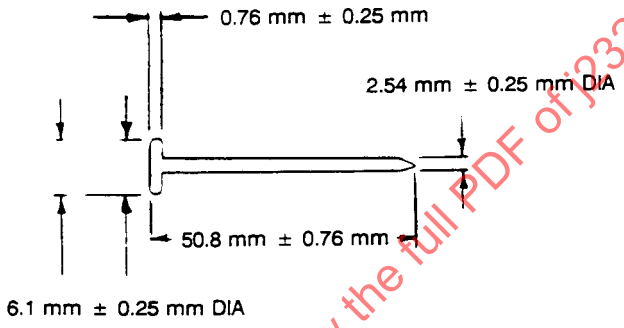


FIGURE 5—SIX PENNY STEEL BOX NAIL DIMENSIONS

4. General Requirements

4.1 Guarding and Shielding

4.1.1 Inadvertent contact with moving machinery parts hazards shall be minimized during normal mounting, starting, operating, or dismounting the equipment by guarding and shielding.

4.1.2 The following are some of the potential hazard areas:

4.1.2.1 Pinch points of gears and the run-on point where a belt or chain contacts a sheave, sprocket, or idler.

4.1.2.2 Outside faces of pulleys, sheaves, sprockets, and gears on rotating drives.

4.1.2.3 Rotating parts with projections such as exposed bolts, keys, or set screws.

4.1.2.4 Revolving shafts, except smooth (without keyways, splines, etc.) shaft ends protruding less than one-half the diameter of the rotating element.

4.1.2.5 Implement input driveline.

4.1.3 Shields shall remain functional under the forces that would be applied by a 123 kg individual leaning on, falling against, or stepping on them. This applies only to those forces that would be expected in normal machine operation or maintenance.

4.1.4 Equipment with access doors and shields which can be opened or removed while components continue to rotate more than 7 s after the power is disengaged, shall have:

a. Visible or audible indication of rotation and
b. A suitable safety sign per SAE J115 FEB1995.

4.1.5 Access doors, guards, and shields which must be opened for normal servicing, shall be easily opened and closed.

4.2 Labels and Instructions

4.2.1 CONTROL IDENTIFICATION—The controls furnished with mower, and their direction or motion for stopping, starting, speed control, and operation, whose functions are not obvious shall be identified by a label per 4.2.3.

4.2.2 MACHINE IDENTIFICATION—The mower shall be provided with identification per 4.2.3.4 giving model number, serial number, and the name and address of the source of replacement parts and service.

4.2.3 LABELS—Labels and name plates provided on units shall meet the following minimum requirements:

4.2.3.1 Labels shall form a durable bond with the base material surface and shall show no appreciable loss of adhesion during weathering exposure. Labels shall not curl at the edges and shall not lose legibility or suffer appreciable loss of adhesion when exposed to occasional contact with gasoline or oil.

4.2.3.2 The label shall meet the weathering requirements of SAE J115 FEB1995 (ASAE S441.1).

4.2.3.3 Embossed, indented, cast, or molded label shall be considered sufficient to meet the requirements of this section.

4.2.3.4 Metal plates over 0.48 mm thick with embossed or etched lettering and fastened with rivets or equivalent fastening means shall be considered sufficient to meet the requirements of this section.

4.2.4 OPERATION AND SERVICE

4.2.4.1 *General Requirements*—Written instructions and a durable weather resistant storage location for the instructions shall be provided, with the equipment explaining proper operation of the machine, proper operational and service procedures, and necessary maintenance procedures to avoid potential hazards. (See also SAE J920 SEP1985 and ASAE EP363.1 DEC97.)

The manual shall also advise that: “In addition to the design and configuration of equipment, hazard control and accident prevention are dependent upon the awareness, concern, prudence, and proper training of personnel involved in the operation, transport, maintenance, and storage of equipment.” Safe Practice Messages, as shown in Appendix B, are suggested to be included in the manual.

4.2.4.1.1 Written hazard avoidance instructions shall include identification of the need for personal protective equipment such as, but not limited to, protection for the eyes, ears, feet, hands, and head.

4.2.4.1.2 The operator's manual shall contain instructions so that a person unfamiliar with the mower will have required information to prepare the mower for operation and to adjust, start, operate, transport, stop, park, and unhitch the mower.

4.2.4.2 *Stored Energy Devices*—Any stored energy device such as, but not limited to, spring loaded mechanisms, and pressurized fluid systems, such as hydraulic accumulators, which can be disconnected, disassembled, or freed in such a way as to release energy or material in a hazardous manner, shall have an appropriate label on or near the device. The label shall include instructions for de-energizing and proper disassembly or include a reference to instructions to be provided in the operator's manual.

4.2.4.3 *Hydraulic Devices*—The operator's service and maintenance manuals shall contain:

4.2.4.3.1 Information that hydraulic fluid escaping under pressure can have sufficient force to penetrate skin and cause serious injury, and that if fluid is injected into the skin it must be surgically removed within a few hours by a doctor familiar with this form of injury or gangrene may result.

4.2.4.3.2 Information cautioning the operator to make sure all hydraulic fluid connections are tight and all hydraulic hoses and lines are in good condition before applying pressure to the system.

4.2.4.3.3 Information explaining how to minimize the hazard during the relieving of all pressure or force in each system before disconnecting the lines or performing work on the system.

4.2.4.3.4 Information cautioning to keep body and hands away from pin holes or nozzles which eject fluid under high pressure and to use paper or cardboard and NOT HANDS to search for leaks.

4.3 Operator Zone—Pressurized Components

4.3.1 Hydraulic hoses furnished with the mower shall meet the requirements of the applicable section of SAE J517 APR2001 based on the working pressure of each system.

4.3.2 Pressurized hoses, lines, and components furnished with the mower shall be located or shielded so that in the event of rupture, fluid is not discharged directly onto the operator when in the operator zone. (See Figures 1, 2, and 3.)

4.4 Safety Signs

4.4.1 Safety signs shall be appropriately displayed when necessary to alert the operator and others of the risk of personal injury during normal operations and servicing.

4.4.2 Safety signs shall be displayed stating the mower must not be operated without guards and shields in place. If safety signs are affixed to removable guards or shields, there shall be a safety sign affixed to the mower under the shield advising that the unit must not be operated without guards and shields in place.

4.4.3 Safety signs shall conform to requirements of SAE J115 FEB1995 (ASAE S441).

4.4.4 To distinguish from safety signs, instructional signs relating to equipment servicing and care should use signal words such as IMPORTANT or NOTICE, without the safety-alert symbols. The appearance of these signs should be different from safety signs and should normally be black and white.

5. Mower Requirements

5.1 Tongue—Any trailed unit should avoid a hitch connection characteristic which could move uncontrollably upward when disconnected. If not avoidable, then it must have a conspicuous label per 4.2.3 in the vicinity of the hitch point identifying the hazard.

5.2 Attachment Means—Three-point hitch mounted and semi-mounted mowers shall be attached to the propelling machine by means of one or a combination of the standardized attachment methods as defined in ASAE S217.11 and ASAE S278.6 JAN01).

6. Functional Component Requirements

6.1 Power Disconnect—Multi-section mowers shall have the means to disconnect power to any section which can be carried in a raised or transport position, while mowing continues with another section. If a raised section is possible and recommended by the manufacturer, then the mower shall also be required to meet the testing requirements in Section 7 in the raised position.

6.2 Guarding and Shielding—Functional components which must be exposed for proper function shall be shielded sufficiently to meet the thrown object test provisions of this document, except arm-type mowers. Any moveable or removable guard(s) shall conform to the following:

6.2.1 Instructions shall be affixed to the mower in a prominent location stating that the mower shall not be operated without guard(s) in place.

6.2.2 The operator's manual shall state that the mower shall not be operated without guard(s) in place.

6.2.3 If any guard or shield which is offered as an option (because of special requirements such as alternate types available, serviceability requirements, or agricultural uses where it may interfere with function or create problems) is required for the mower to comply with the tests in Section 7, this fact shall be prominently noted at each of the following locations:

a. In the price list and sales literature
b. In the operating instructions and
c. On a prominent safety sign located on the mower

6.2.4 If a guard is constructed of woven fabric or other such material which may be subject to rapid wear or deterioration, the mower shall bear a label per 4.2.3 stating that it may require frequent inspection and possible replacement.

6.3 Cutting Elements—The components which are used to attach the cutting elements shall not become worn or fail in a hazardous manner, before the elements themselves are worn beyond practical use.

7. Test for Mower Components

7.1 Test Conditions, General

7.1.1 ASSEMBLY—The mower shall be completely assembled and mounted on or attached to its propelling machine except for tests where mounting on a suitable test fixture is designated, or, where necessary, the mower unit may be tested while separated from the power unit and power provided by some other means. However, speeds must be the same as when on or attached to the propelling machine, and parts which extend into the trajectory area should be duplicated as nearly as practicable. Adjustable guards shall be set in the most open position for the test.

7.1.2 MOWER POSITION—The mower shall rest on a horizontal surface and in a horizontal position that is flat within 2 degrees.

7.1.3 TEST SPEED—Except for static tests, the mower shall be operated at the manufacturer's maximum recommended operating speed.

7.1.4 NUMBER OF TESTS—All tests shall be run once for each blade assembly of the mower except where otherwise herein designated. A new mower may be used for each test, except for the tests of 7.5 and 7.6.

7.1.5 RESTRAINTS—Resilient restraints, such as chains, may be used to keep the mower in position during the test.

7.2 Foot Probe Test—(Not required on arm-type mowers.)

7.2.1 TEST EQUIPMENT—Foot Probe—Figure 6.

7.2.2 TEST CONDITIONS—The test shall be conducted under static conditions on a flat surface.

7.2.3 TEST PROCEDURE—The foot probe shall be introduced horizontally to the mower and be held in a vertical plane and rotated horizontally and vertically a maximum of 15 degrees to either side of the centerline while simultaneously being raised and lowered as shown in Figure 6. The probe must be inserted as far as possible at all point around the blade enclosure with a force of 110 N with the blades in the highest and also the lowest static cutting positions (except the highest cutting position for this test shall not exceed 200 mm). If the blade path height is different for different blade speeds or blade options, the test shall include the two blade height extremes. Components of the mowers or machine, or both, such as frames, etc., may be considered as part of the blade enclosure for the purpose of this test.

7.2.4 TEST ACCEPTANCE—The probe shall not enter the path of the blade or blade assemblies as verified by slow manual rotation of the blades with all power off.

7.3 Blade Impact Tests—(May be conducted before or after any other test.) (Blades shall comply with requirements of ASAE S483.)

7.3.1 TEST EQUIPMENT—The mower shall be completely encircled at the time of test by a wall of target material, per 3.15, resting on the floor. Testing may be performed on sand or concrete. If testing on a sand base, the pins base needs to be raised 75 mm as shown in Figure 8B. The wall shall be approximately 1220 to 2440 mm from the blade tip circle with a minimum height of 1830 mm above the horizontal plane of the blade tip circle. See Figures 2, 3, and 7. A protective barrier shall be provided to protect the operator. Modifications to the mowers lift mechanism may be made to increase the mowers drop velocity.

7.3.2 TEST CONDITIONS—The mower shall be adjusted for approximately 75 mm height of cut or the cutting height setting closest to 75 mm. The mower shall be powered at the manufacturer's minimum recommended power levels.

7.3.3 TEST PROCEDURE—The mower shall be positioned over the fixture (described in Figure 8) and dropped onto the test rod such that the blade makes positive contact with the rod. The mower shall be dropped fast enough so that mower speed is not materially reduced by glancing contact before solid contact is made. The mower shall be dropped onto the rod and allowed to continue for a minimum of 2 s before disengaging the power, or lifting the mower. The test shall be conducted once in each of the two following manners:

a. The mower positioned so that the contact between the blade and the rod is at a point as close to the blade holder connection as possible. If the blade has a bent configuration such that it is raised close to the blade holder, then the pin shall be elevated to ensure adequate blade contact.

b. The mower positioned so that the contact between the blade and centerline of the rod is approximately 25 mm from the outer tip of the blade.

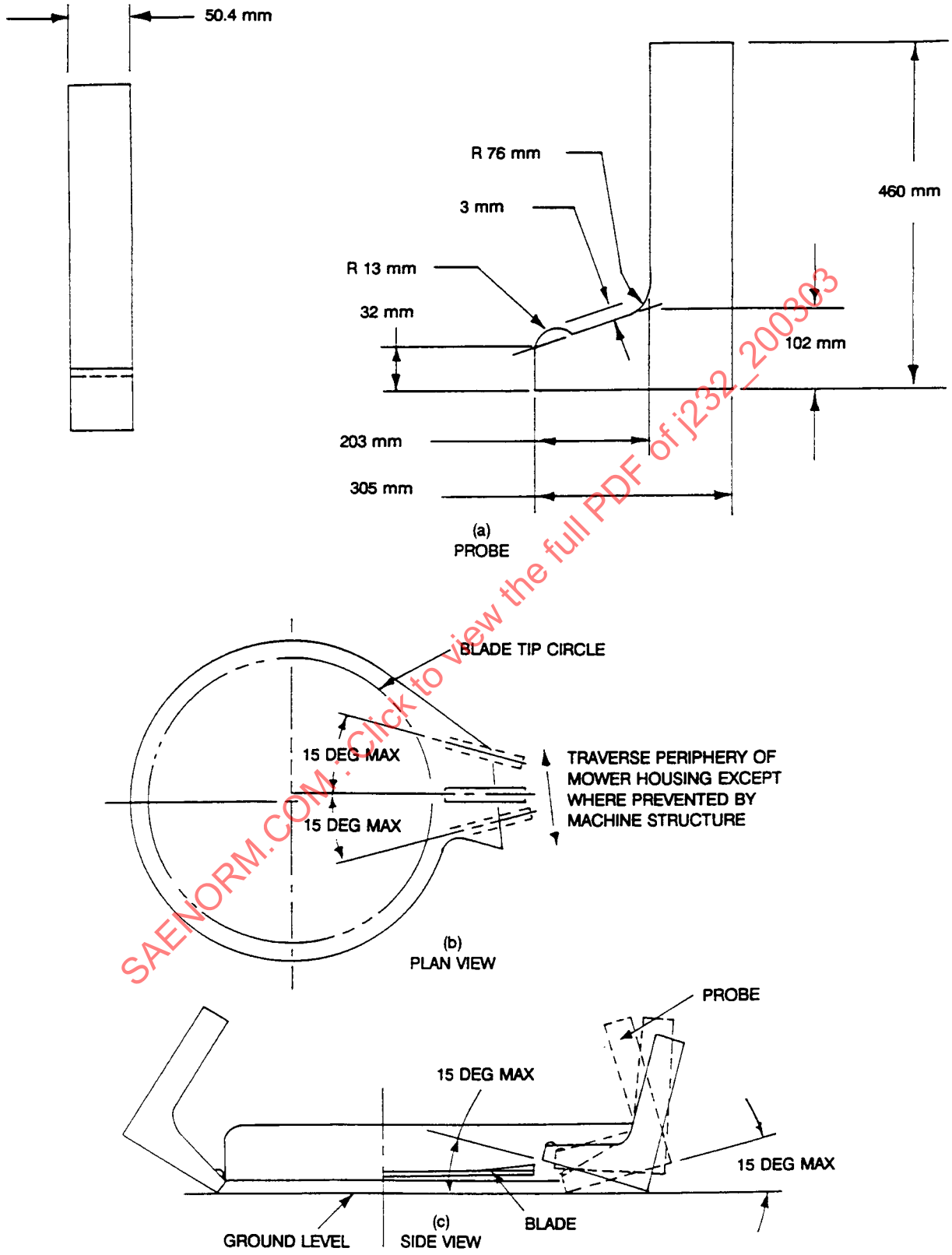


FIGURE 6—FOOT PROBE

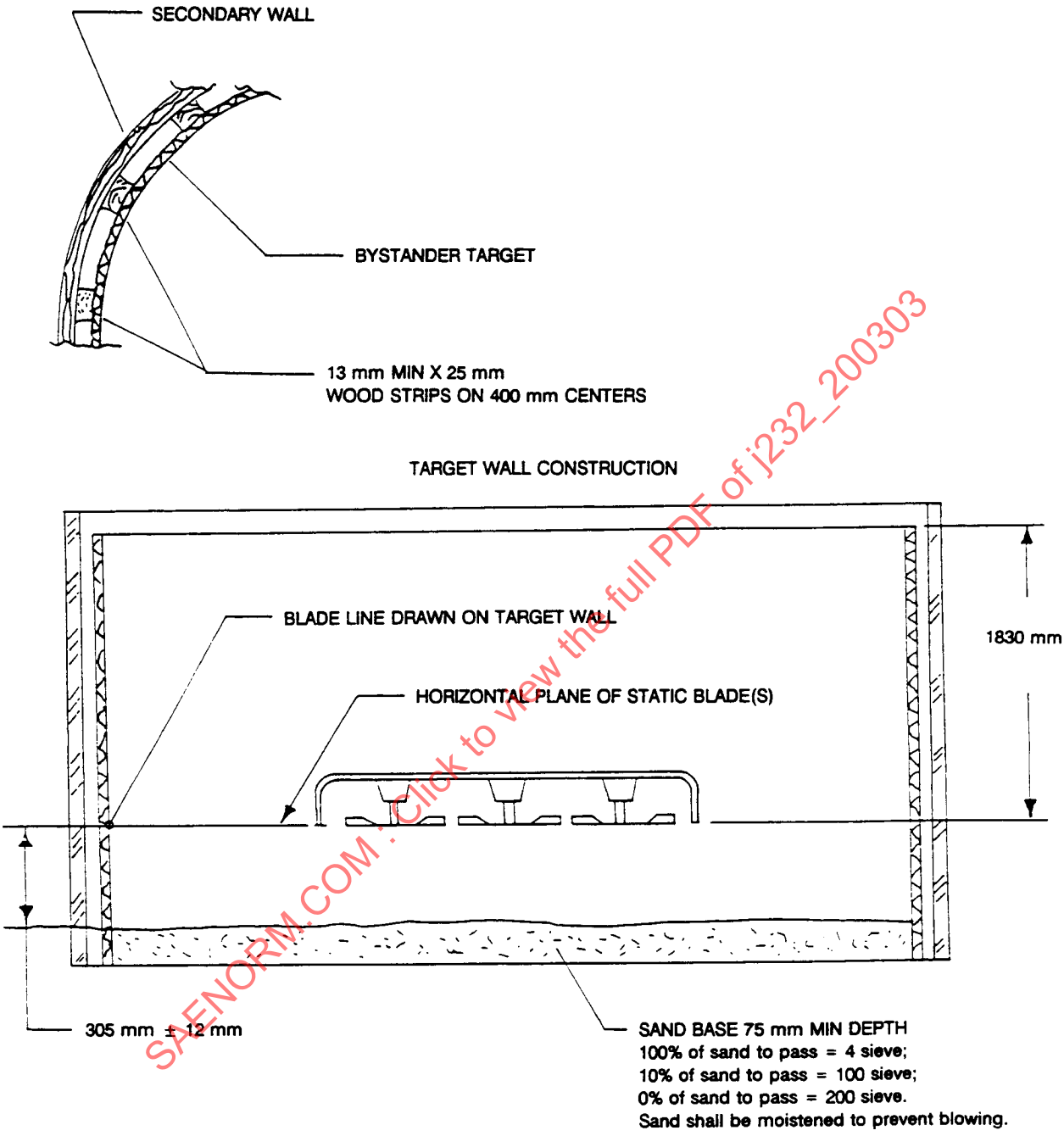


FIGURE 7—MOWER POSITION INSIDE TARGET ENCLOSURE

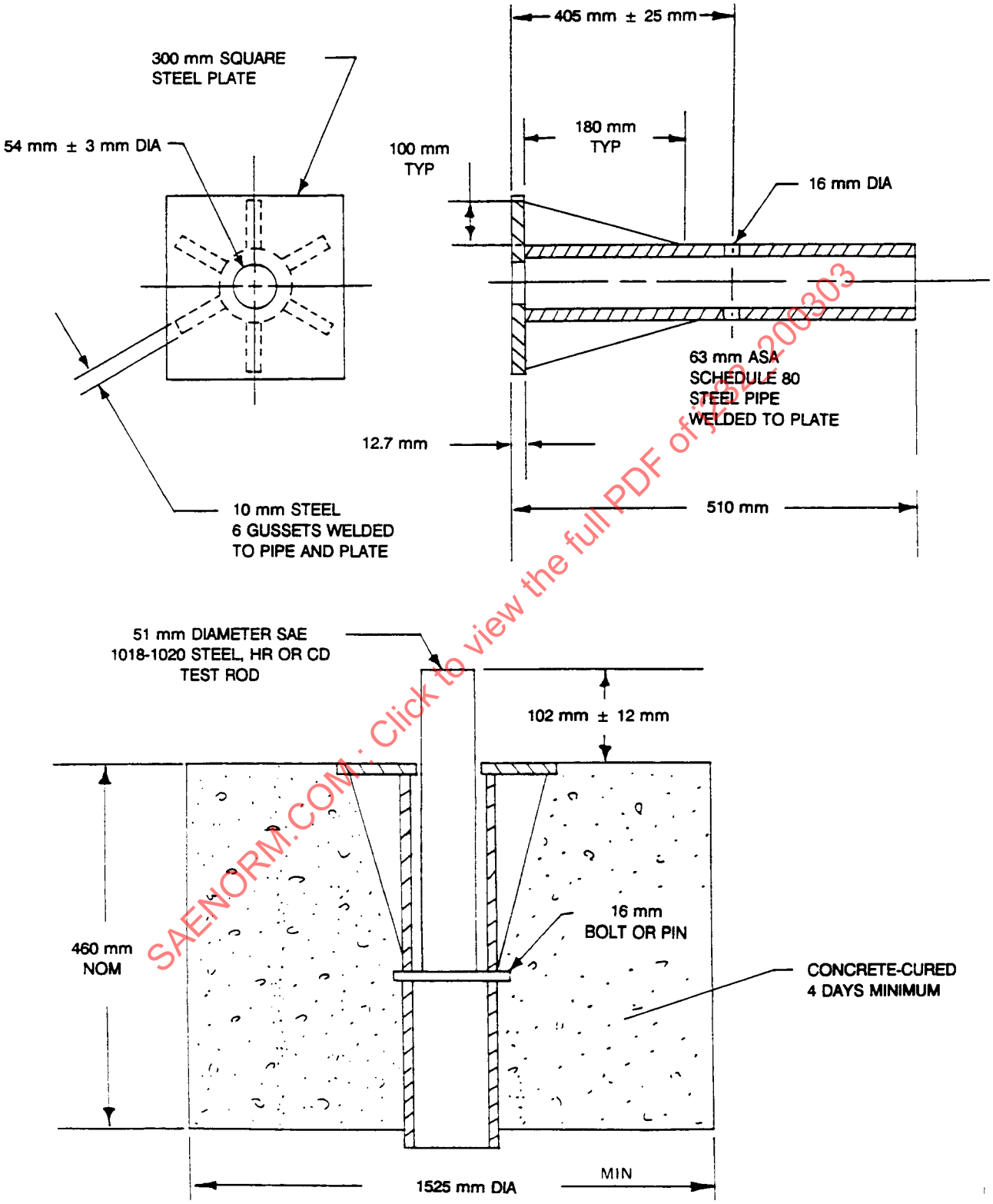


FIGURE 8A—IMPACT TEST FIXTURE

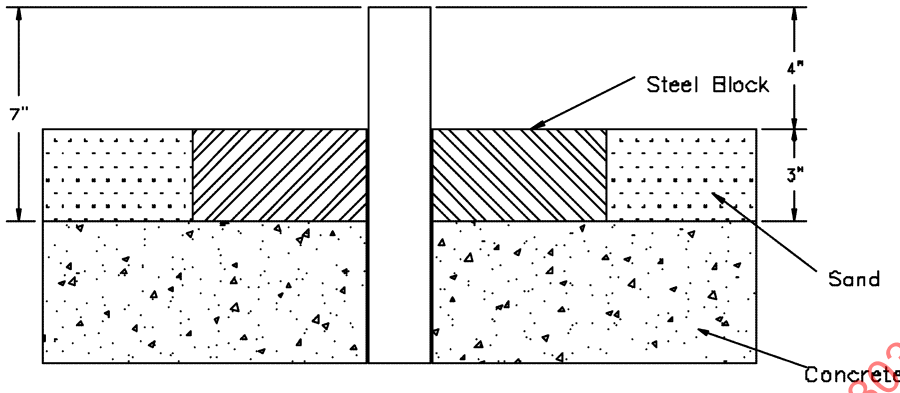


FIGURE 8B—SAND BASE IMPACT TEST FIXTURE

7.3.4 ACCEPTANCE CRITERIA—The test shall be completed without loss of any part of the mower or failure of any mower component in a manner that could be hazardous to the operator or bystanders. Any target puncture by any part of the mower or blades shall constitute failure, excluding portions of the blade with a mass of 30 g or less.

7.4 Blade Unbalance Test

7.4.1 TEST EQUIPMENT—(See 7.3.1)

7.4.2 TEST CONDITIONS—MULTI-PIECE BLADE CONSTRUCTION—Remove one set of cutting elements and fasteners from the end of the blade attaching point.

7.4.2.1 One-Piece Blade—Remove the beveled or sharpened length of the blade on one end only.

7.4.3 TEST PROCEDURE—The mower shall be run for 2 min before shutoff. For multi-spindle mowers, the test may be conducted on all spindles concurrently.

7.4.4 TEST ACCEPTANCE—The test shall be completed without loss of any part of the unit or failure of any component in a manner that could be hazardous to the operator or bystanders. Any target puncture by any part of the mower shall constitute failure.

7.5 Structural Integrity Tests

7.5.1 TEST EQUIPMENT—Use test target enclosures per Figures 2, 3, or 7 as applicable. Use low carbon hot finish sawed or sheared end test rods as follows: For mowers with blades up to 1220 mm tip circle diameter use test rods 9.5 mm diameter x 50.8 mm long. Mowers with one or more blades over 1220 mm tip circle diameter use test rods 12.7 mm diameter x 50.8 mm long. Rod lengths to be ±3 mm.

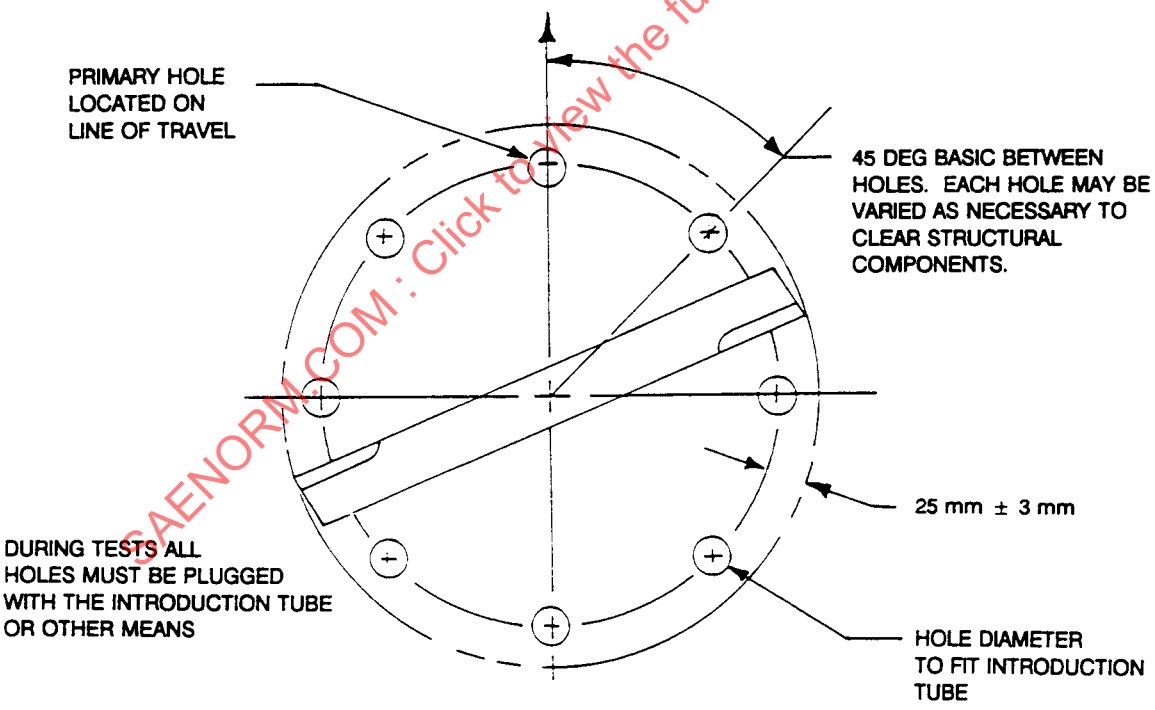
WARNING—Test rods may puncture the test enclosure as noted in Figures 2, 3, or 7. Additional protection, such as straw bales or steel sheets, around the exterior of the target enclosure from the blade line to the sand should be in place.

7.5.2 TEST CONDITIONS—The mower should be positioned so the cutting edge of a stationary blade is 305 mm ± 13 mm above sand base. When supports are necessary to position the mower such that the cutting edge of the blade is 305 mm above the sand base, the supports shall be of round steel bars or tubing no larger than 40 mm in diameter and no more than six shall be used per frame unit. The supports shall be placed as necessary under wheels, side skids, or other structural components which normally rest on the ground if the mower were at the minimum cutting height. If additional supports are needed, they should be located at least 150 mm outside the blade enclosure. The mower may also be supported from above.

7.5.3 TEST PROCEDURE—The test shall consist of vertical downward introduction of test rods inserted into each of eight equally spaced holes for each blade assembly in accordance with Figure 9A. The test rods shall be introduced through the tube and funnel arrangement as specified by Figure 9B or through a similar arrangement with air or mechanical assist. A sufficient number of test rods shall be dropped into each of the eight positions so that a blade contacts at least twelve test rods per position.

7.5.4 TEST ACCEPTANCE—The mower shall remain in compliance with all applicable requirements of this document. The test rods shall not break through the blade housing or blade enclosure but may escape through deflector-type shields such as chain shielding as long as no failure is caused to shielding.

7.6 Thrown Object Test—(To be conducted after the structural integrity test.) (Does not apply to arm-type mowers.) (See reporting form, Appendix A, Figure A1.)



In the situation where tube locations may be varied as necessary to clear structural components, the tube locations shall be positioned to direct the vector of impacted nails toward the target enclosure rather than toward adjacent blades or the sides of the unit.

FIGURE 9A—TYPICAL INTRODUCTION TUBE LOCATION

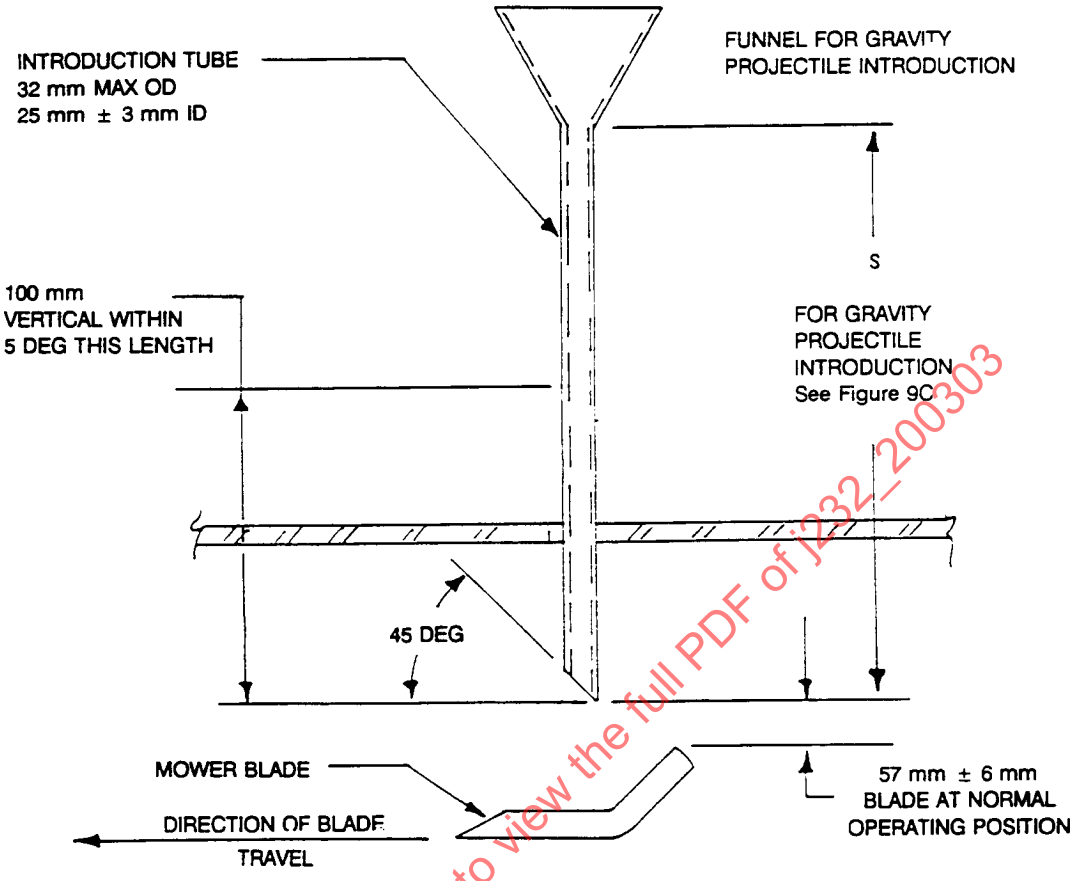


FIGURE 9B—INTRODUCTION TUBE CONFIGURATION

7.6.1 TEST EQUIPMENT—Use test projectiles per 3.16 and test fixture per Figures 2, 3, or 7 as applicable. For undermounted units, a 915 mm diameter vertical cylinder of target material shall be placed in the operator zone such that the back of the cylinder shall be 76 mm behind the back of the operator's seat or 76 mm behind the rear position of an actual operator in the event that there is no back support on the seat. The target cylinder shall extend from the operator's normal foot position to a height of 1 m above the operator's seat.

NOTE—Provisions must be made to protect the operator during the test.

7.6.2 TEST CONDITIONS—(See 7.1)

7.6.3 TEST PROCEDURE—The test shall consist of vertical downward introduction of 75 test projectiles head first and 75 test projectiles point first inserted into each of eight equally spaced holes for each blade assembly in accordance with Figure 9A. The test projectiles shall be introduced through the tube and funnel arrangement as specified by Figure 9B or through a similar arrangement with air or mechanical assist. The introduction shall be repeated three times for each hole (450 per hole) for a total of 3600 per blade assembly.

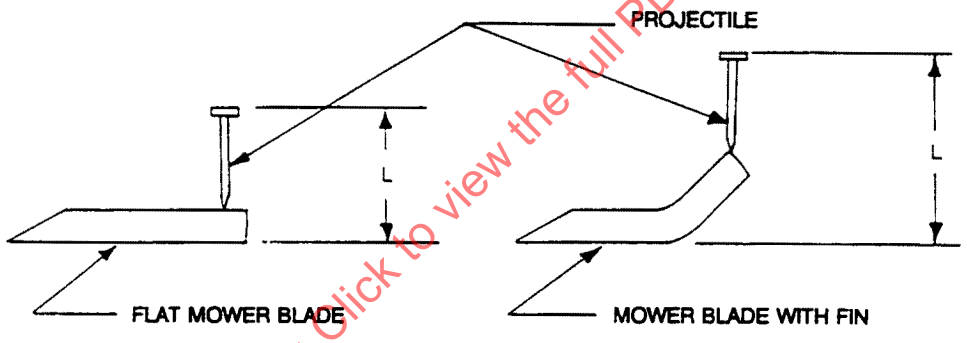
The drop velocity should remain relatively constant and be adjusted to ensure that between 5 and 15% of the test objects drop through the blade without making blade contact (in order to ensure that the entire length of the test object is exposed to the blade). Where a common hole is used between two blades, the 5% requirement of nails dropping through the blade is waived, due to the impossibility of nails passing through the blades. After each 150 test projectiles are introduced, the projectiles in a 610 mm diameter circle under the introduction hole shall be counted to verify that between 5 and 15% of the test projectiles pass through the blade without making blade contact. See Figure 9C for height "s" calculation. On some mowers, it may not be possible to prevent more than 15% of the test projectiles from passing through the blade path without contact. In this case, the 150 quantity must be increased to assure that at least 127 projectiles do make blade contact in each test, however the number of additional nails introduced must remain consistent through the entire blade assembly. This can be determined either by sound or counting the pass-throughs.

$S = 5.66 \times 10^{-8} n^2 L^2$

N = BLADE REVOLUTIONS PER MINUTE
L = LENGTH OF PROJECTILE AND BLADE HEIGHT IN MILLIMETERS, SEE BELOW
S = DROP HEIGHT IN MILLIMETERS, SEE FIGURE 9B

$S = 1.438 \times 10^{-6} n^2 L^2$

N = BLADE REVOLUTIONS PER MINUTE
L = LENGTH OF PROJECTILE AND BLADE HEIGHT IN INCHES, SEE BELOW
S = DROP HEIGHT IN INCHES, SEE FIGURE 9B



THE DROP HEIGHT CALCULATED FROM THE ABOVE FORMULA MAY HAVE TO BE ADJUSTED TO OBTAIN THE PASS THROUGH CRITERIA DUE TO ADVERSE AIR FLOW UP THE INTRODUCTION TUBE GENERATED BY THE MOWER BLADE AND DRAG OF THE PROJECTILE AGAINST THE INSIDE OF THE INTRODUCTION TUBE. AIR OR MECHANICAL ASSIST MAY BE REQUIRED FOR MOWER BLADE DIAMETERS NEAR 775 mm.

FIGURE 9C—DROP HEIGHT "S" CALCULATION FROM FIGURE 9B

7.6.4 SCORING—After every 150 projectiles have been introduced, record the number of nails contacted by the blade and record the marks on the wall above the blade line in the following groups:

a. Hits and punctures in the operator zone
b. Punctures in the operator zone
c. Hits and punctures outside the operator zone
d. Punctures outside the operator zone

Total the number of marks in each of these four categories to obtain their totals for the particular blade spindle. Divide each sum by the total number of blade-nail contacts for that spindle.