

SURFACE VEHICLE RECOMMENDED PRACTICE

an American National Standard

SAE

J232

**REV.
DEC84**

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(R) INDUSTRIAL ROTARY MOWERS

1. PURPOSE:

To establish guidelines for operator and bystander protection for industrial type rotary mowers whose intended use falls within the scope of this recommended practice.

2. SCOPE:

The guidelines for operator and bystander protection in this recommended practice apply to towed, semi-mounted, or mounted mowers with one or more blade assemblies of 78 cm (30-1/2 in) blade tip circle diameter or over, mounted on a propelling tractor or machine of at least 15 kW (20 hp), 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 recommended practice 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.

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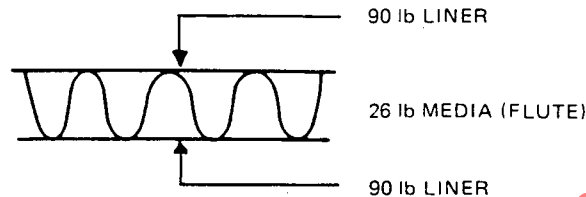
2. (Continued):

Where other standards are referenced such reference applies only to the document identified, not revisions thereof.

3. DEFINITIONS (See also SAE J1150 MAY83):

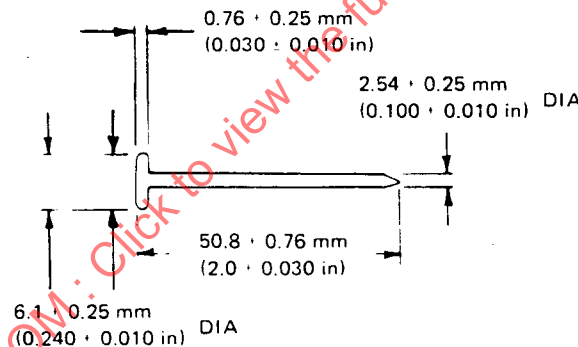
- 3.1 ARM TYPE MOWER: Mowers which are intended to be used frequently with the cutter portion not adjacent or parallel to the ground.
- 3.2 FUNCTIONAL COMPONENT: A working mechanism of an attachment or implement designed to perform a specific task such as the cutting blade of a rotary mower.
- 3.3 GUARDED 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 first 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, 3, and 4 and 7.6.1.
- 3.8 POWER TAKE-OFF (PTO): An external shaft on the rear of a tractor to provide rotational power to implements. (SAE J208 MAY78).
- 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 SAE J208 MAY78 (ASAE S318.7).
- 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 by impact and rotate about a vertical axis.

- 3.13 STANDARD TEST OPERATOR: A person weighing 95 ± 5 kg (209 ± 11 lb) and standing 188 ± 5 cm (74 ± 2 in) tall.
- 3.14 SHIELD (OR GUARD): A barrier which minimizes inadvertent personal contact with hazards created by moving machinery parts.
- 3.15 TARGET MATERIAL: 350 lb uncoated corrugated board, specification paper weight 90 lb-26 lb-90 lb B flute per ASTM D 2738 and D 2529:



SINGLE WALL

- 3.16 TEST PROJECTILE: An uncoated six penny steel box nail with the following dimensional limits:



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 dismantling 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 115 kg (250 lb) 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 SEP79.
- 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 either the U.S. or Canadian 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 SEP79 (ASAE S441).
 - 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 (0.019 in) 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, Service, and Maintenance Instructions:

- 4.2.4.1 General Requirements: Written 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 J1035 JUN80 and ASAE EP363 JUN78.)

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."

- 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 injection 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 JUN81 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, 3, and 4.)

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 following standardized SAE attachments: SAE J715 MAY80 (ASAE S217.10) and SAE J909 APR80 (ASAE S278.6).

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.
- 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 recommended practice, 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 deg.

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 or paragraphs 7.5 and 7.6.

7.1.5 Restraints: Resilient restraints 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 5.

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 held in a vertical plane and rotated horizontally and vertically a maximum of 15 deg to either side of the center line while simultaneously being raised and lowered as shown in Figure 5. The probe must be inserted as far as possible at any point around the blade enclosure with a force of 110 N (25 lb) with the blades in the highest and also the lowest cutting positions, [except the highest cutting position for this test shall not exceed 200 mm (7.8 in)]. 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.)
- 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. The wall shall be approximately 1220 to 2440 mm (4 to 8 ft) from the blade tip circle with a minimum height of 1830 mm (6 ft) above the horizontal plane of the blade tip circle. See Figures 2, 3, and 4. A protective barrier shall be provided to protect the operator.
- 7.3.2 Test Conditions: The mower shall be adjusted for approximately 75 mm (3 in) height of cut or the cutting height setting closest to 75 mm (3 in).
- 7.3.3 Test Procedure: The mower shall be positioned over the fixture (described in Figure 6) 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;
 - (b) The mower positioned so that the contact between the blade and centerline of the rod is approximately 25 mm (1 in) from the outer tip of the blade.
- 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.
- 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.
- 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 fixture per Figures 2, 3, or 4 as applicable. Use low carbon hot finish sawed or sheared end test rods as follows: For mowers with blades up to 1220 mm (48 in) tip circle diameter - 10 mm (0.375 in) diameter x 50 mm (2 in) long. Mowers with one or more blades over 1220 mm (48 in) tip circle diameter - 13 mm (0.5 in) diameter x 50 mm (2 in) long. Rod lengths to be ± 3 mm (0.125 in).

7.5.2 Test Conditions: The mower should be positioned so the cutting edge of a stationary blade is 305 mm (12 in) ± 13 mm (0.5 in) above sand base. When supports are necessary to position the mower such that the cutting edge of the blade is 305 mm (12 in) above the sand base, the supports shall be of round steel bars or tubing no larger than 40 mm (1.6 in) 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 (5.9 in) 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 7B. The test rods shall be introduced through the tube and funnel arrangement as specified by Figure 7A 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 recommended practice. 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.)

7.6.1 Test Equipment: Use test projectiles per 3.16 and test fixture per Figures 2, 3, or 4 as applicable. For undermounted units, a 915 mm (36 in) diameter vertical cylinder of target material shall be placed in the operator zone such that the back of the cylinder shall be 76 mm (3 in) behind the back of the operator's seat or 76 mm (3 in) 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 (39 in) 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 7B. The test projectiles shall be introduced through the tube and funnel arrangement as specified by Figure 7A 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). After each 150 test projectiles are introduced, the projectiles in a 610 mm (24 in) 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 7C 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. This can be determined either by sound or counting the pass-throughs.

7.6.4 Scoring: After every 150 nails 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 in the operator zone
- (b) Punctures in the operator zone
- (c) Hits 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. (Punctures are a result of a hole in both surfaces of the target material so they will also be included when counting hits. Therefore, do not add hits to punctures for scoring purposes as this would count each puncture twice as a hit.) Divide each sum by the total number of blade-nail contacts for that spindle.

7.6.5 Test Acceptance: For each blade spindle, none of the composite individual spindle scores shall exceed the following acceptance criteria:

- (a) 2% hits in the operator zone
- (b) 0.5% punctures in the operator zone
- (c) 15% hits outside the operator zone
- (d) 5% punctures outside the operator zone

7.6.5 (Continued):

Failure of any of the four acceptance criteria shall constitute failure of the machine. In the event the machine fails the test, it may be retested. The scores are then computed on the sum of the two tests. If the score still exceeds the acceptance criteria, the machine has failed the test.

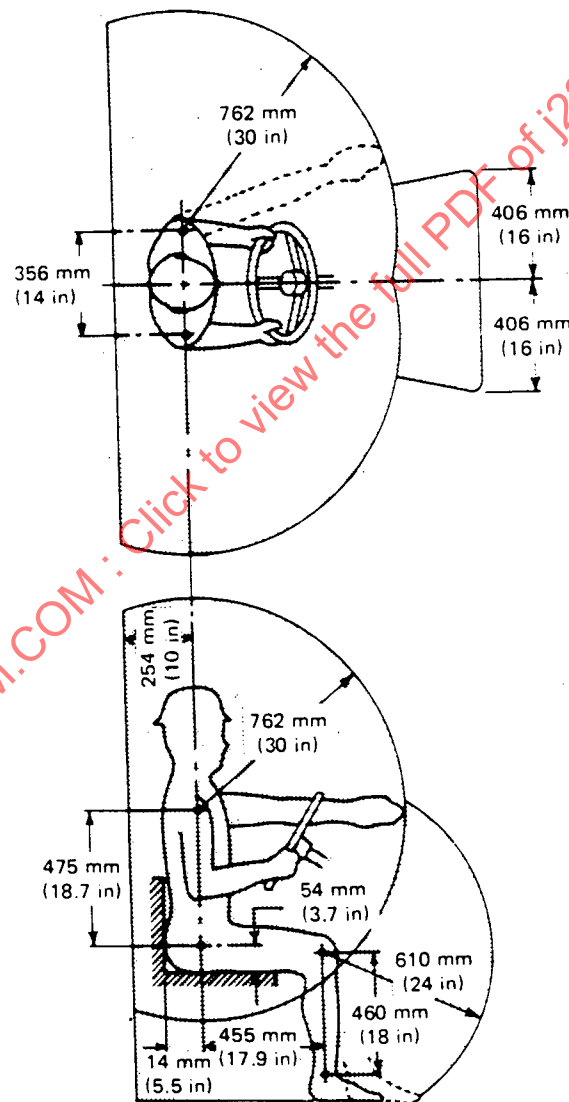


FIGURE 1 - Operator Zone

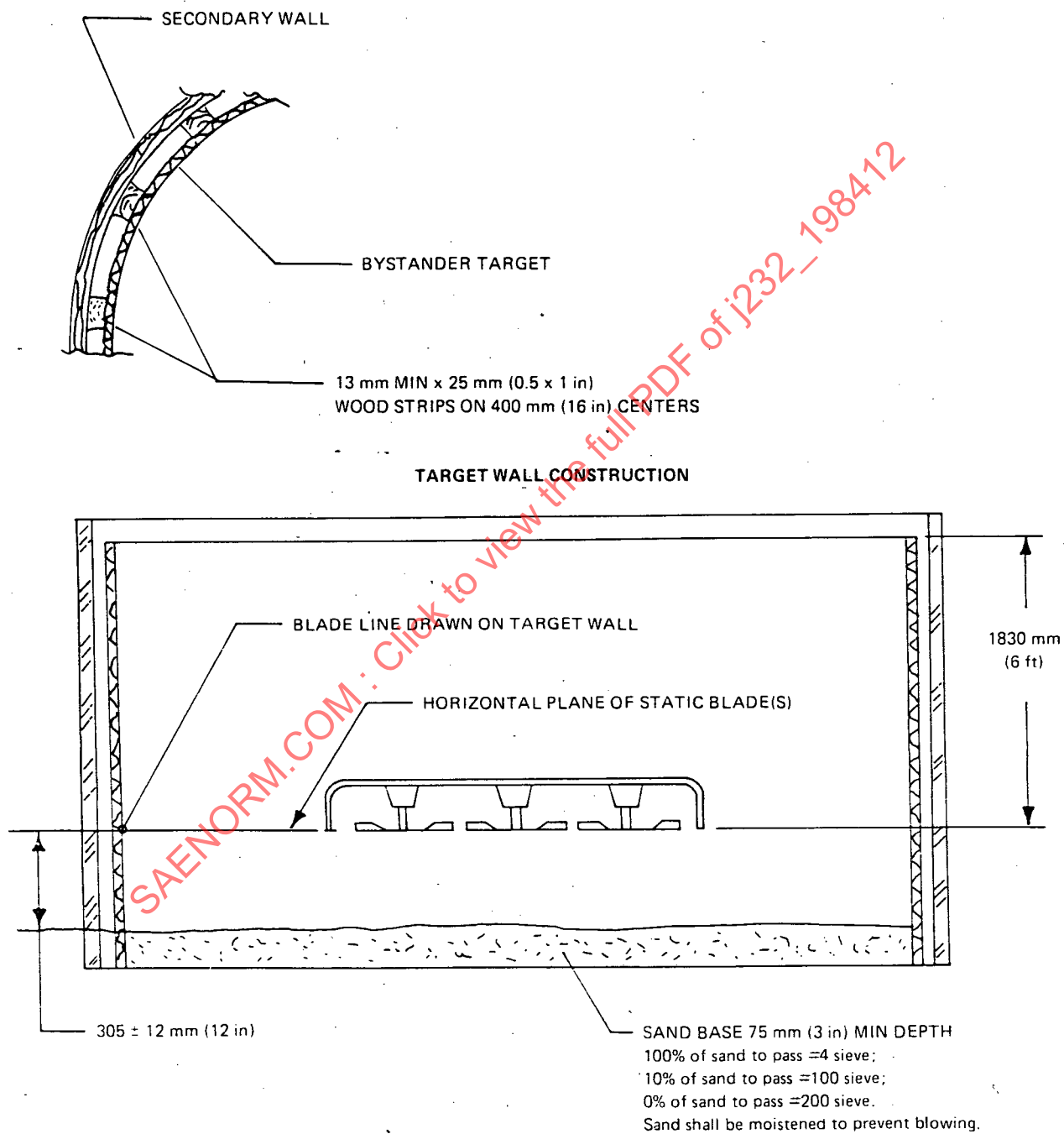


FIGURE 2 - Mower Vertical Position

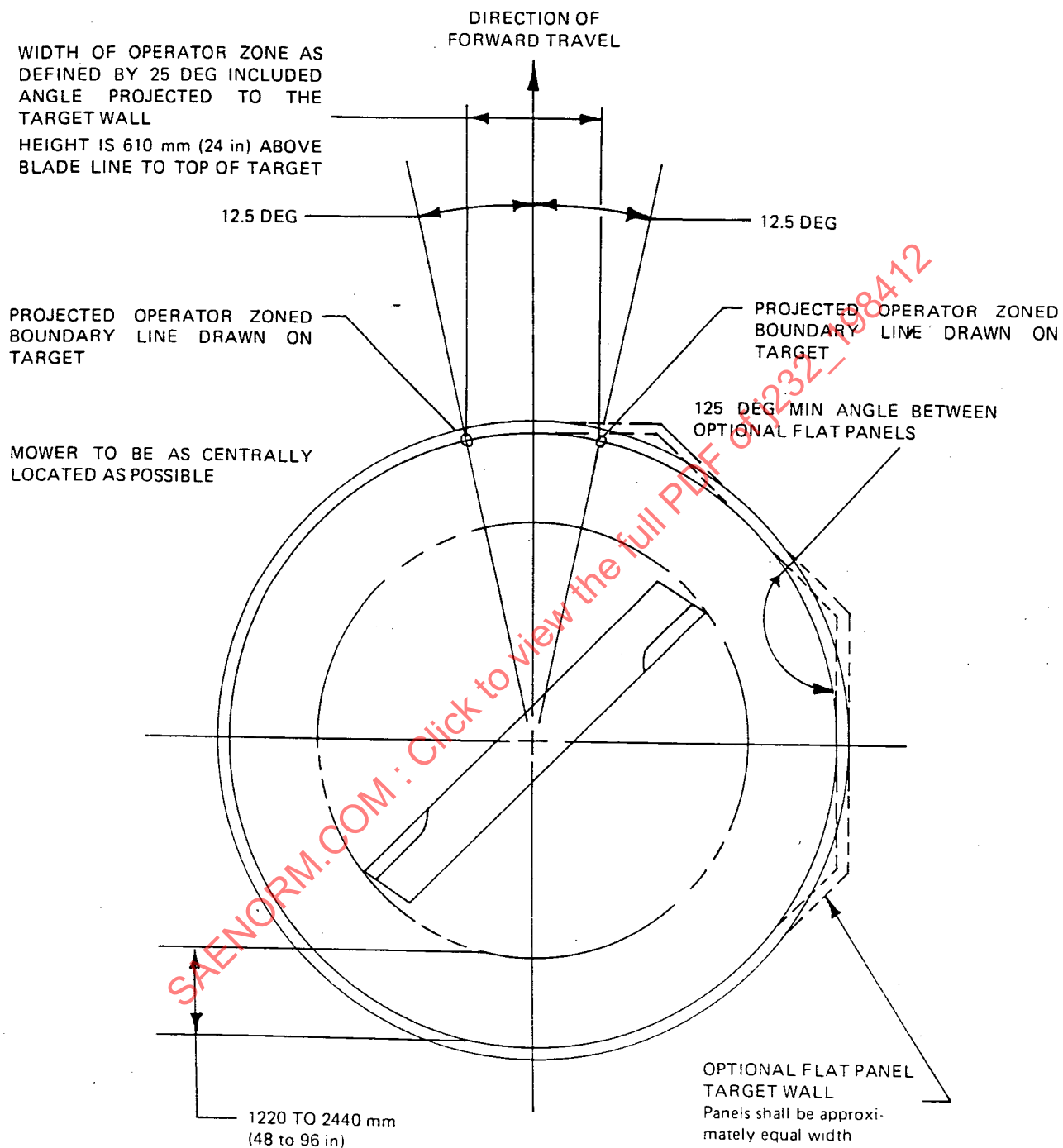
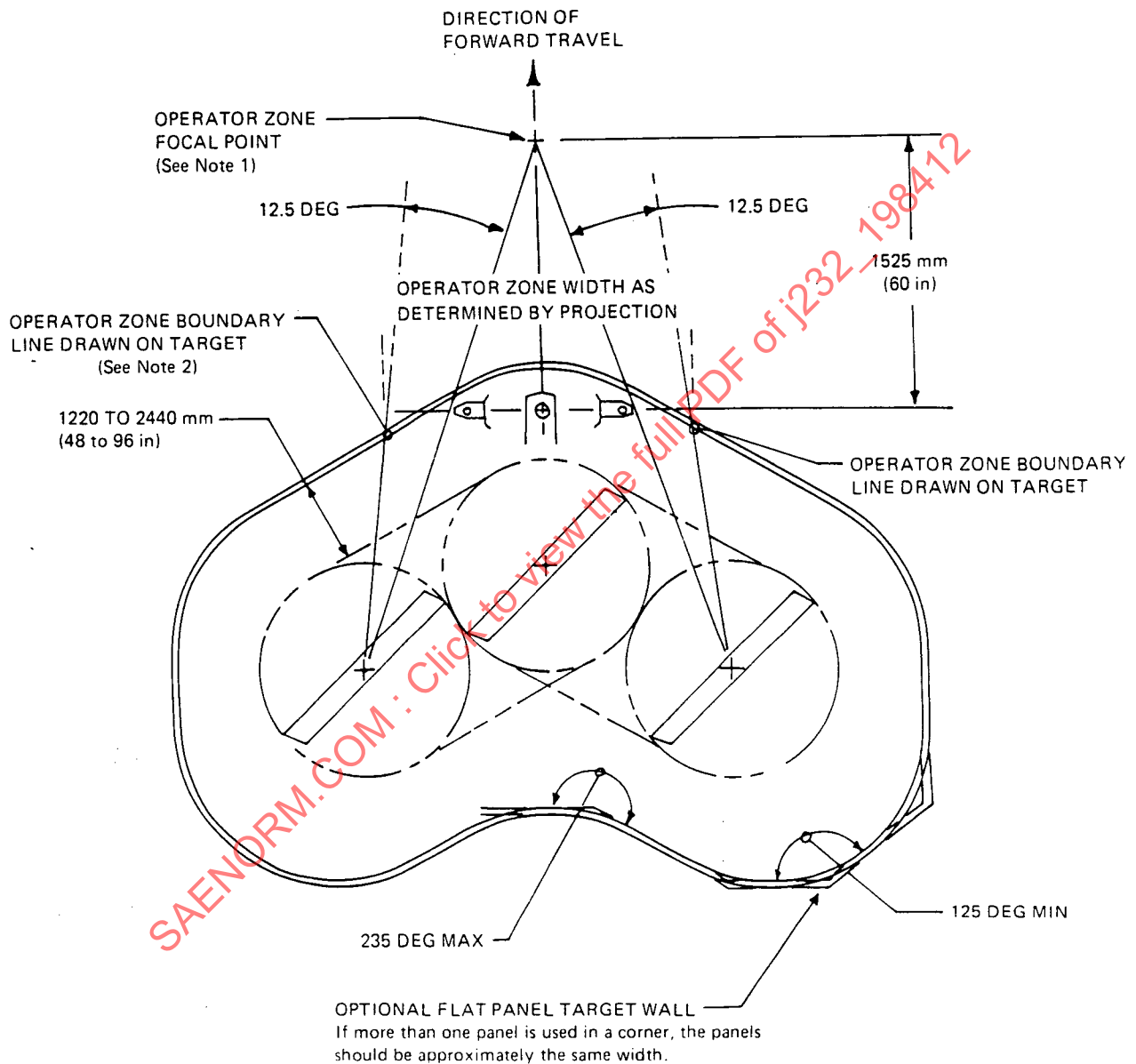


FIGURE 3 - Target Configuration and Operator Zone for Single Blade Mowers



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 (24 in) 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 4 - Target Configuration and Operator Zone for Multi-Blade Mowers

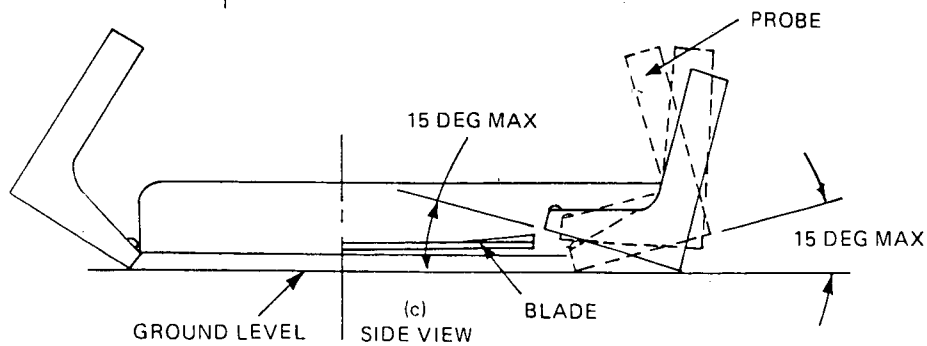
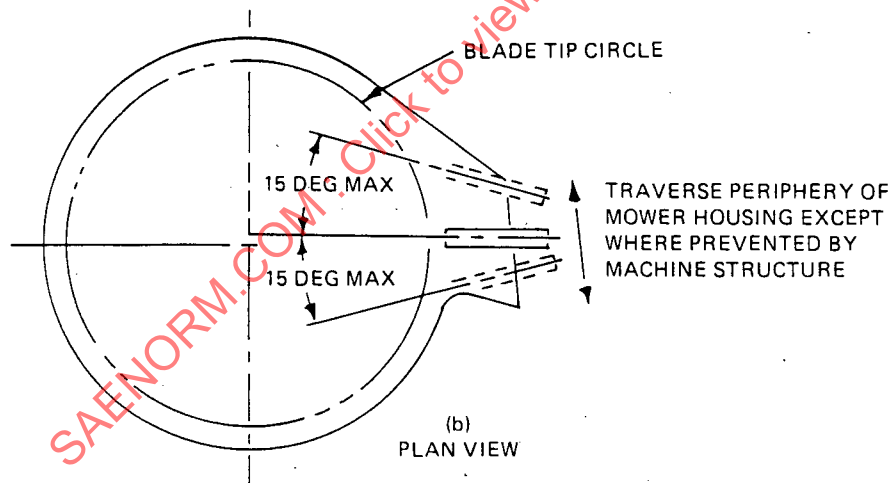
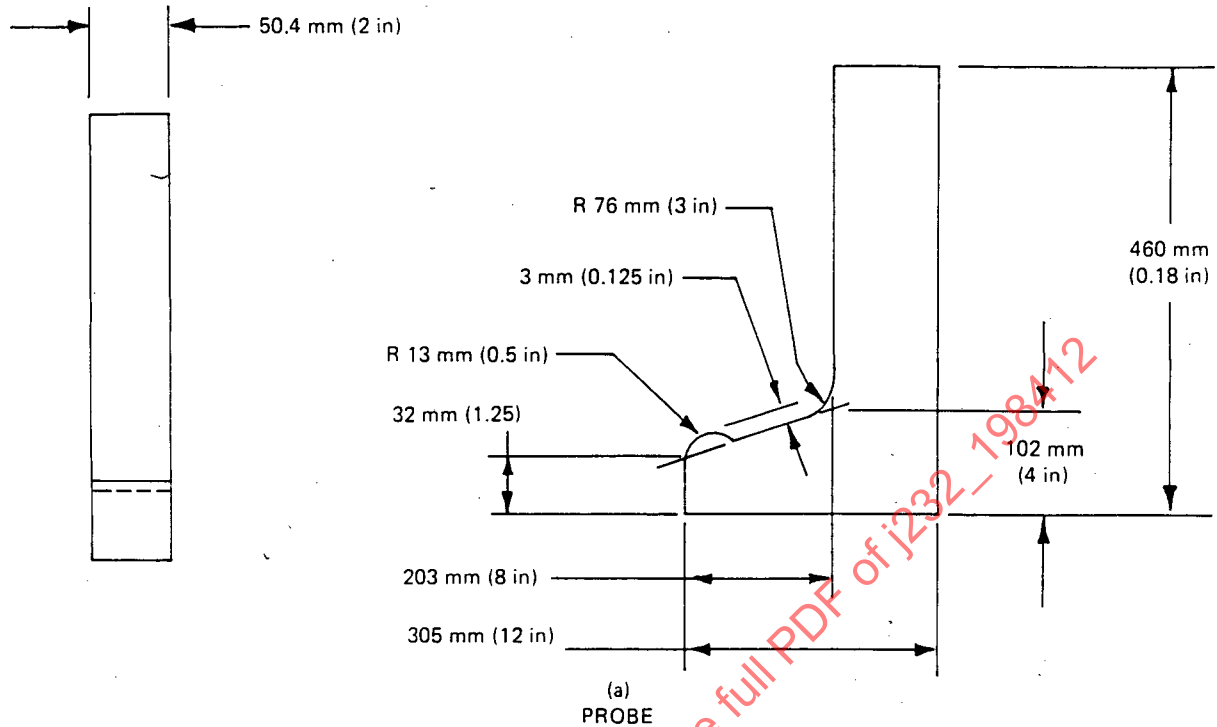


FIGURE 5 - Foot Probe

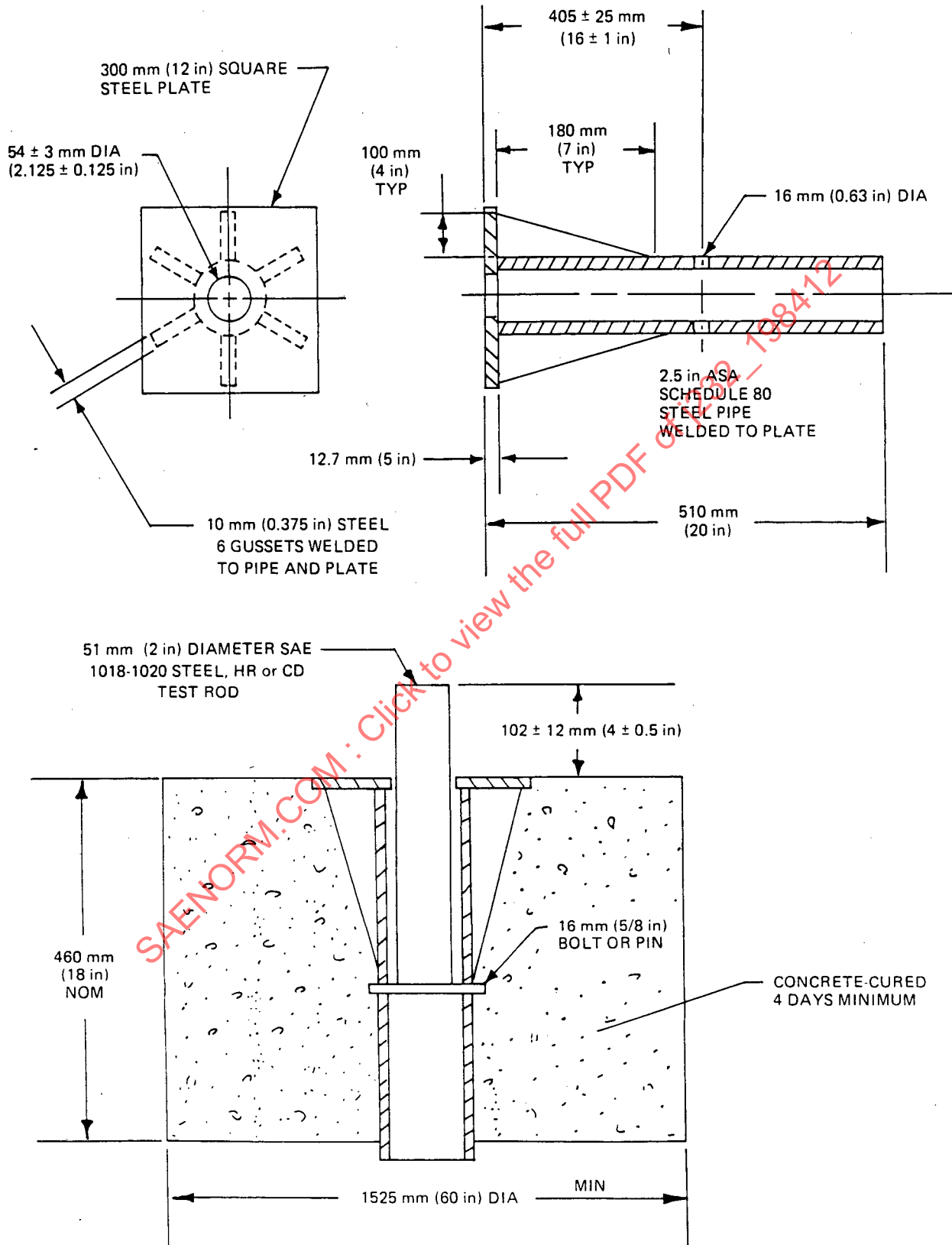


FIGURE 6 - Impact Test Fixture

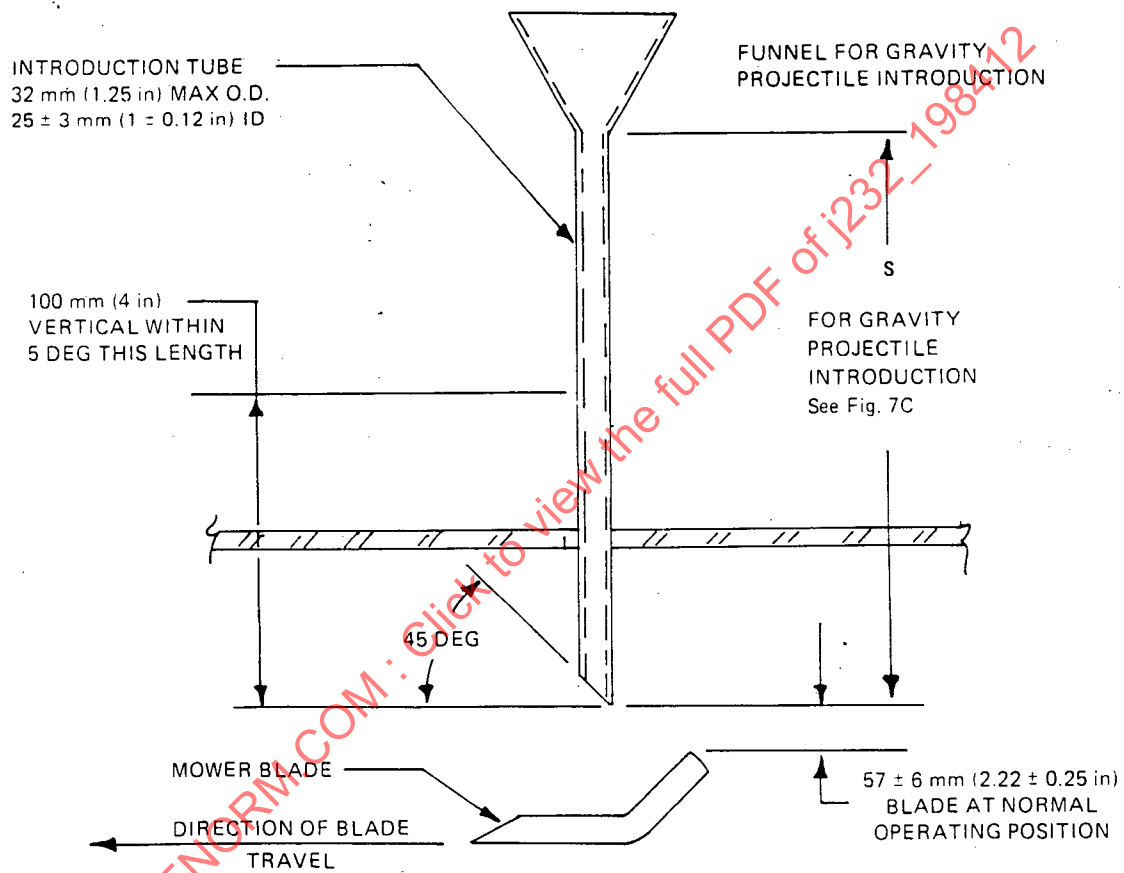


FIGURE 7A - Introduction Tube Configuration

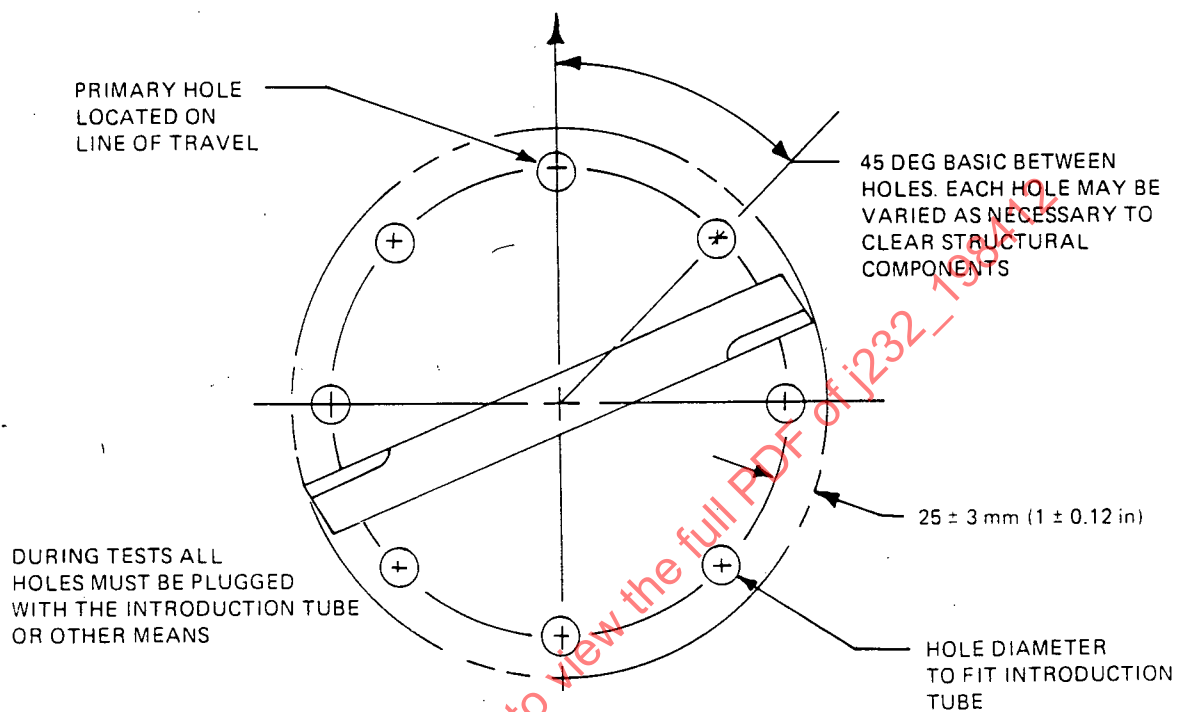


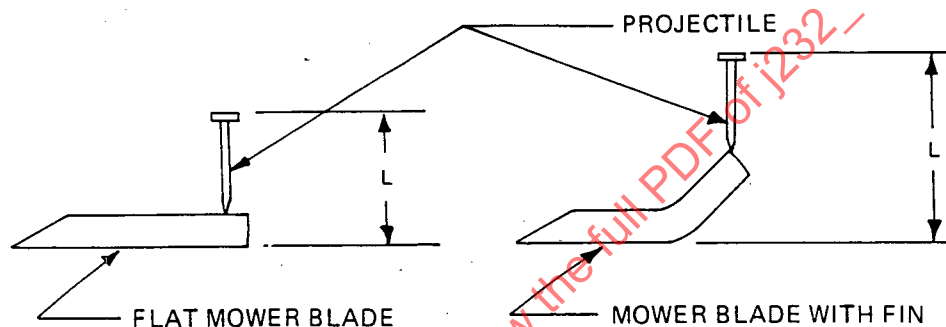
FIGURE 7B - Typical Introduction Tube Location

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

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

N = BLADE REVOLUTIONS PER MINUTE
 L = LENGTH OF PROJECTILE AND BLADE
 HEIGHT IN MILLIMETERS, SEE BELOW
 S = DROP HEIGHT IN MILLIMETERS, SEE
 FIG. 7A

N = BLADE REVOLUTIONS PER MINUTE
 L = LENGTH OF PROJECTILE AND BLADE
 HEIGHT IN INCHES, SEE BELOW
 S = DROP HEIGHT IN INCHES, SEE FIG. 7A



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 (30.5 in).

FIGURE 7C - Drop Height "S" Calculation From Figure 7A

REFERENCES

Standard	Description	Comparable ASAE Standard	
		Standard	Date
SAE J1150 MAY83	Terminology for Agricultural Equipment	S390.1	84
SAE J115 SEP79	Safety Signs	S441	83
SAE J208 MAY78	Safety for Agricultural Equipment	S318.7	84
SAE J1035 JUN80	Technical Publications for Agricultural Equipment	EP 363	DEC78
SAE J517 JUN81	Hydraulic Hose		
SAE J715 MAY80	Three-Point Free-Link Hitch Attachment of Implements to Agricultural Wheeled Tractors	S217.10	DEC79
SAE J909 APR80	Three-Point Hitch, Implement Quick-Attaching Coupler, Agricultural Tractors	S278.6	MAR80
SAE J898 APR80	Control Locations for Construction and Industrial Equipment Design		
SAE J833 JAN80	USA Human Physical Dimensions		
ASTM D2738-71*	Test for Bursting Strength of Corrugated and Solid Fiberboard		
ASTM D2529-74*	Test for Bursting Strength of Paperboard and Linerboard		

* American Society for Testing and Materials.