MIL-STD-2151(SH)
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MILITARY STANDARD

INCLINED LADDER TREAD TEST METHODS AND EQUIPMENT FOR WEAR, SLIP-RESISTANCE AND IMPACT

DEPARTMENT OF THE NAVY
NAVAL SEA SYSTEMS COMMAND

Washington, DC 20362

Inclined Ladder Tread Test Methods and Equipment for Wear, Slip-Resistance and Impact.

MIL-STD-2151(SH)

1. This Military Standard is approved for use by the Naval Sea Systems Command, Department of the Navy, and is available for use by all Departments and Agencies of the Department of Defense.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Naval Sea Systems Command, SEA 55Z3, Department of the Navy, Washington, DC 20362 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

FOREWORD

1. Historically, ladder treads for shipboard use have not been tested except for the type G tread in accordance with Drawing 804-0860041, which is fabricated of layered glass fiber reinforced plastic. The acquisition specification for the type G tread required the following tests for wear, slip-resistance and impact:

(a) The specified test for wear employed a rotating steel disk to which loose abrasive was applied. A 2- by 3-inch sample of the tread surface was forced against the disk causing wear on the sample. The thickness change was then measured and related to the number of turns of the disk.

(b) To measure slip-resistance, three worn samples were tested simultaneously by measuring the force required to pull a weight with three rubber feet across the samples for dry, wet and oily conditions. The force was then converted to coefficient of friction.

(c) The impact test specified for the type G tread consisted of repeatedly dropping a 2-pound steel ball onto a 6- by 6-inch tread sample in a closely spaced pattern. The sample was then inspected for damage or loss of adhesion. Since most damage due to impact occurs on the nose of treads, the impact test did not simulate actual conditions.

2. It has been determined that tests for wear and slip-resistance were unsatisfactory for the following reasons:

(a) The sample was honed to a flat, smooth surface, unlike actual shipboard wear caused by the scuffing action of shoe soles imbedded with abrasive dirt particles.

(b) The relative wear rates of different types of treads were not the same for lab tests as for shipboard tests.

(c) The test was conducted on a flat sample of tread without regard to the influence of the nose configuration on tread life and slip-resistance.

(d) The method of measuring wear indicated average wear rate of the points measured and did not allow prediction of the tread life.

(e) Slip-resistance was measured for the honed flat samples and did not reflect the slip-resistance of a worn tread nose.

3. Tests have been incorporated in this standard which more closely simulate shipboard conditions and permit an evaluation of sample ladder treads with some degree of assurance that shipboard performance will be predicted.

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FIGURES

1. SCOPE

1.1 Purpose. This standard describes test methods and equipment for testing compound filled ladder treads intended for use on Navy ships for wear, slip-resistance and impact resistance.

2. REFERENCED DOCUMENTS

2.1 Issues of documents. The following documents of the issue in effect on date of invitation for bids or request for proposal, form a part of this standard to the extent specified herein.

DRAWINGS

NAVAL SEA SYSTEMS COMMAND
NAVSHIPS 804-0860041 - Ladder Inclined Tread Details, Aluminum, Steel.
NAVSEA 804-5959201 - Test Machine For Ladder Treads.

(Copies of drawings required by contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting officer.)

3. DEFINITIONS

Not applicable.

4. GENERAL REQUIREMENTS

4.1 General description. Shipboard tests and examinations have shown that maximum tread wear and damage occur on the nose of the tread. Test methods for wear, slip-resistance and impact, as described herein, provide an approximate simulation of deterioration of inclined ladder treads encountered on board U.S. Navy ships.

4.1.1 Wear test method. The wear test is designed to provide a wear pattern of approximately the same contour and angle as for shipboard performance by drawing spring-loaded abrasive pads across the nose at an average angle of 30 degrees. The 3- by 6-inch pads are attached to a pair of articulated paddles carried by a rotating arm. The arm is rotated by a 1/3-horsepower (hp), 28.5 revolutions per minute (r/min) gear motor, causing 57 pad strokes per minute. The number of strokes are counted, permitting preset stroke count intervals as specified in the applicable acquisition document for measuring wear. Wear is measured at 17 positions in the contact area with a dial micrometer through holes in a jig plate. Wear rate is compared with the thickness of the slip-resistant material to indicate the life of tread wear.

4.1.2 Slip-resistance test method. The slip-resistance is measured at intervals as specified in the applicable acquisition document by applying a dry, wet, and an oily rubber shoe sole pad to the wear pad and measuring the force required to pull the pad across the nose.

4.1.3 Impact resistance test method. Impact resistance is tested by dropping a 2-pound steel ball on various points of the tread flat and nose and then examined for cracking or loss of slip-resistant material.

5. DETAILED REQUIREMENTS

5.1 Test equipment and accessories.

5.1.1 Description of wear test machine. The wear test machine, as shown on Drawing 804-5959201, consists of a motor driven twin leg stroke assembly. Each leg consists of an articulated, spring loaded, wear pad support. The 3- by 6-inch rubberized abrasive wear pad is mounted to the pad support with two-sided foam tape. A tread support fixture is provided to permit mounting of the tread at the required angle, height and transverse position regardless of the tread design. A predetermining mechanical counter is mounted to record each revolution (two strokes per revolution) and to stop operation when the desired number of strokes is reached.

5.1.2 Wear measuring accessories. The wear measuring accessories consist of a data point locating jig as shown on figure 1, and a depth dial micrometer, Starrett No. 644, or equal. The jig is designed to permit the perpendicular measurement of tread thickness changes at an angle of 30 degrees to the top of the tread at 17 points on the nose wear area. One end support for the jig is adjustable to eliminate rocking due to unevenness of the tread surface. Two additional holes in the jig are provided to permit reference readings to verify consistent jig positioning.

5.1.3 Slip-resistance measuring accessories. Slip-resistance is measured by pulling sole pads across the wear contact area and measuring the force required. Three sole pads (see figure 2) are used. Sole material is "Cats Paw", or equal, 12 iron (1/4 inch thick) rubber shoe sole material. Plain tap water is used for the wetting agent for the wet test condition, and SAE 10W-30 motor oil is applied for the oily condition. The force gage is a Chatillon Model DPP 50, or equal, with a scale of zero to 50 pounds and 0.5 pound graduations. The winch is a 1/135-hp by 12-r/min gear motor mounted as shown on Drawing 804-5959201 and fitted with a 5/8-inch diameter shaft extension to provide a tow speed of approximately 24 inches per minute. Tow rigging is one 1/8-inch diameter cotton rope loop and a small diameter flexible tow wire fitted with a hook for attachment to the force gage.

5.1.4 Impact equipment. Impact resistance is measured using the test fixture shown on figure 3. A 2-pound steel ball is dropped onto the tread from the height and at the locations specified. The fixture can be adjusted for variations in drop height, tread length and impact angle. A plumb bob used for accurate position of the impact point and a hand-held vacuum release device (Neward Enterprises, Inc., Mitivac #6810 or equal) is used for dropping

the ball. Full treads may be bolted directly to the fixture. When cap treads are tested, a type F extruded aluminum tread (see Drawing 804-0860041) is first installed, and the cap tread is bolted or clamped to it. Foam padding is installed in the bottom of the fixture to catch the ball after impact.

5.2 Test methods.

5.2.1 Wear test procedure.

5.2.1.1 Tread mounting. The sample tread shall be mounted as shown on figure 6 using C-clamps. The mounting fixture shall be adjusted so that the tread is in the location and angle as shown on figure 4. Wood blocking or shims may be required when the tread is too narrow or has ribs which prevent solid clamping to the fixture. Transverse positioning is not critical. The clamps shall be located to also secure the positioning blocks for the wear measuring jig as shown on figure 5.

5.2.1.2 Wear pad installation. The 3- by 6- by 3/8-inch rubberized abrasive wear pads, shall be affixed to the face of the pad support with three strips of 1- by 1/16-inch, two-sided urethane foam tape along the length. Contact surfaces of the pad shall be thoroughly cleaned with soap and water and dried. Dirt and adhesive residue shall be removed from the pad support with solvent and a razor blade to assure proper adhesion. When the pads show signs of uneven wear or deep grooves, they shall be smoothed with a dressing stick (Brightboy #90 or equal), or replaced with a new pad. If the pad is worn to less than 3/16-inch thick in any part, it shall be replaced before the next tread test.

5.2.1.3 Machine operation and care. After connecting to a 115 volt outlet, the predetermining counter shall be set to half the number of strokes as specified in the applicable acquisition document. Pad force on the tread nose shall be checked to ensure proper spring tension by measuring the perpendicular force required to pull the pad away from the tread nose. The force gage and rope sling may be used for this purpose (see figure 7). If a force of 15 to 18 pounds is not obtained, adjustment of the spring length by modifying the mounting hooks, or replacement of the springs, may be necessary. After any spring has been in service in excess of 50,000 strokes and the pad force falls below 15 pounds the spring shall be replaced. Low force is an indication that the spring may fail from fatigue causing personnel injury and machine damage.

5.2.1.3.1 Before the wear test procedure, all set screws, mounting bolts and clamps shall be tight, and arm return bumpers and flexible coupling inserts shall be in good condition. Lubrication of the gear motor is not required. When necessary, a drop of oil shall be placed on the pad arm pivot for smooth operation and the pivot shaft nuts shall be tightened to reduce play.

5.2.1.3.2 When the thumb lever on the side of the counter is depressed all the way down and released the machine will start and the counter will reset to the present number. Caution shall be taken to stand clear while the machine is in operation. If necessary, the machine may be turned off during operation using the switch with the red cover plate. When using the counter lever, stopping and restarting will reset the counter and disrupt the stroke count.

5.2.2 Wear measurement.

5.2.2.1 Measuring jig adjustment. Before mounting the measuring jig on the tread, excessive tread surface variations shall be removed in the area of jig contact at each end of the jig with a course file. The jig shall be placed between the clamp blocks as described in 5.2.1.1 and as shown on figure 5. The end plate adjustment screw shall be loosened at one end and the end plate moved until both end plates sit hard on the tread surface with no rocking. The screw shall be retightened.

5.2.2.2 Depth readings. Tread wear shall be determined by measuring the change in distance from the jig face to the tread surface by placing the depth dial micrometer through each of the holes in the jig and recording the reading as specified in 5.2.2.3. Data points "R" (see figure 1) shall be read first and shall be the same for each reading to verify consistent positioning of the jig. Contact surfaces between the jig and micrometer shall be clean to ensure accurate readings.

5.2.2.3 Reading data. Depth readings, rounded off to the nearest thousandth of an inch, shall be recorded (figure 11 illustrates an acceptable format). Date and initials of the person taking the data shall be recorded. Observations of unusual happenings or conditions shall also be recorded on the form.

5.2.2.4 Computing the average wear. Initially, and after each specified stroke count interval, depth readings shall be taken of the test sample through the 17 holes in the jig, as shown on figure 1, with the depth dial micrometer. The depth readings shall be recorded in the left portion of the spaces, as shown on figure 8, corresponding to the hole location in the jig, as shown on figure 1. After the data has been recorded for the final stroke interval, the last readings shall be compared with corresponding initial readings and the differences recorded in the right portion of the appropriate spaces as shown on figures 8 and 10. The highest five differences (10, 13, 14, 12 and 13, spaces with shaded upper right corner) recorded shall be averaged. The average wear figure (12.4 at 50,000 strokes) shall be recorded in the lower right box as shown on figure 10. When determining wear for other count intervals (10,000, 20,000) the same five data points (determined to be the high five after the final interval) shall be used.

5.2.3 Slip-resistance measurement.

5.2.3.1 Preparation and care of sole pads. Three sole pads, as shown on figure 2, shall be prepared by abrading the tread contact surface with 100 grit abrasive paper until the surface is thoroughly and uniformly abraded. Before use, foreign material shall be removed from the surface of the pads with a dry cotton cloth. The dry sole shall be used without further preparation. The wet sole shall be held under running tap water and rubbed to ensure thorough wetting. Excess water shall be removed and the wet sole applied directly to the tread. The oily sole contact surface shall be thoroughly coated with a thin coat of SAE 10W-30 motor oil at room temperature. The surface shall appear uniformly glossy. Before each test, the oily sole shall be cleaned of all foreign material and recoated with oil.

5.2.3.2 Preparation of machine and accessory arrangement. Rigging for the slip-resistance test shall be as shown on figure 6 and prepared as follows:

(a) Loosen the motor side of the drive shaft coupling and disengage the coupling.
(b) Place the stop under the back side of the pad support arm as shown on figure 7 to prevent reverse rotation of the assembly and properly position the sole pad on the tread.
(c) Verify sole pad pressure as specified in 5.2.3.3.
(d) Loop the rope sling over the pad support arm and hang the hook end of the force gage on it.
(e) Hook the wire ladder from the winch to the screw on the back of the force gage.

5.2.3.3 Pad force. Using the rope sling and force gage, as shown on figure 7, the force required to pull the sole pad free of the tread surface shall be determined with the sole pad located at the starting position for the slip-resistance test and rope sling centered on the tread nose. Pull shall be gently exerted on the gage until the sole pad lifts from the tread. This procedure shall be repeated three times. The average force shall be recorded (see figure 8).

5.2.3.4 Slip-resistance readings. After rigging, as described in 5.2.3.2, the force gage indicator dial shall be set to "0" and the switch placed on the indicator next to the dial in the "lock" position. The tow winch shall be activated to pull the sole pad across the tread nose for approximately 1-1/2 inches and then the winch shall be stopped. The dial will read the maximum force required to start movement of the sole pad. The rigging shall be disconnected, the sole pad returned to the start position, and the force gage reset. This process shall be repeated two more times. The average reading shall be recorded. If one reading is inconsistent by more than 2 pounds, the process shall be repeated until uniform readings are obtained.

5.2.3.4.1 Loose material shall be removed from the tread contact area with a stiff brush and the process repeated with the wet sole pad.

5.2.3.4.2 The tread surface shall be dried with a cotton cloth and the readings procedure repeated for the oily sole pad. Upon completion of the slip-resistance tests, the tread contact surface shall be cleaned with a 95 percent solution of ethyl alcohol to remove all traces of oil before additional wear testing.

5.2.3.5 Data recording. Test data shall be recorded on the tread test record (see figure 8). The first set of readings for wear, slip-resistance and pad pressure shall be taken before the wear tests. The data will be the basis for determining changes caused by the tests. (See figures 8 and 10 for an illustration of typical completed forms.)

5.2.4 Impact tests. The impact test fixture (see figure 3) shall be used. The test results shall be recorded (see figure 9). The impact tests will usually consist of dropping a 2-pound steel ball from a height of 60 or 72 inches onto different points on the ladder tread. Drop height, number of drops, location and angle of impact shall be as follows:

(a) Treads 6 inches wide, with end plates, of between 18 and 24 inches long may be mounted, as shown on figure 3, using 3/8-inch diameter bolts. One end of the mounting fixture is adjustable to accommodate various length treads. Additional mounting holes are provided to permit mounting of the tread at 30 and 90 degrees to horizontal for the angular nose impact tests. Mounting of 4- or 9-inch wide treads will require modification of mounting hole spacing.

(b) Cap treads shall be mounted directly on a type F aluminum tread (see Drawing 804-0860041) to simulate shipboard installations.

(c) When the cap tread is in position, adjust the drop height, if necessary, by removing the pins at the rear of the ball locator support and moving the support up or down to the desired position. Drop height is measured from the impact point on the tread to the under side of the ball when held by the vacuum support cup.

(d) Set the drop position by placing the bob support plug into the hole in the locator bar with the cord and plumb bob hanging freely. Adjust the cord length, if necessary, so that the bob clears the tread by approximately 1/4 inch.

(e) Adjust the impact position by moving the locator bar until the plumb bob stabilizes at the desired impact position on the tread.

(f) Remove the bob support plug from the hole, slide it to the side so that the cord enters the adjacent slot, then lift the bob up and stow it on the locator bar. This is done to avoid hitting the bob with the ball. Place the ball support cup in the locator hole and hold the ball by actuating the hand-held vacuum pump. Release the ball by opening the pump valve. The impact points shall be within 1/8 inch of the target or the drop pattern shall be repeated in a different location. Each drop shall be recorded (see figure 9). Inspect the impact point and record the results, such as: surface crushing, hairline cracks, delamination, dislodged pieces. Always describe the size and extent of the damage.

Preparing activity:
Navy - SH
(Project 2090-N082)

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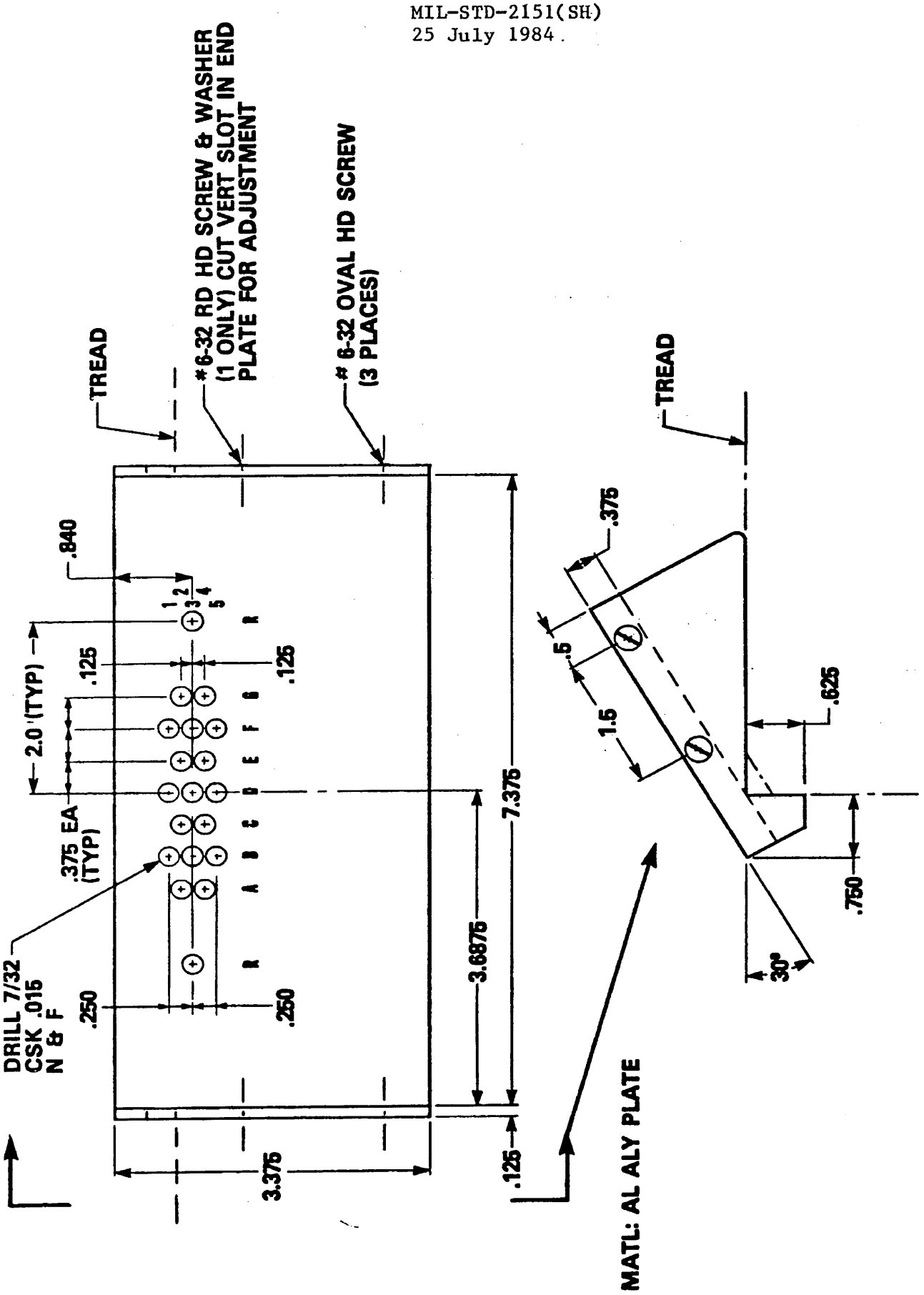

FIGURE 1. Data point locating jig.

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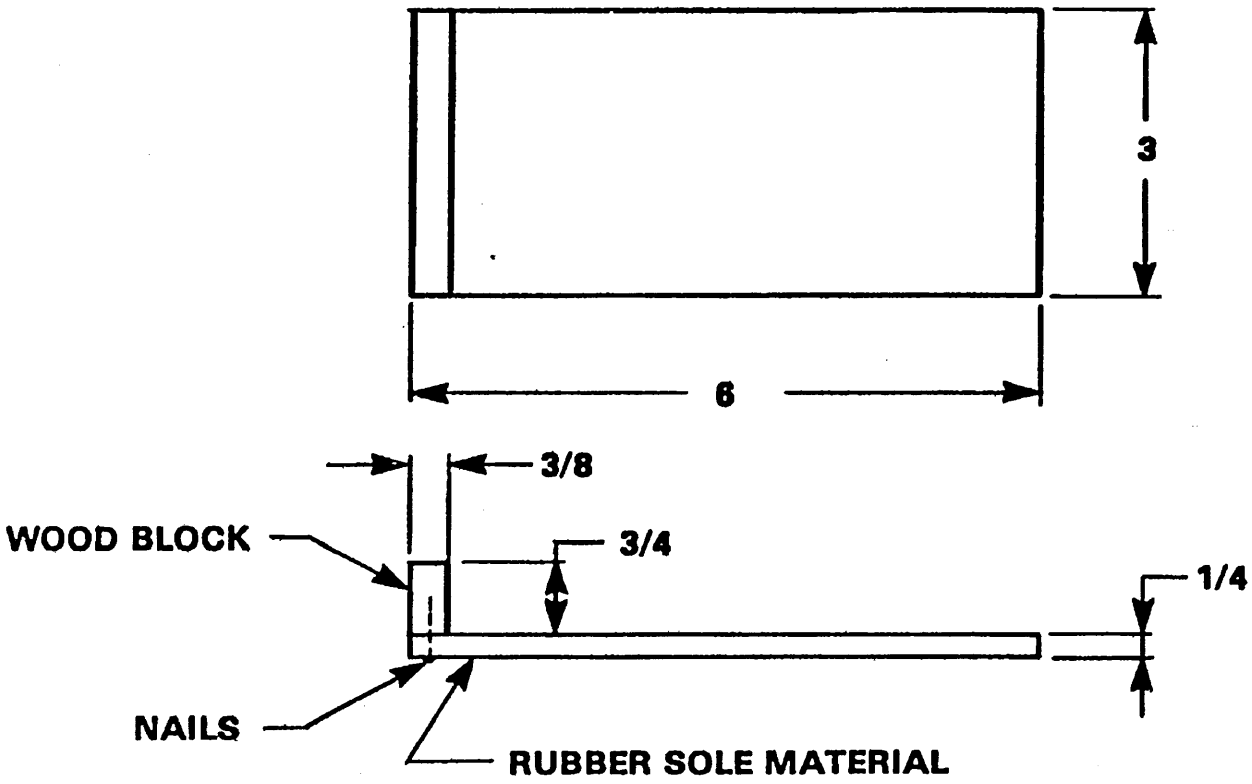

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FIGURE 2. Sole pad.

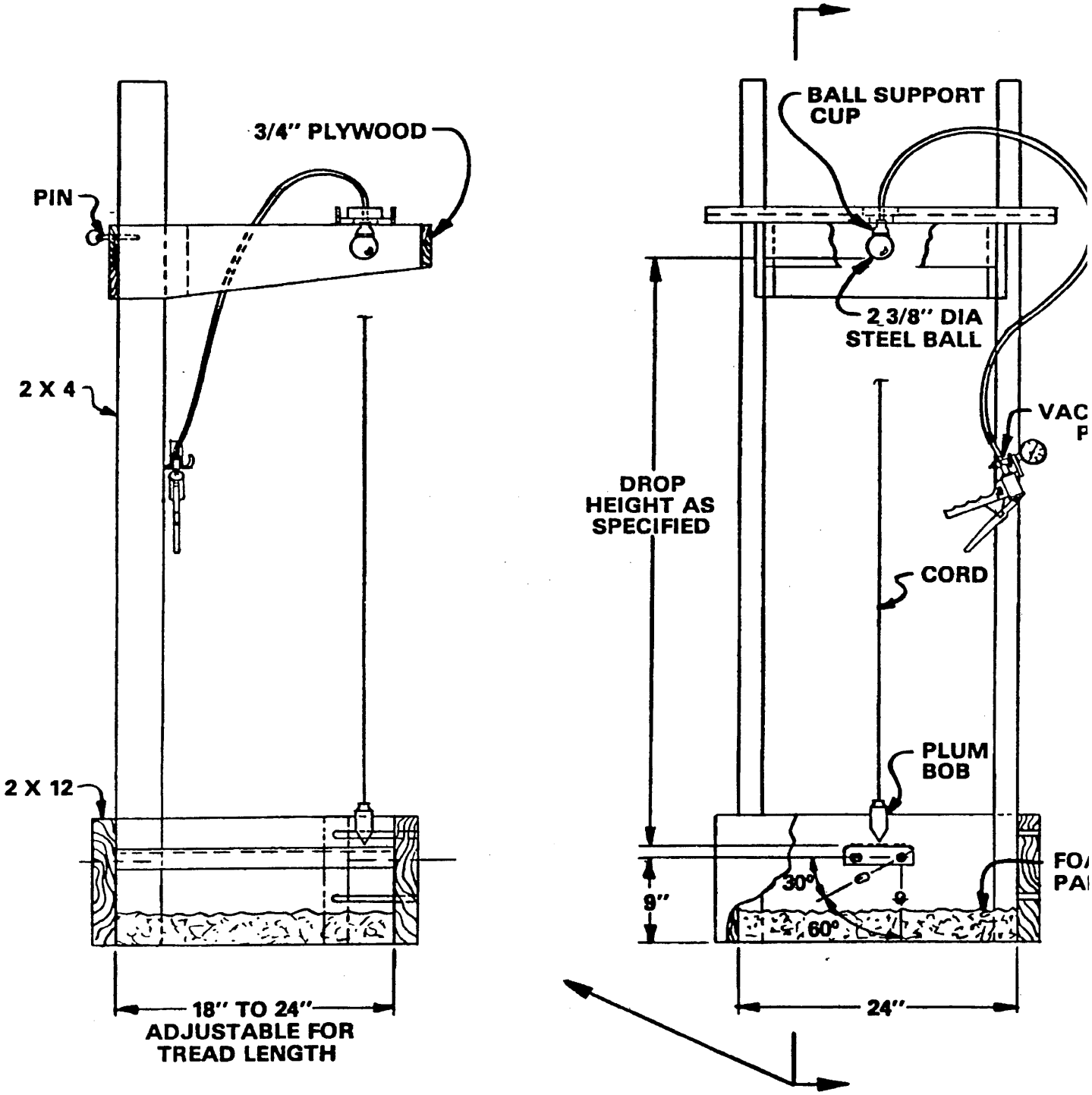

FIGURE 3. Tread impact test fixture.

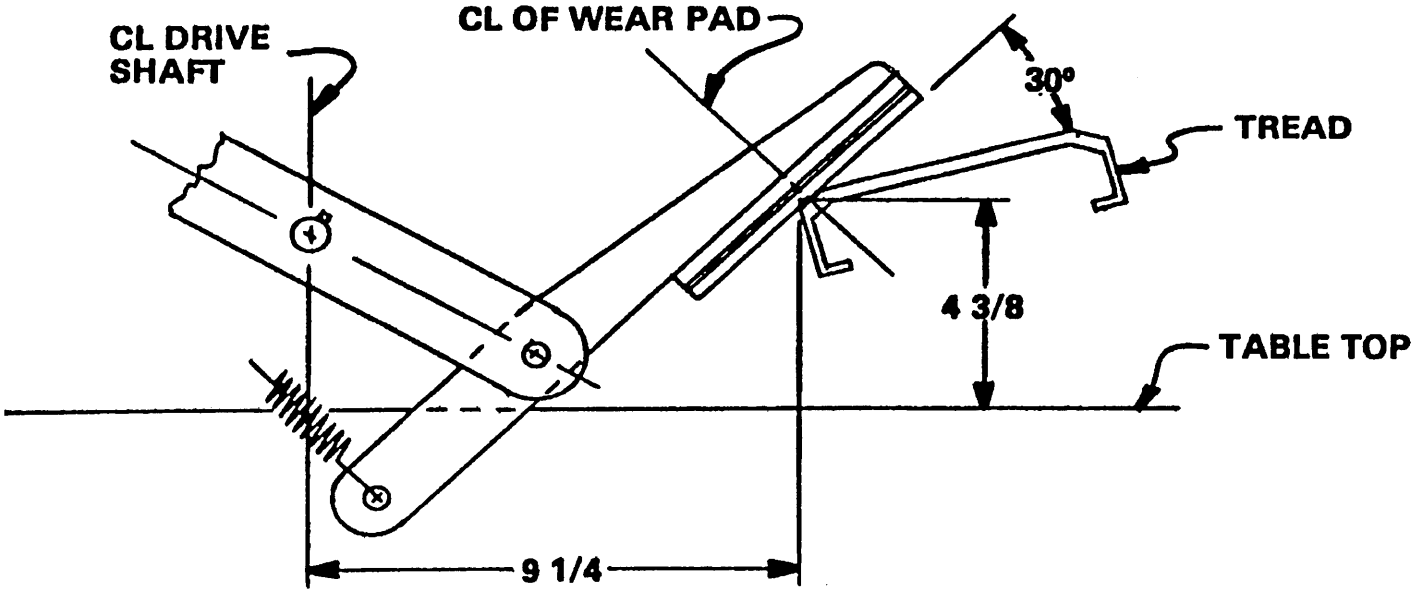

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FIGURE 4. Tread positioning.

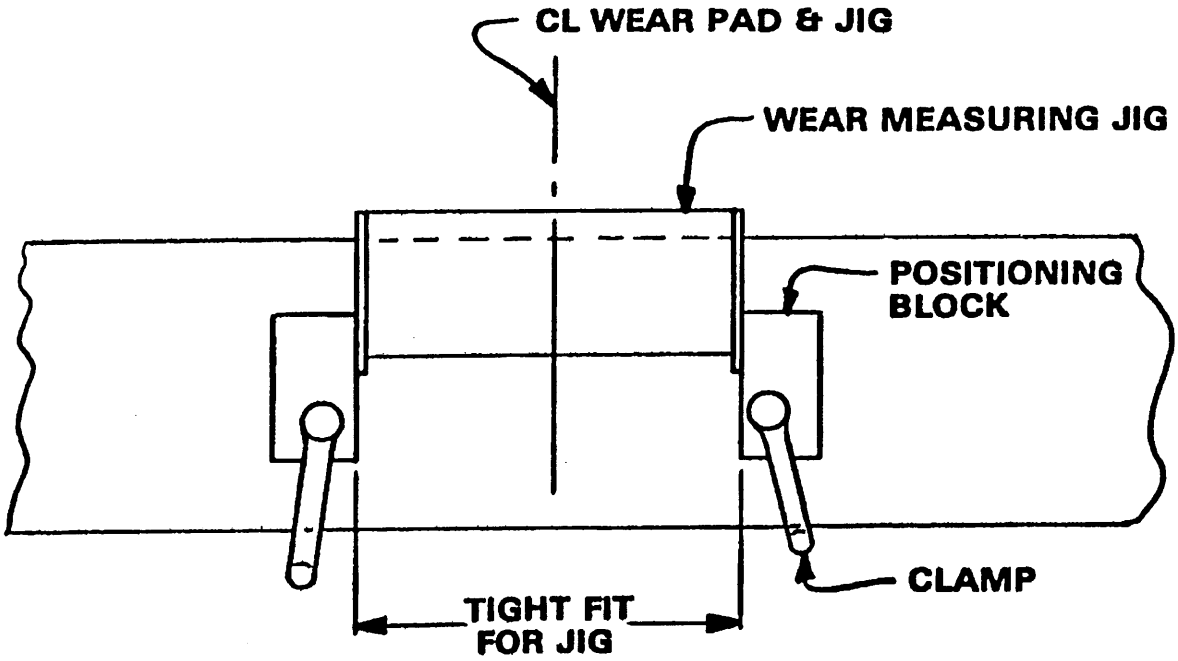

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FIGURE 5. Clamp positioning.

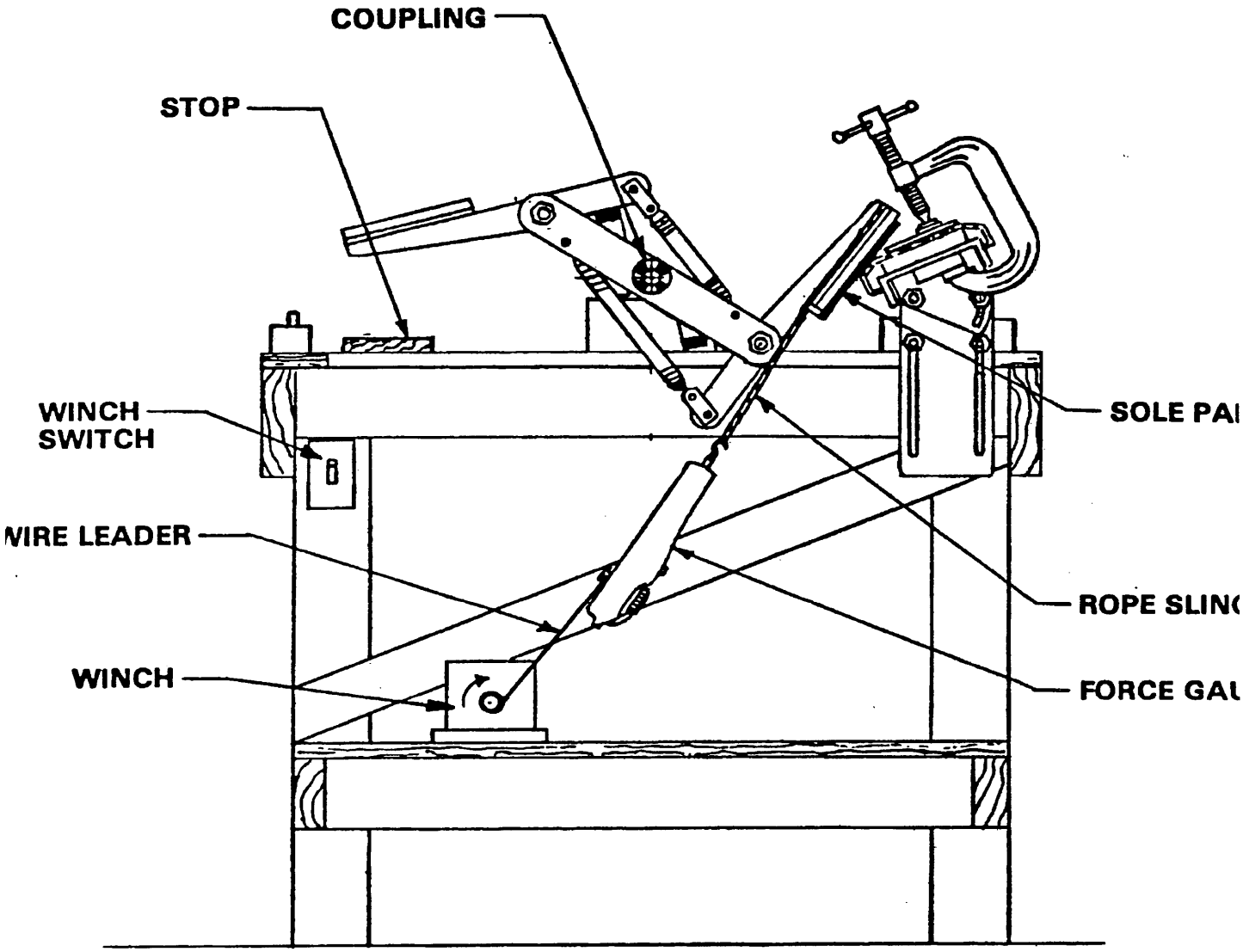

FIGURE 6. Rigging for slip-resistance test.

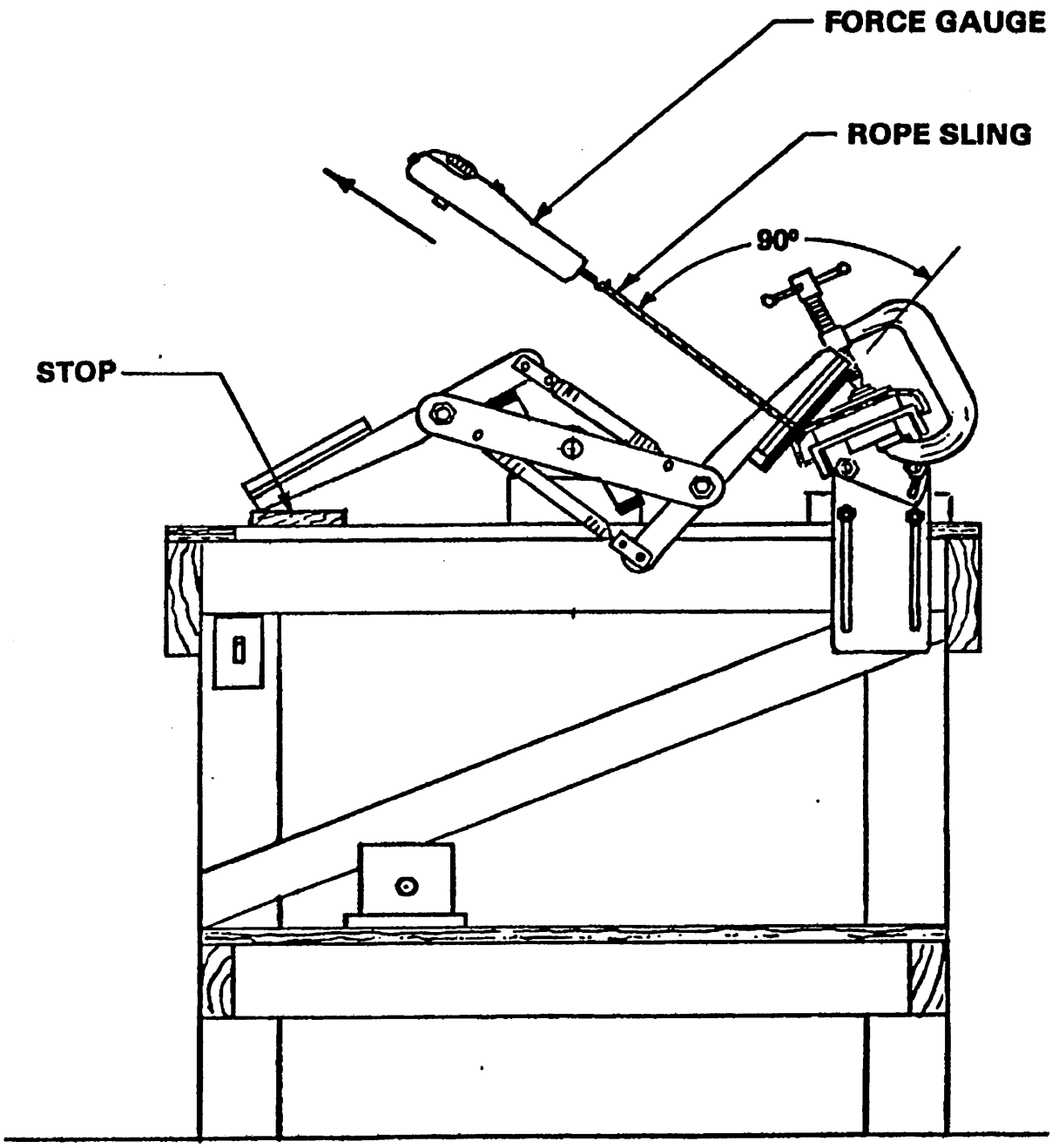

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FIGURE 7. Testing for pad pressure.

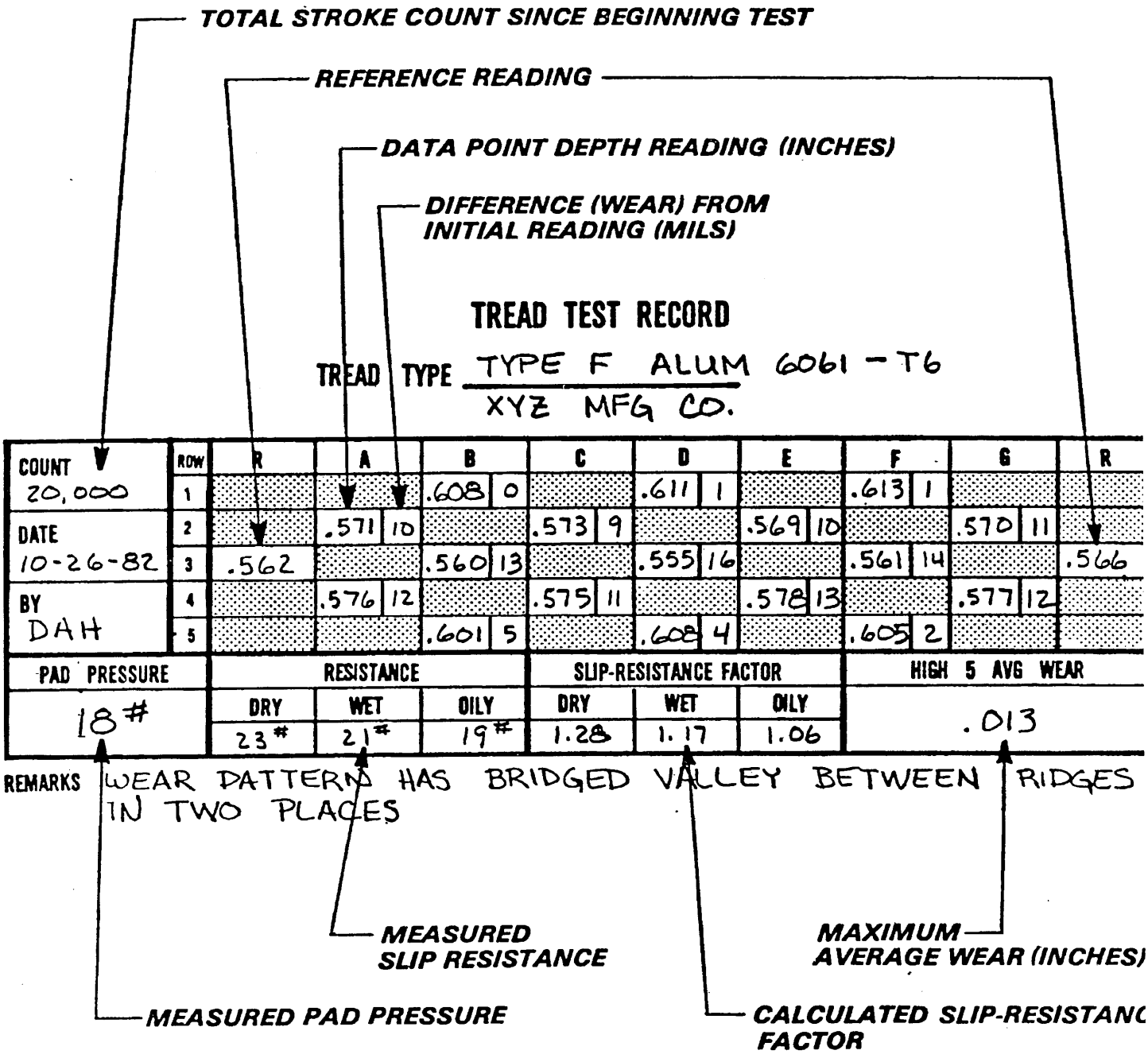

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FIGURE 8. Example of completed record form.

TREAD IMPACT TEST RECORD

TREAD TYPE _____

DATE _____

BY _____

DROP NO.	DROP HEIGHT	DIAGRAM OF IMPACT LOCATION	OBSERVED DAMAGE
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

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FIGURE 9. Tread impact test record.

TREAD TEST RECORD

TREAD TYPE MANUFACTURER X , CAP , GREY COLOR

COUNT 0	ROW	R	A	B	C	D	E	F	G	R
	1			498		504		498		
DATE 9-23-81	2		484		484		478		479	
	3	485		484		480		478		483
BY DAH	4		502		493		496		491	
	5			540		534		542		

PAD PRESSURE	RESISTANCE			SLIP-RESISTANCE FACTOR			HIGH 5 AVG WEAR
	DRY	WET	OILY	DRY	WET	OILY	
18	35	33	25.5	1.94	1.83	1.42	N.A

REMARKS

COUNT 10,000	ROW	R	A	B	C	D	E	F	G	R
	1			500		508		502		
DATE 9-23-81	2		489		484		481		481	
	3	485		487		487 7		485 7		483
BY DAH	4		505		498 5		501 5		497 6	
	5			540		534		542		

PAD PRESSURE	RESISTANCE			SLIP-RESISTANCE FACTOR			HIGH 5 AVG WEAR
	DRY	WET	OILY	DRY	WET	OILY	
18	30	27	20.5	1.67	1.5	1.14	6.0

REMARKS

COUNT 20,000	ROW	R	A	B	C	D	E	F	G	R
	1			501		509		503		
DATE 9-24-81	2		492		486		484		484	
	3	485		491		490 10		489 11		483
BY DAH	4		507		500 7		504 8		500 9	
	5			540		535		543		

PAD PRESSURE	RESISTANCE			SLIP-RESISTANCE FACTOR			HIGH 5 AVG WEAR
	DRY	WET	OILY	DRY	WET	OILY	
18	30.5	29.5	22	1.69	1.64	1.22	9.0

REMARKS

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FIGURE 10. Example of tread test record.

TREAD TEST RECORD

TREAD TYPE MANUFACTURER X, CAP, GREY COLOR

COUNT 30,000	ROW	R	A	B	C	D	E	F	G	R
DATE 10-4-81	1			501		511		504		
	2		494		487		486		485	
	3	485		494		492 12		492 14		483
BY DAH	4		509		502 9		506 10		503 12	
	5			541		536		544		

PAD PRESSURE	RESISTANCE			SLIP-RESISTANCE FACTOR			HIGH 5 AVG WEAR
	DRY	WET	OILY	DRY	WET	OILY	
18	30.5	28	21	1.69	1.56	1.17	11.4

REMARKS

COUNT 40,000	ROW	R	A	B	C	D	E	F	G	R
DATE 10-4-81	1			501		511		504		
	2		494		487		487		485	
	3	485		494		493 13		492 14		483
BY DAH	4		509		503 10		507 11		503 12	
	5			541		536		544		

PAD PRESSURE	RESISTANCE			SLIP-RESISTANCE FACTOR			HIGH 5 AVG WEAR
	DRY	WET	OILY	DRY	WET	OILY	
18	29	27.5	20.5	1.61	1.53	1.14	12

REMARKS

COUNT 50,000	ROW	R	A	B	C	D	E	F	G	R
DATE 10-4-81	1			501 3		511 7		504 6		
	2		494 0		487 3		487 9		485 6	
	3	485		494 10		493 13		492 14		483
BY DAH	4		509 7		503 10		508 12		504 13	
	5			541 1		536 2		544 2		

PAD PRESSURE	RESISTANCE			SLIP-RESISTANCE FACTOR			HIGH 5 AVG WEAR
	DRY	WET	OILY	DRY	WET	OILY	
18	28	26	19	1.56	1.44	1.06	12.4

REMARKS

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FIGURE 10. Example of tread test record. - Continued

INCLINED LADDER TREADS

TEST RESULTS SUMMARY

Manufacturer _____

Tread Type _____ Length _____ Width _____

Date of manufacture _____

Facility conducting tests _____

Date of tests _____

SPEC PARA.	TEST TITLE	REQUIREMENT	RESULTS PASS	RESULTS FAIL
4.6.1.1	Deflection Test	0.10 inch maximum		
4.6.1.2	Local Load Test	No deformation or damage		
4.6.2	Slip-resistance	After 50,000 - Dry 1.50		
		Wet 1.25		
		Oily 1.0		
		0.75 max diff between initial and final		
4.6.3	Resistance to wear	Max 0.01" after 10,000		
		Max 0.008, 20,001 to 50,000 strokes		
4.6.4	Moisture and temperature	No deterioration		
4.6.5	Resistance to impact	No loss of filler deeper 0.15 inches, cracks or separation		
4.6.6	Fire resistance	No destruction,		
		Comb. plus ignition time 4 min max		
		Light smoke		

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FIGURE 11. Inclined ladder treads test results summary.