Control Locations for Off-Road Work Machines—SAE J898 JUL82

SAE Recommended Practice
Completely Revised July 1982

THIS IS A PREPRINT WHICH IS SUBJECT TO REVISIONS AND CORRECTIONS. THE FINAL VERSION WILL APPEAR IN THE 1984 EDITION OF THE SAE HANDBOOK.

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PREPRINT

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SAE Recommended Practice

Report of the Off-Road Machinery Technical Committee, approved June 1974, completely revised by the Human Factors Technical Committee July 1982. The document conforms in all significant details with ISO 6682. Rationale statement available.

1. Purpose—This recommended practice is intended as a guide for convenient placement of hand and foot operated controls derived from the overlapping reach capability of large and small operators. The large operator approximates the 95th percentile male, and the small operator approximates the 5th percentile female of the U. S. population.

2. Scope

2.1 This recommended practice applies to Construction, General Purpose Industrial, Agricultural, Forestry and Specialized Mining categories of off-road self-propelled work machines, as defined in SAE J1116 (June 1980). Powered Industrial Trucks and Agricultural Equipment, other than the basic agricultural tractor, are excluded from the scope of this document.

2.2 This recommended practice defines zones in which controls used by a seated operator would ordinarily be placed. Constraints peculiar to individual machine applications may require modification to these defined zones.

2.3 The established zones are based upon singular reach capability; appropriate consideration must be made for effort, displacement, and simultaneous operation of two or more controls.

3. Definitions

3.1 SIP—Seat Index Point as defined in SAE J1163 (October 1976) with seat fixed in the nominal adjustment positions.

3.2 Control Displacement—The travel or movement of a control through its operational range.

3.3 Control Location—The positions of a control including the corresponding displacement, defined from the SIP.

3.4 Primary Controls—Controls whose use are frequently or continuously required to maintain operational control of the machine or its functions, such as:

3.4.1 MACHINE CONTROLS—Transmission, brakes, steering, engine speed, etc.

3.4.2 WORKING TOOL CONTROLS—Blade, bucket, ripper, etc.

3.5 Secondary Controls—Controls that are infrequently used by the operator such as: lights, windshield wipers, starter, heater, air conditioner, etc.

3.6 Zones of Comfort—Preferred control location zones for primary hand and foot operated controls. Both large and small operators should be able to comfortably and quickly reach controls in these zones.

3.7 Zones of Reach—Control location zones for secondary hand and foot operated controls. Both large and small operators should be able to reach controls in these zones from the seated position, but the operator may be required to rotate, lean forward or to each side.

3.8 XYZ Coordinate System—Coordinate system used to define the control zone locations:

3.8.1 Origin at the SIP

3.8.2 X AXIS—Fore-aft, positive to the front of the SIP

3.8.3 Y AXIS—Lateral, positive to the right of the SIP

3.8.4 Z AXIS—Vertical, positive upward from the SIP

4. General Conditions—The following conditions were utilized to define the control zones:

4.1 The seat back cushion has a 10 deg nominal angle aft of the vertical and a width of 500 mm.

4.2 The seat has a fore and aft adjustment range of approximately 150 mm. The small operator adjusts the seat to the most forward position, and the large operator adjusts the seat to the most rearward position.

4.3 Both large and small operators position the seat at the nominal vertical adjustment. Vertical seat adjustment is used by individual operators to account for anthropometric variations: long legs but short arms; long trunk but short legs, etc.

4.4 Large and small operators are defined by body pivot dimensions listed in Table 1.

4.5 Large and small operators are capable of the range of movement angles defined in Table 2.

4.6 Control location zones are defined by the common reach zones for large and small operators under the conditions in paragraphs 4.1–4.5. The profile of the control zones has been established by overlaying the reach dimensions of the large operator when the seat is positioned full aft (75 mm aft of SIP) with that of the small operator when the seat is positioned full forward (75 mm forward of the SIP). The recommended zone boundary is the most restrictive of these two conditions.

4.7 These control location zones assume fixed controls and that fitment to the range of large and small operators is accomplished by seat adjustment only. However, adjustment for some or all of the necessary range could be accomplished by adjusting the control itself; i.e., telescoping or adjustable (angle) steering wheel, brake pedals, etc.

TABLE 1—SUMMARY—BODY PIVOT DIMENSION

Fig. 4 Ref.	Body Elements	Dimensions in mm	
		Large Operator	Small Operator
SH	Shoulder-hip	480	396
HK	Hip-knee	452	372
KA	Knee-ankle	445	367
AA′	Ankle-shoe sole	119	98
A′P	Ankle-pedal (when $A_7 = 90$ deg)	150	124
SE	Shoulder-elbow	300	247
EW	Elbow-wrist	267	220
EHg	Elbow-hand grasp	394	325
A′T	Ankle-toe (when $A_7 = 90$ deg)	243	200
H_1H_2	Hip-hip (lateral)	185	152
S_1S_2	Shoulder-shoulder (lateral)	376	310

5. Control Location Zones

5.1 Zones of comfort and zones of reach for hand and foot controls are determined in relation to the SIP and are shown in Figs. 1–3. The zones will be affected if the seat back angle exceeds ±5 deg variation from 10 deg aft of the vertical or if the seat back cushion width exceeds 550 mm.

5.2 The zones of comfort and reach have been established assuming the body is free to move within the range of angles defined in Table 2; consequently, if placement of any control or other constraints to body movement are included in the design, the boundary of the zone must be modified accordingly.

6. Location of Controls

6.1 Figs. 1–3 shall be used to define control location zones for machines having 150 mm fore-aft seat adjustment. The figures shall be used by positioning the intersections of the vertical (Z), longitudinal (X), and transverse (Y) axis at the SIP location on the machine.

6.2 Control locations for machines that have between 100 and 150 mm fore-aft seat adjustment can be derived:

6.2.1 Use hand control location zones defined in Figs. 1–3.

TABLE 2—SUMMARY—RANGE OF MOVEMENT ANGLES

Fig. 4 Ref.	Angle (Right Side Joint)	Movement	Angle (Deg.)	
			Comfort	Maximum
A_1	Seat Back Angle	Aft of vertical	10	5–15
A_2	Trunk	Abduction[a]	0	420 (Left or Right)
A_3	Hip	Flexion[b]	75–100	60–110
A_4	Hip	Adduction[c]	10	10
A_5	Hip	Abduction	22	30
A_6	Knee	Flexion Adduction	75–160	75–170
A_7	Ankle	Flexion	85–108	78–115
A_8	Shoulder	Flexion	−35–85	−50–180
A_9	Shoulder	Adduction	20	20
A_{10}	Shoulder	Abduction	70	120
A_{11}	Clavicle	Circumduction[d]	20	20
A_{12}	Elbow	Flexion	60–180	45–180

[a] Abduction—Movement in a plane normal to the plane of flexion and directed away from the mid axis (XZ plane) of the body.

[b] Flexion—Movement that changes the angle between body parts.

[c] Adduction—Movement in a plane normal to the plane of flexion and directed towards or past the mid axis (XZ plane) of the body.

[d] Circumduction—Movement about an axis that circumscribes a cone.

6.2.2 Narrow the foot control location zones defined in Figs. 1–3 by adding one-half the difference in seat adjustment from the X coordinates of the boundaries closest to the SIP and by subtracting half the difference in seat adjustment from the X coordinates of the boundaries farthest from the SIP.

6.3 Primary controls, including their displacements, should be located within the zone of comfort. Secondary controls to be operated from the seated position should be within the zone of reach.

6.3.1 If a wheel is used for steering, at least 180 deg of its arc should be located within the zone of comfort.

6.4 Controls should be designed to be actuated within the appropriate zones to eliminate potential interference between the body limbs when simultaneously operating hand and foot controls.

6.5 The zone of comfort for hand controls may be rotated up to 30 deg about a vertical axis through the SIP for locating rear equipment controls that are used while the operator is turned in the seat.

6.6 The zone of comfort and zone of reach for hand controls are based on the hand grasp point; the zone boundaries may be extended 75 mm when finger tip controls are utilized.

6.7 The zone of comfort and zone of reach for foot controls is based upon pedal actuation by the ball of the foot; heel actuated controls may be up to 200 mm aft of the zone boundary.

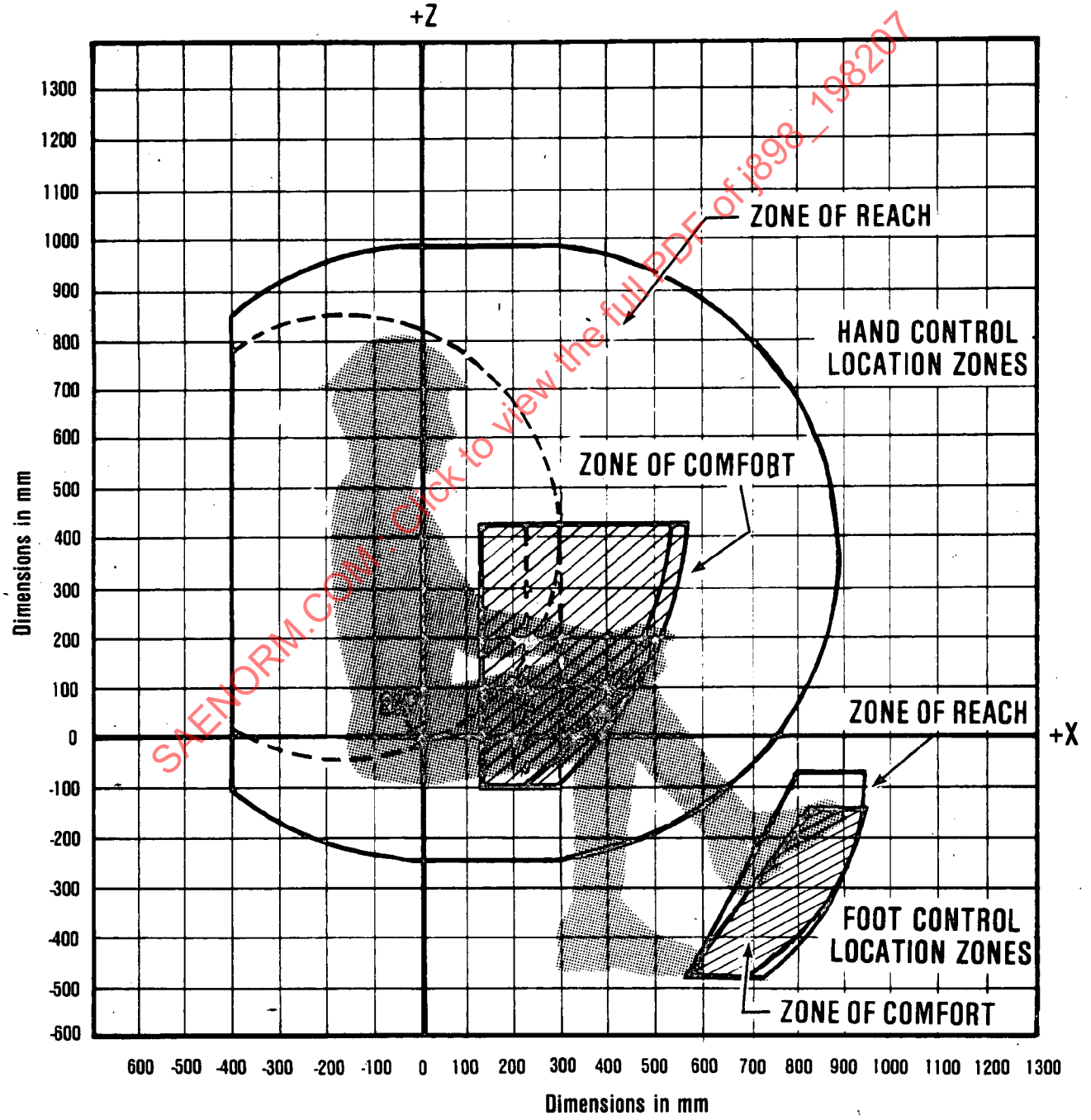

FIG. 1—SIDE VIEW—ZONES OF COMFORT AND REACH (NOTE: AVERAGE OPERATOR IS SHOWN WITH SEAT ADJUSTED TO THE MID-RANGE POSITION.)

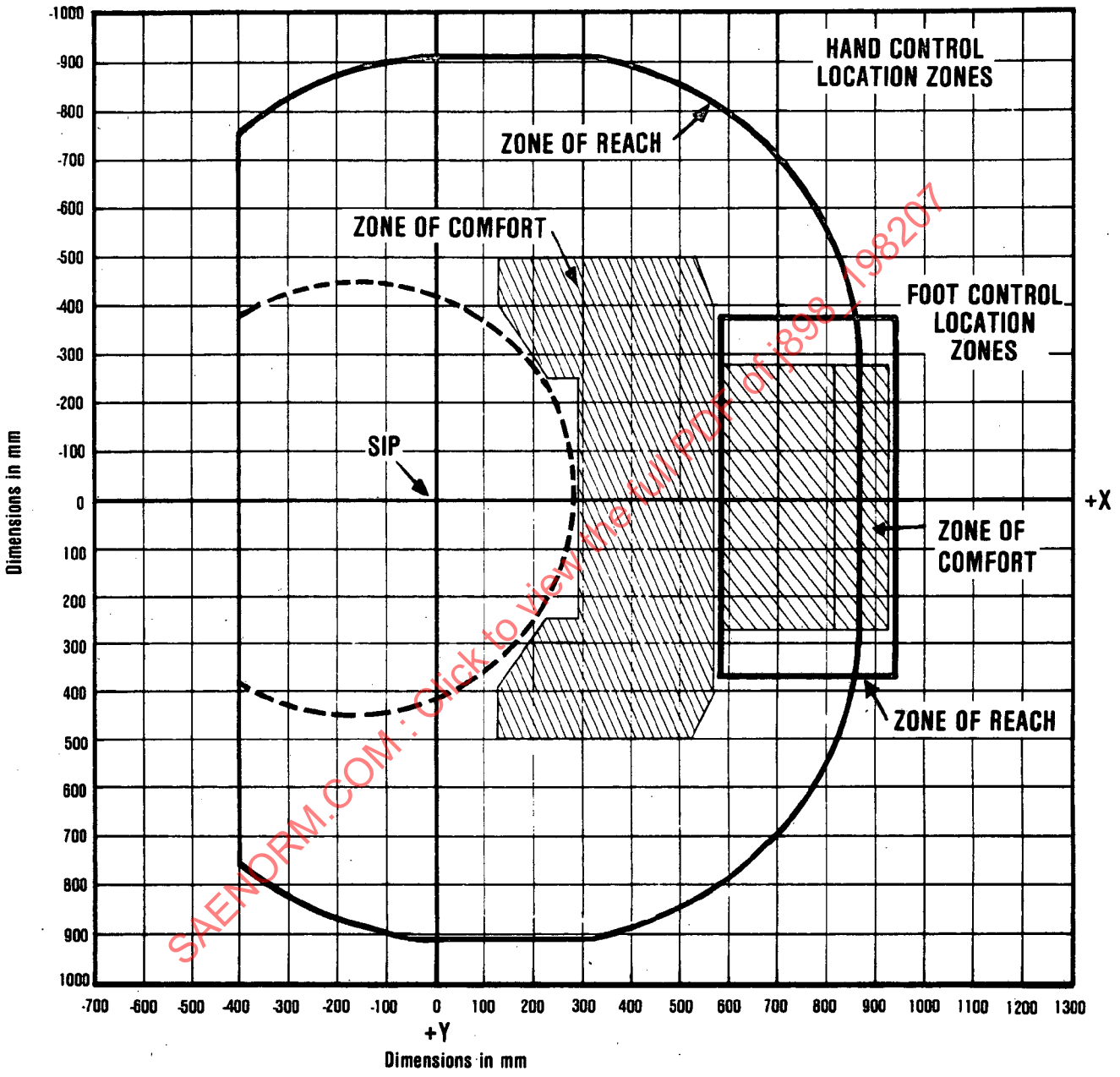

FIG. 2—TOP VIEW—ZONES OF COMFORT AND REACH

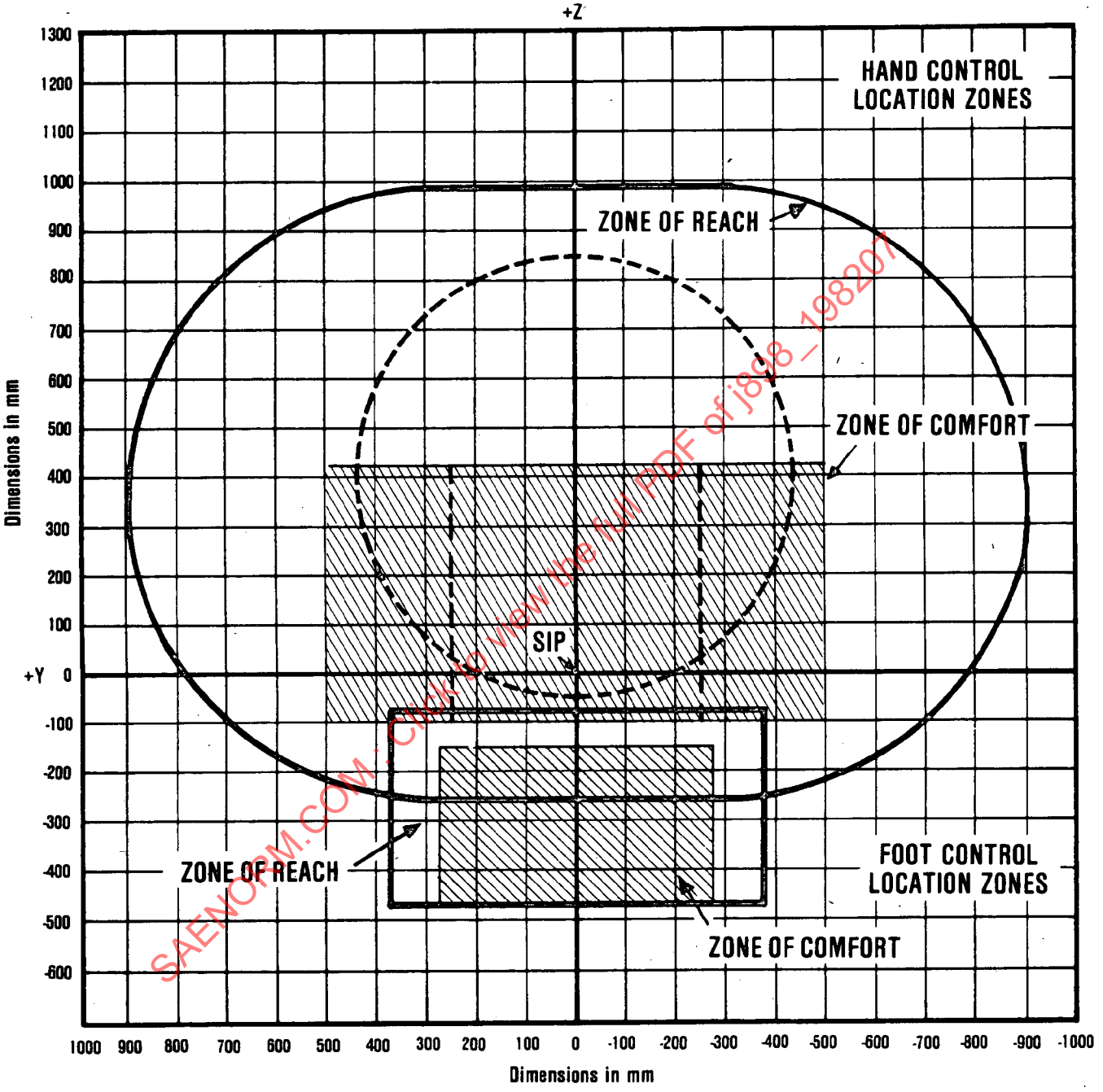

FIG. 3—FRONT VIEW—ZONES OF COMFORT AND REACH

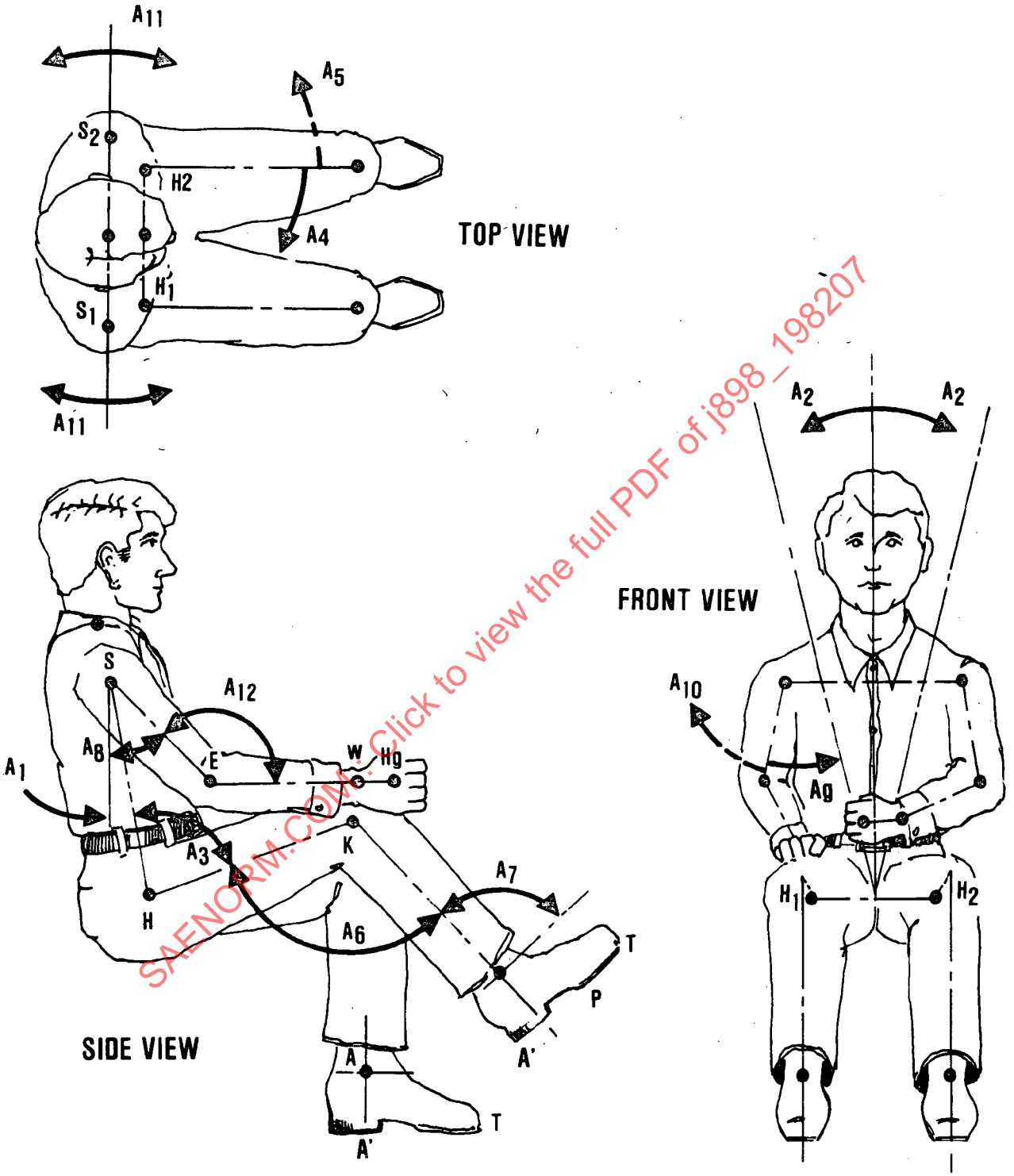

FIG. 4—SCHEMATIC OF BODY PIVOT DIMENSION NOMENCLATURE

APPENDIX—SUMMARY OF COORDINATES FOR DEFINING CONTROL LOCATION ZONES

Coordinates to define the zone of comfort and zone of reach for control location are summarized in Tables A-1, A-2, A-3, and A-4. Since the control location zones are symmetrical about the XZ plane, only one half is defined. The other half can be defined by changing the sign of the Y coordinates.

The control location zones are defined by coordinates for the corners of planar surfaces, and by the center of curvature coordinates and the radii of spherical and cylindrical surfaces. The zone of reach for hand controls is defined by planar and cylindrical boundaries that are tangential to the spherical surfaces defined in Table A-2.

TABLE A-1—COORDINATES FOR ZONE OF COMFORT HAND CONTROL LOCATION ZONE

Center of Curvature[a]	(X, Y, Z) Coordinates	Radius
S_L	(−159, 188, 476)	$R_1 = 734$ $R_2 = 691$
Point[a]	**(X, Y, Z) Coordinates**	
A_1	(132, 500, 425)	
A_2	(132, 500, −100)	
B_1	(132, 400, 425)	
B_2	(132, 400, −100)	
C_1	(230, 250, 425)	
C_2	(230, 250, −100)	
D_1	(296, 250, 425)	
D_2	(296, 250, −100)	
E_1	(530, 500, 425)	
E_2	(221, 500, −100)	
F_1	(573, 400, 425)	
F_2	(296, 400, −100)	

[a] Refer to Figs. A-1, A-2, and A-3.

TABLE A-2—COORDINATES FOR ZONE OF REACH—HAND CONTROL LOCATION ZONE

Center of Curvature[a]	(X, Y, Z) Coordinates	Radius
S_{B1}	(6, 283, 368)	$R_3 = 625$
S_{B2}	(245, 283, 368)	$R_3 = 625$
S_M	(−160, 0, 400)	$R_4 = 450$
Point[a]	**(X, Y, Z) Coordinates**	
G	X = −400	

[a] Refer to Figs. A-1, A-2, and A-3.

TABLE A-3—COORDINATES FOR ZONE OF COMFORT—FOOT CONTROL LOCATION ZONE

Center of Curvature[a]	(X, Y, Z) Coordinates	Radius
K_{S1}	(466, −75, −32)	$R_5 = 500$
Point[a]	**(X, Y, Z) Coordinates**	
H	(581, −275, −470)	
I	(820, −275, −150)	
J	(932, −275, −150)	
K	(687, −275, −470)	

[a] Refer to Figs. A-1, A-2, and A-3.

TABLE A-4—COORDINATES FOR ZONE OF REACH—FOOT CONTROL LOCATION ZONE

Center of Curvature[a]	(X, Y, Z) Coordinates	Radius
K_{S2}	(441, −75, −65)	$R_6 = 500$
Point[a]	**(X, Y, Z) Coordinates**	
L	(581, −375, −470)	
M	(796, −375, − 75)	
N	(941, −375, − 75)	
O	(734, −375, −470)	

[a] Refer to Figs. A-1, A-2, and A-3.

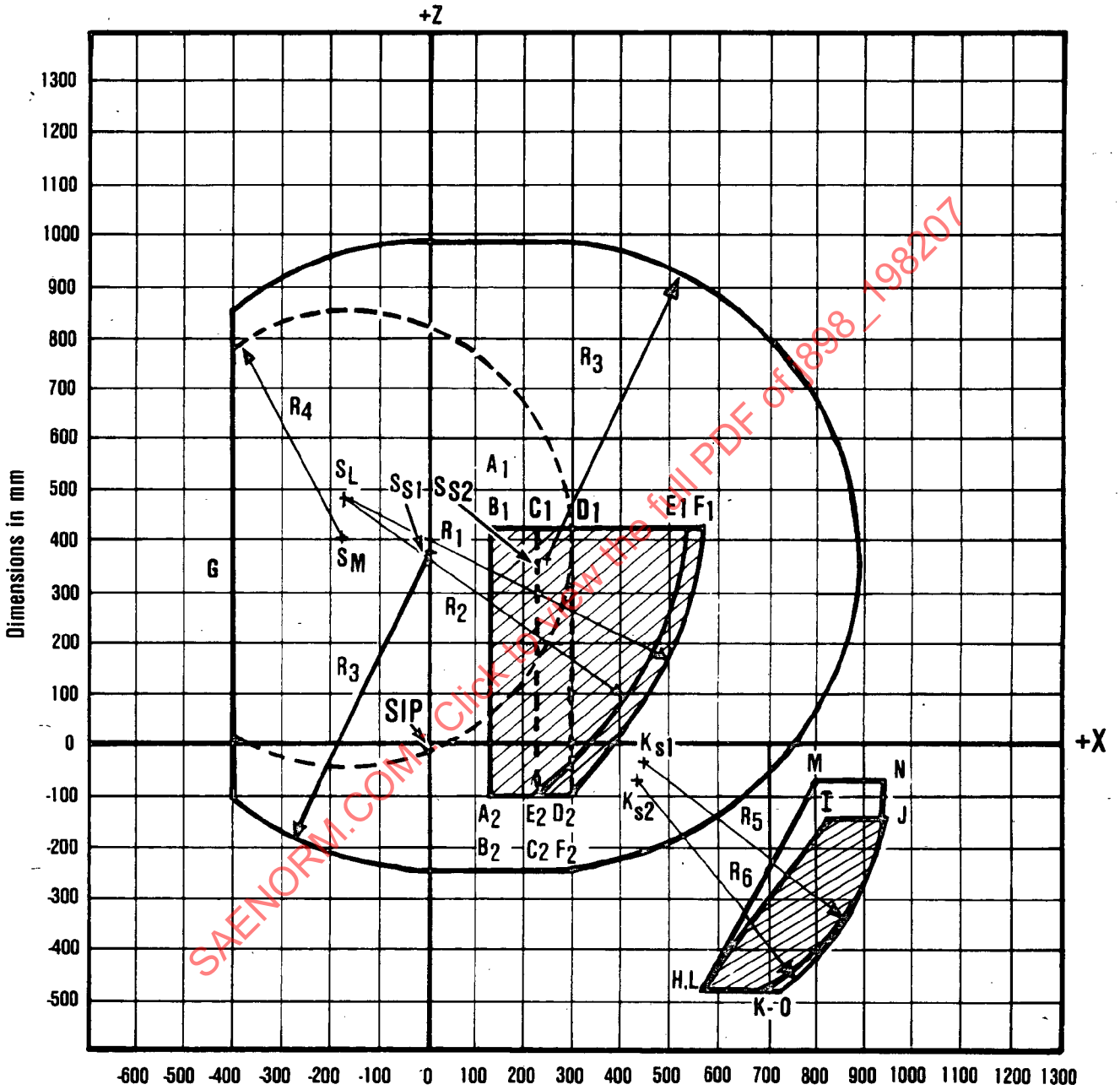

FIG. A-1—SIDE VIEW COORDINATES FOR ZONES OF COMFORT AND REACH