INTERNATIONAL STANDARD

ISO 3958

Second edition
1996-02-15

Passenger cars — Driver hand-control reach

Voitures particulières — Portée des mains du conducteur

Reference number
ISO 3958:1996(E)

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 3958 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 13, *Ergonomics applicable to road vehicles*.

This second edition cancels and replaces the first edition (ISO 3958:1977), which has been extended to include tables for hand-reach envelope unrestrained.

Annex A of this International Standard is for information only.

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Introduction

The hand-reach envelopes described in this International Standard were developed using data acquired from test subjects performing reach tasks in test fixtures simulating a range of actual vehicle configurations [1], [2]. The test subjects included equal numbers of men and women selected to represent the driving population on the basis of standing height and age. Subjects were tested with upper torso three-point restraint (a type 1 lap strap and a diagonal non-extending shoulder strap independent of the lap strap), and with only a type 1 lap strap. The data were analysed in a manner to account for different proportions of male and female users.

The hand-reach envelopes are three-dimensional surfaces described in tabular form and can be referenced to a particular vehicle seating configuration according to the procedures described in clauses 4 and 5.

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Passenger cars — Driver hand-control reach

1 Scope

1.1 This International Standard defines hand-reach envelopes: the boundaries of passenger car hand-control locations that can be reached by different proportions of male and female driver populations.

This International Standard applies to passenger cars (term 3.1.1 in ISO 3833:1977). It is primarily directed towards the initial design stages of a new vehicle programme. Its application for checking purposes in actual vehicle prototype seat models will take into account the allowable tolerances for the actual H-point and actual torso angle (see ISO/TR 9511).

The hand-reach envelopes apply directly to left-hand-drive passenger cars designed for seated operators in full-width or single-width seats having approximately horizontal fore-and-aft seat adjustment. Application to right-hand-drive vehicles is assumed to be symmetrically opposite.

1.2 The envelopes constructed using the static three-point restraint described in the Introduction are meant to define a restrained reach. The envelopes constructed using lap belt only (type 1) are meant to define an unrestrained reach applicable to all restraint systems with free shoulder movement.

The hand-reach envelopes are directly applicable for a three-finger grasping reach to a forward-mounted control knob of 25 mm diameter manoeuvred horizontally in the fore-and-aft direction. The hand-reach envelopes are also applicable to other types of forward controls by using an appropriate adjustment factor that will account for the mode of operation of the control:

a) extended-finger-operated forward control: an adjustment factor of 50 mm is added to the values of the reach envelope in the appropriate table;

b) full-hand-grasped forward control: an adjustment factor of 50 mm is subtracted from the tabled values of the reach envelope.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 3833:1977, *Road vehicles — Types — Terms and definitions.*

ISO 4130:1978, *Road vehicles — Three-dimensional reference system and fiducial marks — Definitions.*

ISO/TR 9511:1991, *Road vehicles — Driver hand-control reach — In-vehicle checking procedure.*

3 Definitions

For the purposes of this International Standard, the following definitions apply.

3.1 driver hand-reach capability: Maximum reach capability of drivers in a simulated driving situation with the non-reaching hand on the steering-wheel and the right foot on the accelerator pedal.

3.2 basic reach task: Hand-reach to a forward-mounted control with the control held in a three-finger grasp. (See figure 1.)

NOTE 1 This diagram represents a three-finger grasping reach to a 25 mm (≈ 1 in) diameter control knob. All measurements for the hand-reach envelope are referenced to the centre of the control knob face.

3.3 hand-reach envelope: Geometric description of the hand-reach capability for a specified proportion of a driver population and type of torso-restraint system.

3.3.1 restrained reach envelope: Envelope applicable to vehicles using restraint systems with 100 mm of shoulder movement.

3.3.2 unrestrained reach envelope: Envelope applicable to vehicles using restraint systems with free shoulder movement.

3.4 interior dimensions: Characteristics of seating configuration described in terms of the R-point. (See figure 2.)

NOTES

2 The interior dimensions are measured with the front seat in a position according to its R-point location. All adjustable features, such as vertical seat adjustment or seatback adjustment or an adjustable steering-wheel, are set in the design position according to the manufacturer's specifications. Positions of adjustable features, when not specified by the manufacturer, are the middle of their adjustment range.

3 All interior dimensions shown in figure 2 are measured to the vertical and horizontal body zero planes by setting up the vehicle relative to the front and rear fiducial mark heights, as specified in ISO 4130, with respect to the vehicle attitude specified by the manufacturer.

3.5 R-point; seating reference point: Manufacturer's design H-point which

a) establishes the rearmost normal design driving or riding position of each designated seating position that accounts for all modes of adjustment (horizontal, vertical and tilt) that are available for the seat, but does not include seat travel used for purposes other than normal driving and riding;

b) has coordinates established with respect to the designed vehicle structure;

c) simulates the position of the pivot centre of the human torso and thigh;

d) is the reference point employed to position a two-dimensional design layout.

3.6 H-point: Pivot centre of the torso and thigh of the three-dimensional H-point machine used for actual H-point determination, located on the centreplane of the device which is between the H-point sight buttons on either side of the H-point machine. [ISO 6549]

3.7 actual H-point: Pivot centre of the torso line and thigh centreline of the three-dimensional H-point machine using one of the appropriate leg lengths installed in the rearmost normal driving or riding position of the seat as specified by the manufacturer, measured to the H-point sight buttons.

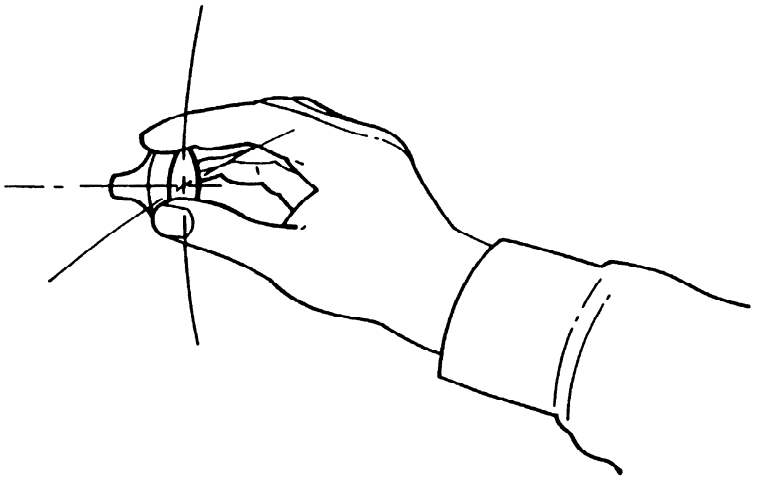

Figure 1 — Three-finger grasping reach

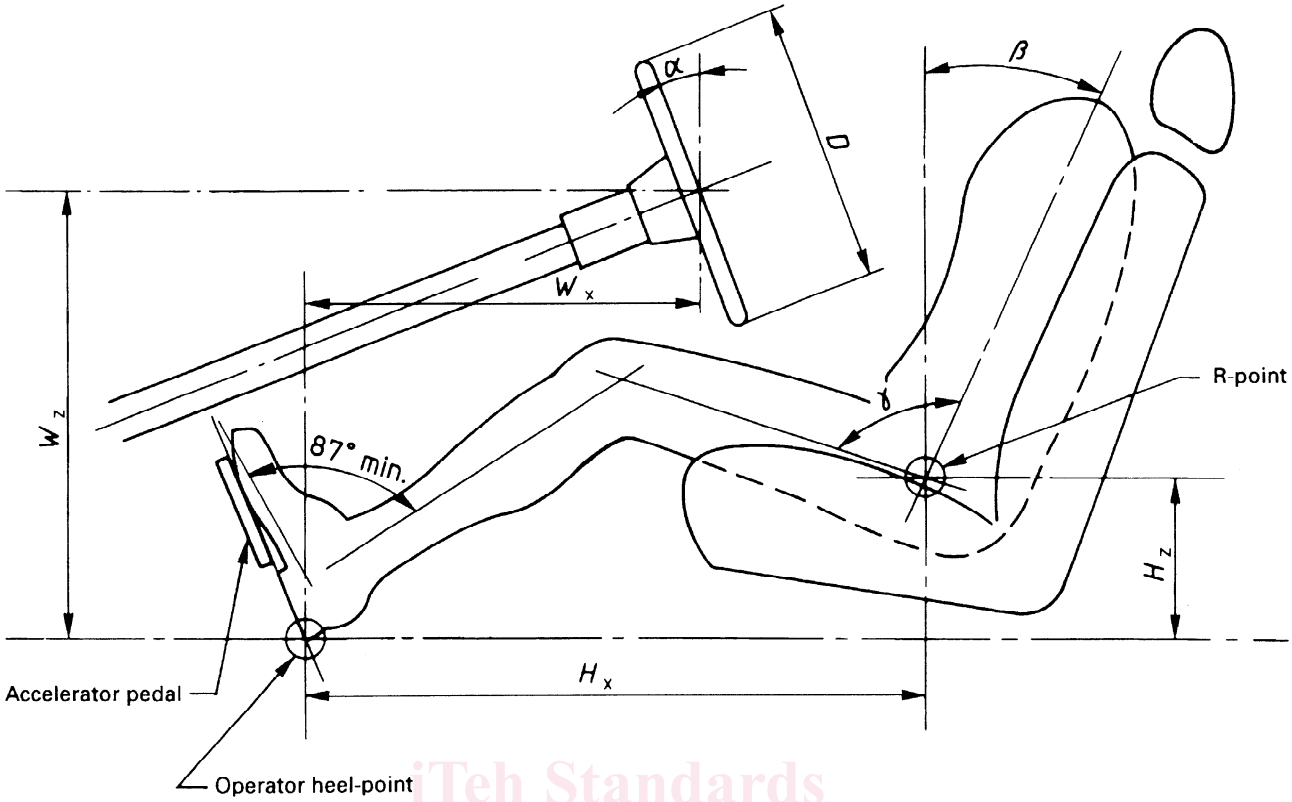

Figure 2 — Vehicle seating configuration

3.8 torso line: Centreline of the headroom probe in its fully rearward position against the back pan of the three-dimensional H-point machine.

3.9 design torso angle, β: Angle measured between a true vertical line through the R-point or seating reference point and the torso line on a two-dimensional design layout.

3.10 actual torso angle: Angle measured from a true vertical line through the actual H-point using the back angle quadrant on the three-dimensional H-point machine and the headroom probe in the fully rearward position.

3.11 operator heel-point: Intersection of the right heel of the three-dimensional H-point machine with the surface of the depressed floor covering or other heel support.

NOTE 4 When 95th percentile leg elements are used, the shoe sole of the device touches, and is allowed to depress, the accelerator pedal through some portion of its travel as specified by the manufacturer. When 50th percentile leg elements are used, the shoe sole of the device does not contact the accelerator pedal and both feet are allowed to take natural positions on the floor with the legs extended: in this case, the heel-point is as defined by the manufacturer. The seat is located according to its R-point (seating reference point) location.

3.12 foot angle: Angle measured between the lower leg centreline and a line tangential to the bottom of the bare right foot.

NOTE 5 The foot angle is restricted to not less than 87°. A scale on the foot assembly of the three-dimensional H-point machine indicates the foot angle. The angle to the bottom of the device's shoe is 6,5° less than the bare foot angle because of the shoe sole and heel thickness.

3.13 hip angle, γ: Angle, in degrees, between the torso line and the thigh centreline.

3.14 horizontal R-point to heel-point, H_x: Horizontal dimension from the R-point to the operator heel-point.

3.15 vertical R-point to heel-point, H_z: Vertical dimension from the R-point to the operator heel-point.

3.16 horizontal seat track travel: Horizontal dimension between the R-point and the foremost normal design driving or riding position.

3.17 steering-wheel diameter, D: Maximum outside diameter of the steering-wheel.

NOTE 6 If the steering-wheel is not round, assume twice the largest swept radius.

3.18 steering-wheel angle α: Angle, in degrees, that the steering-wheel surface plane makes with the vertical.

3.19 horizontal wheel-centre to heel-point W_x: Distance from the operator heel-point to the centre of the steering-wheel in the plane tangent to the steering-wheel rim.

3.20 vertical wheel-centre to heel-point W_z: Distance from the operator heel-point to the centre of the steering-wheel in the plane tangent to the steering-wheel rim.

3.21 centreplane of operator; C/PO: Y-coordinate of the R-point or actual H-point.

NOTE 7 This represents the centreplane of the operator or of the three-dimensional H-point machine. In vehicles with individual seats, the centreplane of the seat represents the centreplane of the operator. On other seats, the centreplane of the operator is specified by the manufacturer.

3.22 general package factor, G: Single index value resulting from an algebraic equation that expresses, in summarized form, the geometry of a particular vehicle seating configuration.

NOTE 8 G is a synthesized variable that provides a quantitative index of a vehicle's workspace geometry. The G-value for a vehicle can be calculated by substituting the principal package dimensions describing the vehicle seating configuration as shown in figure 2 into the following equation (for computations where lengths are expressed in millimetres and angles in degrees):

$$G = 0{,}0018H_z - 0{,}0197\beta + 0{,}0027D + 0{,}0106\alpha - 0{,}0011W_x + 0{,}0024W_z + 0{,}0027\gamma - 3{,}0853$$

3.23 hand-reach reference plane; HR plane: Vertical reference plane extending laterally across the vehicle.

NOTE 9 It is used to position the hand-reach envelopes with respect to the geometry of the vehicle seating configuration. The horizontal location of the HR plane rearward of the operator heel-point is determined by application of the general package factor G. (See 4.4.)

4 Requirements

4.1 The following list establishes the ranges of the operator workspace dimensions for which these envelopes apply. Application to vehicles whose dimensions are outside these ranges shall be made with the necessary corrections:

Torso angle, β	9° to 33°
Vertical R-point to heel-point, H_z	130 mm to 520 mm
Horizontal seat track travel	130 mm min.
Steering-wheel diameter, D	330 mm to 600 mm
Steering-wheel angle, α	10° to 70°
Wheel centre to heel-point, horizontal, W_x	152 mm to 660 mm
Wheel centre to heel-point, vertical, W_z	530 mm to 838 mm

4.2 The envelopes describe the boundaries of control locations that can be reached by at least 95 % of certain driver populations that include mixtures of 50/50, 75/25 and 90/10 male/female driver population ratios. The envelopes for each of these categories are located in relation to specified reference planes. The envelopes extend from 400 mm outboard to 600 mm inboard of the operator centreplane and from 100 mm below the R-point or actual H-point to 800 mm above the R-point or actual H-point (see figure 3). Information concerning controls located not more than 130 mm outside this region may be extrapolated from the tables using, for example, conventional graphical or analytical methods which take account of the curvature and shape of the envelope.

4.3 Hand-reach envelopes are specified in tables 1 to 42 for restrained and unrestrained reach, for seven different seating configurations and for three male/female driver population ratios. The selection of an envelope for a vehicle is based on the type of reach (restrained or unrestrained), the calculated value of the general package factor, G, and the identification of the male/female driver population ratio appropriate for the vehicle.

4.4 The hand-reach envelope is located in the vehicle by selecting a relationship that uses the value of the general package factor, G. The horizontal component of a point on the reach envelope is measured as the distance forward of a hand-reach reference plane, HR (see 3.23). The location of this plane is measured rearward from the operator heel-point, determined in millimetres, and is calculated using the general package factor, G, from the formula:

$$HR = 786 - 99G$$

NOTE 10 The dimension HR is not the dimension from the H-point to the R-point.

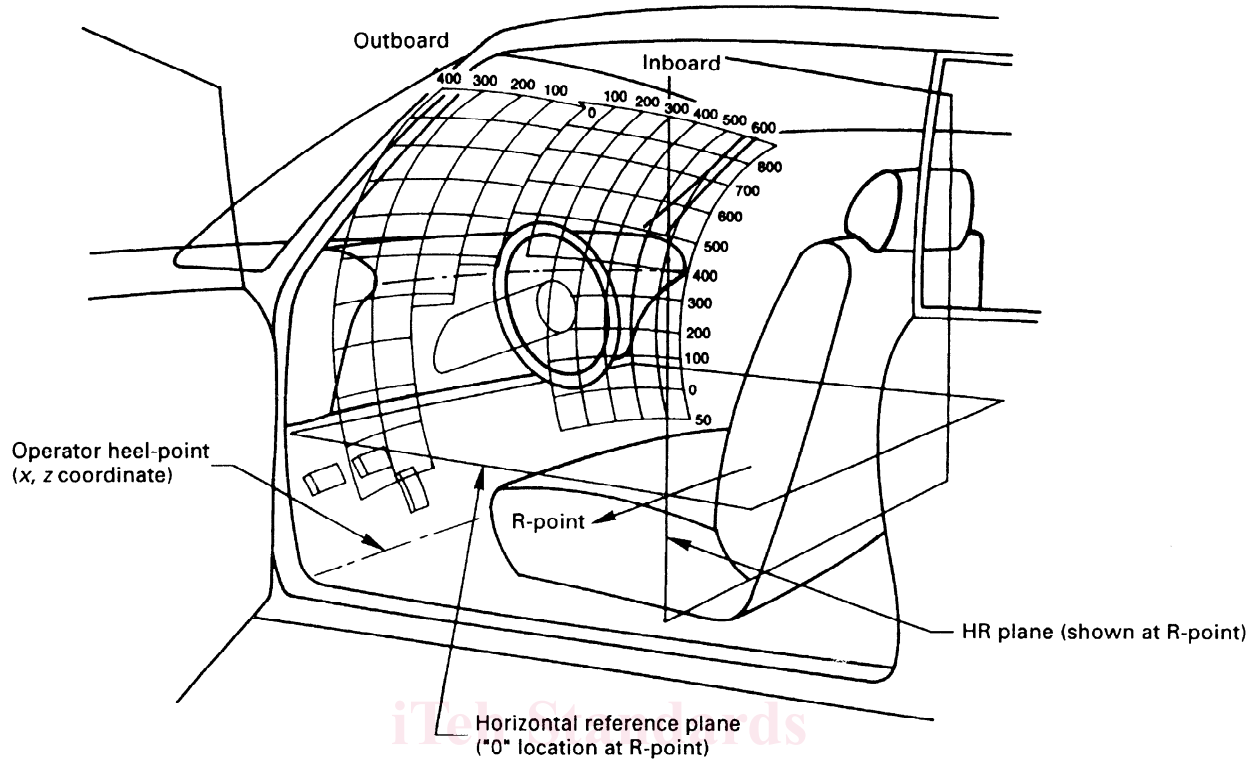

Figure 3 — Hand-reach envelope in vehicle position

5 Procedure for using hand-reach envelopes

5.1 Reference planes

The envelopes are located in the vehicle according to a set of orthogonal reference planes[1]: a horizontal elevation reference plane through the R-point, the HR plane, and a vertical plane extending along the C/PO and parallel to the plane of symmetry of the vehicle.

5.2 Establishment of reference origin

5.2.1 Specify the dimensions describing the geometry of the vehicle seating configuration and calculate the value of the general package factor, G, as defined in 3.22.

5.2.2 Calculate HR from the value of the general package factor, G, as specified in 4.4. Determine the longitudinal location of the hand-reach reference plane.

- If (HR $- H_x$) is less than zero, the hand-reach reference plane is located longitudinally at a distance HR rearward of the operator heel-point.
- If (HR $- H_x$) is greater than zero, the hand-reach reference plane is located longitudinally at the R-point location.

5.3 Identification of appropriate hand-reach envelope

5.3.1 Referring to tables 1 to 42, identify the hand-reach envelope appropriate for the value of the general package factor, G, calculated for this vehicle and the specified driver population.

5.3.2 The blank areas in the hand-reach tables are regions where hand-reach was not measured or where design limit values could not be established. The areas underlined are regions where the difference between the hand-reach model and the observed design values exceed 25 mm. The hand-reach values shown in these areas should be used with caution.

1) The reference planes are defined as planes perpendicular to the three-dimensional reference system (see ISO 4130).

5.4 Determination control is within reach

5.4.1 Determine the lateral locations of the controls of interest. These locations are described as lateral locations from the C/PO. Determine the height of the control above the horizontal elevation reference plane specified in 5.1.

5.4.2 The limiting value of reach can be read from the appropriate table at the designated elevation and station location. Interpolation may be required if the necessary locations are not included in the table. Interpolate laterally first before interpolating vertically. Curvilinear interpolations should be made using two locations on either side of the desired control.

5.4.3 The contour of the hand-reach envelope refers to the geometric centre of the control knob face. If the control knob face is at, or rearward of, the contour, it is estimated that at least the specified proportion of the indicated driver population can reach and operate the control.

Table 1 — Hand-reach envelope restrained — Vehicle range ($G < -1{,}25$) — Population mix: 50/50 males/females

Dimensions in millimetres

Horizontal reach: forward of the HR reference plane at stations located laterally from the centreplane of operator (C/PO) and at elevations above and below the R-point or actual H-point. The envelope describes a 95 % level of performance of a driver population composed of 50 % male and 50 % female drivers wearing three-point static restraint.																
Elevation above/below R-point	**Stations outboard of C/PO**							**Stations inboard of C/PO**								
	400	300	250	200	100	50	0	0	50	100	200	250	300	400	500	600
800	387	438	456	470	490	497	502	493	501	504	495	483	468	426	377	
700	463	506	520	531	546	551	556	550	562	566	557	546	532	499	455	
600	519	555	567	576	586	586	584	590	605	611	604	595	584	555	514	449
500	556	586	598	606	609	603	589	614	630	638	637	631	622	595	553	486
450	567	595	607	615	615	604	583	620	636	645	649	644	636	609	565	498
400	574	600	612	621	618	601	571	621	637	648	656	654	646	619	572	506
350	576	601	614	623	616	594	555	619	633	646	660	660	654	625	574	511
300	574	597	612	622	611					639	660	662	658	626	572	510
250	567	590	605	617	602					628	657	662	658	624	564	506
200	557	578	596	608	590					613	649	658	656	618	551	498
100	524	544	566	581							624	639	640	593	510	469
0	474										584	607	610	551	449	423
− 100	410										528	561	567	493	367	360

Table 2 — Hand-reach envelope restrained — Vehicle range ($G < -1,25$) — Population mix: 75/25 males/females

Dimensions in millimetres

Horizontal reach: forward of the HR reference plane at stations located laterally from the centreplane of operator (C/PO) and at elevations above and below the R-point or actual H-point. The envelope describes a 95 % level of performance of a driver population composed of 75 % male and 25 % female drivers wearing three-point static restraint.

Elevation above/below R-point	Stations outboard of C/PO							Stations inboard of C/PO								
	400	300	250	200	100	50	0	0	50	100	200	250	300	400	500	600
800	422	470	488	501	520	526	532	530	539	542	532	520	505	466	419	
700	496	536	550	560	574	579	584	582	595	600	590	580	567	534	492	
600	550	584	596	604	612	612	609	619	634	640	634	626	615	586	545	480
500	584	614	625	633	634	625	610	638	654	663	664	658	649	622	580	513
450	594	622	634	641	639	625	602	642	658	668	673	670	662	634	589	523
400	600	626	639	647	640	620	587	642	657	668	679	678	671	642	594	529
350	601	627	640	648	637	611	568	637	651	664	681	682	677	646	594	531
300	598	623	637	646	631					656	680	683	679	646	589	529
250	591	615	630	641	621					643	675	681	678	642	578	523
200	579	603	620	632	607					625	666	675	673	633	563	513
100	544	568	590	604							637	654	654	604	517	480
0	492										593	618	621	558	451	430
– 100	426										534	569	575	496	364	363

Table 3 — Hand-reach envelope restrained — Vehicle range ($G < -1{,}25$) — Population mix: 90/10 males/females

Dimensions in millimetres

Horizontal reach: forward of the HR reference plane at stations located laterally from the centreplane of operator (C/PO) and at elevations above and below the R-point or actual H-point. The envelope describes a 95 % level of performance of a driver population composed of 90 % male and 10 % female drivers wearing three-point static restraint.																
Elevation above/below R-point	**Stations outboard of C/PO**							**Stations inboard of C/PO**								
	400	300	250	200	100	50	0	0	50	100	200	250	300	400	500	600
800	443	490	507	519	538	544	550	551	561	564	554	542	527	489	443	
700	516	555	568	578	591	596	600	601	615	619	610	600	587	555	513	
600	568	601	613	621	628	627	624	635	651	657	652	644	633	605	564	498
500	601	630	641	649	648	639	622	653	669	678	680	674	666	639	595	528
450	611	638	650	657	653	638	612	655	671	681	688	685	677	649	604	537
400	616	642	654	662	653	632	597	654	668	680	693	692	685	656	607	542
350	616	642	655	663	649	621	575	648	661	675	694	695	690	659	605	543
300	613	638	652	661	642					665	691	695	691	657	598	540
250	605	630	645	655	631					651	685	692	689	652	587	533
200	592	618	635	646	617					632	675	685	684	642	570	521
100	556	583	604	617							644	662	662	611	521	486
0	503										598	624	627	562	451	434
– 100	436										537	573	579	497	361	365

Table 4 — Hand-reach envelope restrained — Vehicle range ($-1{,}25 \leqslant G < -0{,}75$) — Population mix: 50/50 males/females

Dimensions in millimetres

Horizontal reach: forward of the HR reference plane at stations located laterally from the centreplane of operator (C/PO) and at elevations above and below the R-point or actual H-point. The envelope describes a 95 % level of performance of a driver population composed of 50 % male and 50 % female drivers wearing three-point static restraint.

Elevation above/below R-point	Stations outboard of C/PO							Stations inboard of C/PO									
	400	300	250	200	100	50	0	0	50	100	200	250	300	400	500	600
800	391	441	460	474	494	501	507	500	509	512	502	491	475	435	386	
700	466	509	523	535	550	555	560	556	569	573	564	553	540	507	464	
600	521	558	570	579	589	590	589	595	611	617	611	602	591	562	521	456
500	558	589	600	609	613	606	594	618	635	643	644	638	629	602	559	492
450	569	597	609	618	619	608	588	624	640	649	654	650	643	615	571	504
400	576	602	615	623	621	605	577	625	640	651	661	660	653	625	577	512
350	578	602	616	625	620	598	560	622	636	649	665	665	660	630	579	516
300	576	599	613	624	615					641	665	668	663	631	575	515
250	569	591	607	618	606					630	661	667	664	629	567	510
200	559	580	597	610	594					614	653	662	660	622	553	502
100	525	545	566	582							627	643	644	596	511	471
0	476										586	611	614	554	449	425
– 100	411										530	564	570	495	367	362