

INTERNATIONAL STANDARD



3958

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Road vehicles — Passenger cars — Driver hand control reach

Véhicules routiers — Voitures particulières — Portée des mains du conducteur

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FOREWORD

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Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 3958 was drawn up by Technical Committee ISO/TC 22, *Road vehicles*, and was circulated to the member bodies in October 1975.

It has been approved by the member bodies of the following countries:

Australia	Iran	Romania
Austria	Italy	South Africa, Rep. of
Belgium	Japan	Spain
Brazil	Korea, Dem. P. Rep. of	Sweden
Bulgaria	Korea, Rep. of	Turkey
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Germany	New Zealand	U.S.S.R.
Hungary	Poland	Yugoslavia

No member body expressed disapproval of the document.

Road vehicles — Passenger cars — Driver hand control reach

0 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, and were tested with upper torso three-point restraint (a diagonal non-extending shoulder strap independent of the lap strap).

The envelopes constructed using the safety belt described above are meant to define a restrained reach.

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.

1 SCOPE

This International Standard defines the boundaries of road vehicle hand control locations that can be reached by desired proportions of different driver populations.

2 FIELD OF APPLICATION

2.1 This International Standard applies to passenger cars (term 3.1.1 in ISO 3833¹⁾). 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 tolerance for the H-point.

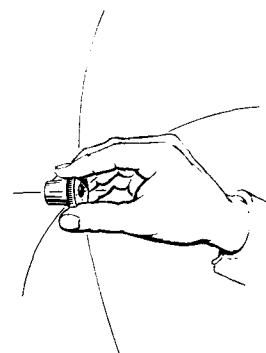
2.2 The hand-reach envelopes are directly applicable to left-hand drive motor vehicles designed for seated operators in full-width or single-width seats having fore-and-aft seat adjustment approximately horizontal. Application to right-hand drive vehicles is assumed to be symmetrically opposite.

2.3 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. For reach to finger-operated controls or for reach to controls grasped by the whole hand, incremental adjustments are required.

3 DEFINITIONS

3.1 driver hand-reach capability: The 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: The hand-reach to a forward-mounted control with the control held in a three-finger grasp (see figure 1).



This diagram represents a three-finger grasping reach to a 25 mm (1.0 in) diameter control knob. All measurements for the hand-reach envelope are referenced to the centre of the control knob face.

FIGURE 1 — Three-finger grasping reach

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

1) ISO 3833, *Road vehicles — Types — Terms and definitions*.

3.4 interior dimensions : The characteristics of seat geometry are described in terms of the R-point (see figure 2). The interior dimensions are measured with the front seat in the rearmost normal driving position as specified by the manufacturer. All adjustable features, such as vertical seat adjustment or an adjustable steering wheel, are set in the design position according to the manufacturer's specifications. When the seat back has an angular adjustment separate from the seat cushion, the normal driving seat back angle is specified by the manufacturer. Positions of adjustable features other than horizontal seat adjustment, when not specified by the manufacturer, will be the middle of their adjustment range.

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 mark¹⁾ heights with respect to the vehicle attitude specified by the manufacturer.

3.5 R-point²⁾ : The seating reference point. It is the pivot centre of the torso line and thigh centreline on the two-dimensional H-point machine template with 95 % leg lengths used to describe vehicle seating geometry.

3.6 H-point²⁾ : The pivot centre of the torso line and thigh centreline of the three-dimensional H-point machine installed in the rearmost normal driving position of the operator's seat as specified by the manufacturer.

3.7 accelerator heel-point : The intersection of the heel of the two- or three-dimensional H-point device with the surface of the depressed floor covering; the foot of the device is allowed to depress the accelerator pedal through some proportion of its travel as specified by the manufacturer. The foot angle of the device is restricted to not less than 87°.

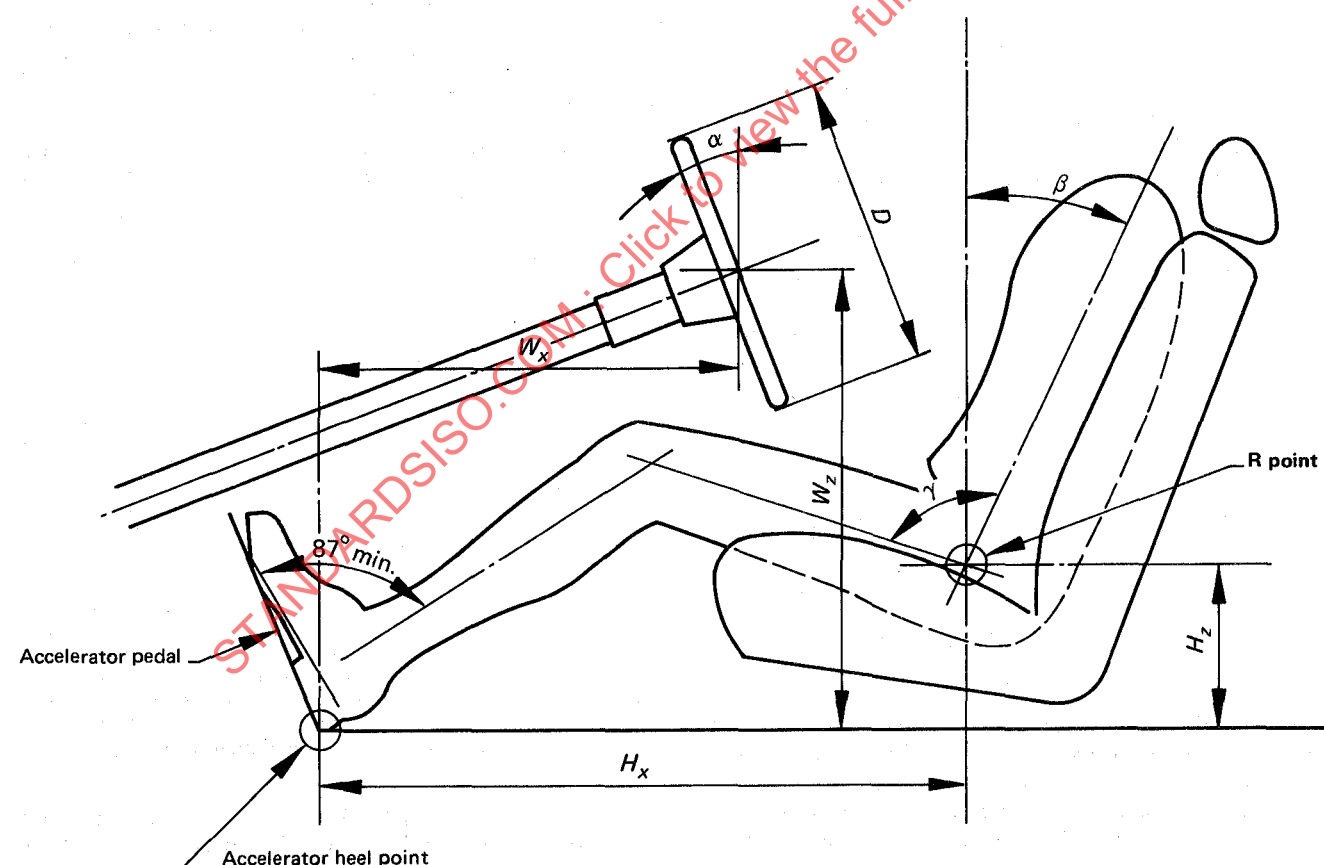


FIGURE 2 – Vehicle seating configuration

1) See ISO 4130, *Road vehicles – Three-dimensional reference system and fiducial marks – Definitions*. (At present at the stage of draft.)

2) New definitions and determinations of points R and H are at present being studied by Sub-committee ISO/TC 22/SC 13, *Ergonomics applicable to road vehicles*.

3.8 back angle (β) : The angle, in degrees, between a vertical line through the R-point and the torso line.

3.9 hip angle (γ) : The angle, in degrees, between the torso line and the thigh centreline.

3.10 horizontal R-point to heel-point (H_x) : The horizontal dimension from the R-point to the operator heel-point.

3.11 vertical R-point to heel-point (H_z) : The vertical dimensions from the R-point to the operator heel-point.

3.12 horizontal R-point travel : The horizontal dimension between the R-point and the foremost designed H-point.

3.13 steering wheel diameter (D) : The maximum outside diameter of the steering wheel. If the steering wheel is not round, assume twice the largest swept radius.

3.14 steering wheel angle (α) : The angle, in degrees, that the steering wheel surface plane makes with the vertical.

3.15 wheel centre to heel-point, horizontal (W_x) : The distance from the operator heel-point to the centre of the steering wheel in the plane tangent to the steering wheel rim.

3.16 wheel centre to heel-point, vertical (W_z) : The distance from the operator heel-point to the centre of the steering wheel in the plane tangent to the steering wheel rim.

3.17 centreline of occupant (C/LO) : A vertical plane passing longitudinally through the centre of the operator's station.

3.18 general package factor (G) : A single index value resulting from an algebraic equation that expresses in summarized form the geometry of a particular vehicle seating configuration.

It 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 using millimetres and degrees) :

$$G = 0,001\,8\,H_z - 0,019\,7\,\beta + 0,002\,7\,D + 0,010\,6\,\alpha - \\ - 0,001\,1\,W_x + 0,002\,4\,W_z + 0,002\,7\,\gamma - 3,085\,3$$

3.19 hand-reach reference plane (HR plane) : A vertical reference plane extending laterally across the vehicle, used to properly 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 accelerator heel-point is determined by application of the general package factor (G). (See 4.4.)

4 REQUIRED CHARACTERISTICS

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

Back angle (β) :	9,0 to 33,0°
Vertical R-point to heel-point (H_z) :	130 to 520 mm
Horizontal R-point travel :	130 mm min.
Steering wheel diameter (D) :	330 to 600 mm
Steering wheel angle (α) :	10,0 to 70,0°
Wheel centre to heel-point, horizontal (W_x) :	660 to 152 mm
Wheel centre to heel-point, vertical (W_z) :	530 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 described as referenced in a fore-and-aft direction to specified seating co-ordinates. The envelopes extend from 400 mm outboard to 600 mm inboard of the operator centreline and from - 100 mm below the H-point to 800 mm above the 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 provided in tables 1 to 21 for seven different seating configurations and three male/female driver population ratios. The selection of an envelope for a vehicle is based on 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 employing a relationship that utilizes the value of the general package factor (G). The horizontal component of a point on the envelope is measured as the distance forward of a hand-reach reference plane. The fore-and-aft location of this plane rearward from the accelerator heel-point is determined, in millimetres, from the value of the general package factor (G) from the formula :

$$d = HR^{1)} = 786 - 99\,G$$

1) The dimension HR is not the dimension from the "H" point to the "R" point.

5 PROCEDURE FOR USING THE HAND-REACH ENVELOPES

5.1 Reference planes¹⁾

The envelopes are located in the vehicle according to a set of orthogonal reference planes: a horizontal elevation reference plane through the R-point of the rearmost normal driving position, the lateral HR plane, and a vertical plane extending along the C/LO and parallel to the plane of symmetry of the vehicle.

5.2 Establish a 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 indicated in 3.18.

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

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

5.2.2.2 If $(HR - H_x)$ is greater than zero, the hand-reach reference plane is located longitudinally at the R-point of the rearmost normal driving position.

5.3 Identify the appropriate hand-reach envelope

5.3.1 Referring to tables 1 to 21, 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 Determine the lateral locations of the controls of interest. These locations will be described as lateral locations from the C/LO. Determine the height of the control above the horizontal elevation reference plane described in 5.1.

5.4 Determine if the control is within reach²⁾

5.4.1 The limiting value of reach can be read from the appropriate table at the designated elevation and station locations. 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.

5.4.2 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.

BIBLIOGRAPHY

[1] ROE, R., HAMMOND, D., *SAE Controls Reach Study*, SAE Publication 72 0199, presented at 1972 SAE Automotive Engineering Congress and Exposition, Detroit, Michigan, U.S.A., January 1972.

[2] HAMMOND, D., MAURER, D., RAZGUNAS, L., *Controls Reach - The Hand Reach of Drivers*, SAE Publication 75 0357, SAE Automotive Congress and Exposition, Detroit, Michigan, U.S.A., February 1975.

1) The reference planes are defined as planes perpendicular to the three-dimensional reference system. An International Standard is in preparation.

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 enclosed by broken lines are regions where the difference between the hand-reach model and the observed design limit values exceeded 25 mm. The hand-reach values shown in these areas should be used with caution.

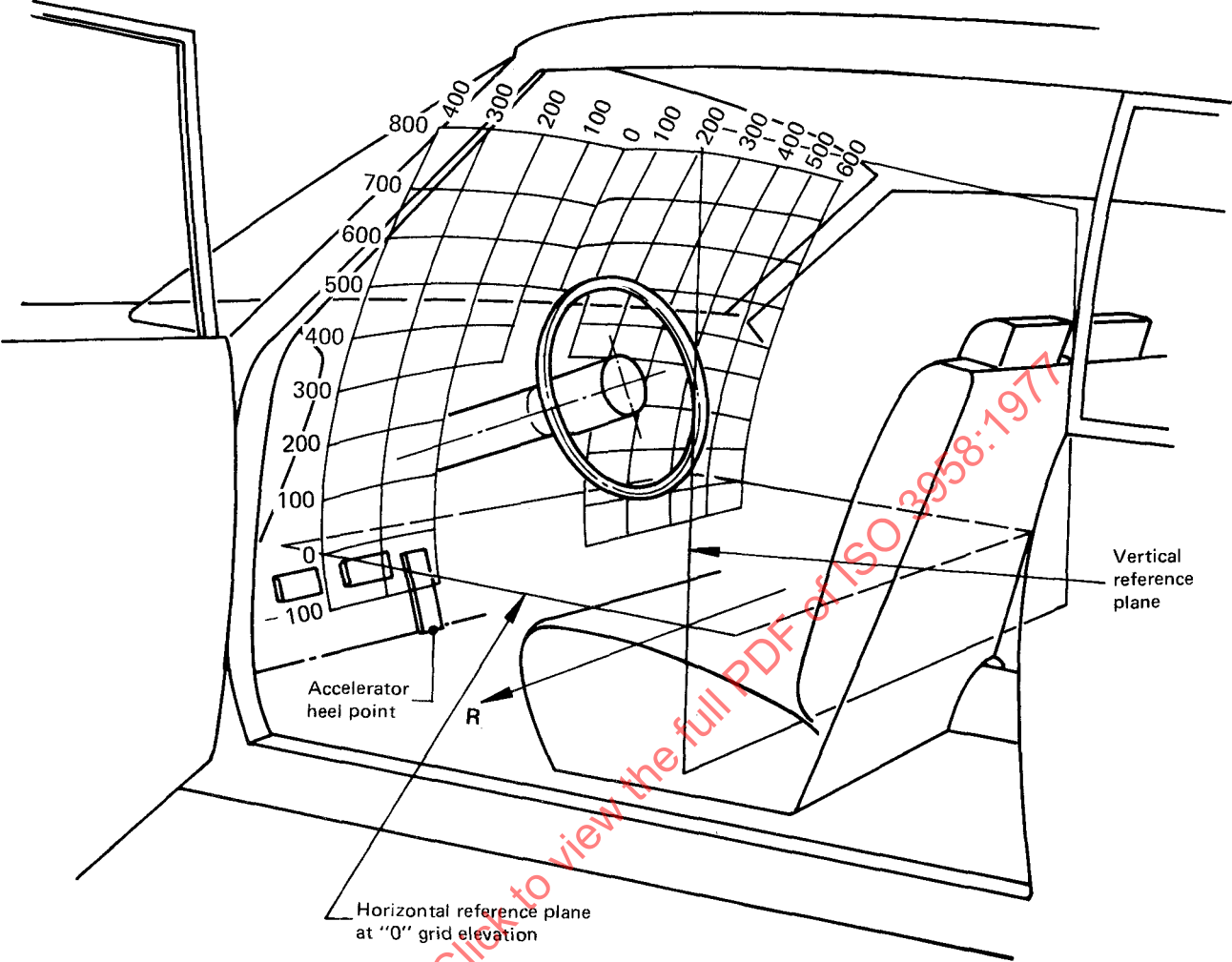


FIGURE 3 — Hand reach envelope in vehicle position

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

Horizontal reach forward of the HR reference plane at stations located laterally from the centreline of operator (C/LO) and at elevations above the rearmost H-point. The envelope describes a 95 % level of performance of a driver population composed of 50 % male and 50 % female drivers wearing a three-point restraint (see clause 0).

Dimensions in millimetres

Elevation above H-point	Stations outboard of C/LO							Stations inboard of C/LO								
	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 — Vehicle range ($G < -1,25$)
Population mix 75/25 males/females

Horizontal reach forward of the HR reference plane at stations located laterally from the centreline of operator (C/LO) and at elevations above the rearmost H-point. The envelope describes a 95 % level of performance of a driver population composed of 75 % male and 25 % female drivers wearing a three-point restraint (see clause 0).

Dimensions in millimetres

Elevation above H-point	Stations outboard of C/LO							Stations inboard of C/LO								
	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 — Vehicle range ($G < -1,25$)
Population mix : 90/10 males/females

Horizontal reach forward of the HR reference plane at stations located laterally from the centreline of operator (C/LO) and at elevations above the rearmost H-point. The envelope describes a 95 % level of performance of a driver population composed of 90 % male and 10 % female drivers wearing a three-point restraint (see clause 0).

Dimensions in millimetres

Elevation above H-point	Stations outboard of C/LO							Stations inboard of C/LO								
	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	480	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 — Vehicle range ($-1,24 < G < -0,75$)
Population mix : 50/50 males/females

Horizontal reach forward of the HR reference plane at stations located laterally from the centreline of operator (C/LO) and at elevations above the rearmost H-point. The envelope describes a 95 % level of performance of a driver population composed of 50 % male and 50 % female drivers wearing a three-point restraint (see clause 0).

Dimensions in millimetres

Elevation above H-point	Stations outboard of C/LO							Stations inboard of C/LO								
	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

TABLE 5 — Hand-reach envelope — Vehicle range ($-1,24 < G < -0,75$)
Population mix : 75/25 males/females

Horizontal reach forward of the HR reference plane at stations located laterally from the centreline of operator (C/LO) and at elevations above the rearmost H-point. The envelope describes a 95 % level of performance of a driver population composed of 75 % male and 25 % female drivers wearing a three-point restraint (see clause 0).

Dimensions in millimetres

Elevation above H-point	Stations outboard of C/LO							Stations inboard of C/LO								
	400	300	250	200	100	50	0	0	50	100	200	250	300	400	500	600
800	427	475	493	506	525	532	538	536	546	549	539	527	512	474	426	
700	500	541	555	565	579	584	589	588	602	606	597	587	574	542	499	
600	553	588	600	608	617	617	615	624	640	646	641	633	622	594	553	487
500	587	617	628	636	638	631	616	644	660	669	670	665	657	629	586	519
450	597	625	637	645	643	631	606	647	663	673	680	676	669	641	596	529
400	603	629	641	650	645	626	595	646	661	673	685	684	678	649	600	535
350	604	629	642	651	642	617	576	641	655	668	687	688	683	652	599	537
300	601	625	639	649	636					659	685	689	685	652	593	535
250	593	617	632	643	626					646	680	687	684	647	583	528
200	582	605	622	634	612					628	671	681	679	639	567	518
100	546	569	591	606							641	659	660	609	521	484
0	494										597	623	627	563	454	435
- 100	427										538	574	580	500	367	368

TABLE 6 — Hand-reach envelope — Vehicle range ($-1,24 < G < -0,75$)
Population mix : 90/10 males/females

Horizontal reach forward of the HR reference plane at stations located laterally from the centreline of operator (C/LO) and at elevations above the rearmost H-point. The envelope describes a 95 % level of performance of a driver population composed of 90 % male and 10 % female drivers wearing a three-point restraint (see clause 0).

Dimensions in millimetres

Elevation above H-point	Stations outboard of C/LO							Stations inboard of C/LO								
	400	300	250	200	100	50	0	0	50	100	200	250	300	400	500	600
800	448	496	513	526	544	551	557	557	567	570	560	549	534	496	450	
700	520	560	573	583	597	602	606	608	621	626	617	607	594	562	520	
600	572	606	617	626	633	633	630	641	657	663	659	651	640	612	571	504
500	605	634	645	653	654	645	630	658	674	683	686	681	673	646	602	535
450	614	642	653	661	658	644	620	661	676	687	694	692	684	656	610	544
400	619	646	658	665	658	639	605	659	673	686	699	698	692	663	613	549
350	620	645	658	666	655	629	585	653	666	680	700	702	697	665	611	550
300	616	641	655	664	648					670	697	702	698	664	604	546
250	608	632	648	658	637					655	691	699	696	658	592	539
200	595	620	637	648	623					636	681	692	690	648	575	527
100	558	584	605	619							650	668	669	616	526	492
0	505										604	630	634	568	456	440
-100	437										543	579	585	503	366	371

TABLE 7 — Hand-reach envelope — Vehicle range ($-0,74 < G < -0,25$)
Population mix : 50/50 males/females

Horizontal reach forward of the HR reference plane at stations located laterally from the centreline of operator (C/LO) and at elevations above the rearmost H-point. The envelope describes a 95 % level of performance of a driver population composed of 50 % male and 50 % female drivers wearing a three-point restraint (see clause 0).

Dimensions in millimetres

Elevation above H-point	Stations outboard of C/LO							Stations inboard of C/LO								
	400	300	250	200	100	50	0	0	50	100	200	250	300	400	500	600
800	394	445	464	478	498	505	511	507	516	519	510	498	483	443	395	
700	469	512	527	538	553	559	564	562	576	580	571	561	548	515	472	
600	524	560	573	583	593	594	593	601	617	623	618	610	599	570	529	463
500	560	591	603	612	616	610	598	623	639	648	650	644	636	609	566	498
450	571	600	612	621	622	612	593	628	643	654	660	657	649	622	576	510
400	578	604	617	626	624					655	667	666	659	631	582	517
350	580	604	618	627	623					652	670	671	666	636	583	520
300	578	601	615	626	618					644	669	673	669	636	579	519
250	571	593	608	620	609					632	665	672	669	633	569	514
200	561	581	598	611	597					615	657	667	665	626	555	505
100	527	545	566	583							630	647	648	599	512	474
0	478	494	521	542							588	614	618	556	450	
-100	412	429	461	487							532	567	574	497	368	

TABLE 8 — Hand-reach envelope — Vehicle range ($-0,74 < G < -0,25$)
Population mix : 75/25 males/females

Horizontal reach forward of the HR reference plane at stations located laterally from the centreline of operator (C/LO) and at elevations above the rearmost H-point. The envelope describes a 95 % level of performance of a driver population composed of 75 % male and 25 % female drivers wearing a three-point restraint (see clause 0).

Dimensions in millimetres

Elevation above H-point	Stations outboard of C/LO							Stations inboard of C/LO								
	400	300	250	200	100	50	0	0	50	100	200	250	300	400	500	600
800	431	480	498	512	531	538	544	543	552	556	546	534	519	481	434	
700	504	545	559	570	584	590	594	595	608	613	604	594	581	549	507	
600	556	591	604	613	622	622	620	630	646	653	648	640	629	601	560	493
500	590	620	632	640	643	636	622	649	665	674	677	672	664	636	593	525
450	600	628	640	648	648	636	615	652	667	678	686	683	676	648	602	535
400	606	632	644	653	649					677	691	690	684	655	605	541
350	607	632	645	654	647					673	693	695	690	658	604	543
300	604	627	642	652	640					663	690	695	692	658	598	540
250	596	619	635	646	631					649	685	693	690	653	587	534
200	584	606	624	636	617					631	675	687	685	644	571	523
100	548	570	591	607							646	664	665	614	524	489
0	496	518	545	565							601	628	632	567	457	
-100	428	451	484	509							543	579	585	505	371	

TABLE 9 — Hand-reach envelope — Vehicle range ($-0,74 < G < -0,25$)
Population mix : 90/10 males/females

Horizontal reach forward of the HR reference plane at stations located laterally from the centreline of operator (C/LO) and at elevations above the rearmost H-point. The envelope describes a 95 % level of performance of a driver population composed of 90 % male and 10 % female drivers wearing a three-point restraint (see clause 0).

Dimensions in millimetres

Elevation above H-point	Stations outboard of C/LO							Stations inboard of C/LO								
	400	300	250	200	100	50	0	0	50	100	200	250	300	400	500	600
800	454	501	519	532	551	557	563	564	574	577	567	556	541	503	457	
700	584	565	578	589	603	608	613	614	628	632	624	614	601	570	528	
600	575	610	622	630	639	639	637	647	663	670	666	658	647	619	578	511
500	608	638	649	657	659	651	637	664	680	689	693	688	680	653	609	541
450	617	645	657	665	663	651	628	666	681	692	701	698	691	663	616	550
400	622	649	661	669	664					691	705	705	699	670	619	555
350	623	648	661	670	661					685	706	708	704	672	617	556
300	619	643	657	667	654					674	703	708	705	670	609	552
250	611	634	650	661	643					660	697	705	703	664	597	545
200	598	622	639	651	629					640	686	698	697	654	580	533
100	561	585	606	621							655	674	675	622	530	498
0	507	532	559	578							609	637	640	574	461	
-100	438	465	498	522							548	586	592	509	372	

TABLE 10 — Hand-reach envelope — Vehicle range ($-0,24 < G < +0,24$)
Population mix : 50/50 males/females

Horizontal reach forward of the HR reference plane at stations located laterally from the centreline of operator (C/LO) and at elevations above the rearmost H-point. The envelope describes a 95 % level of performance of a driver population composed of 50 % male and 50 % female drivers wearing a three-point restraint (see clause 0).

Dimensions in millimetres

Elevation above H-point	Stations outboard of C/LO							Stations inboard of C/LO								
	400	300	250	200	100	50	0	0	50	100	200	250	300	400	500	600
800	397	449	467	482	503	510	516	514	524	527	517	506	491	452	403	
700	472	515	530	542	557	563	568	569	583	588	579	568	555	523	480	
600	526	563	576	586	596	597	596	606	623	629	625	617	606	578	536	470
500	562	593	605	614	619	614	603	627	644	653	656	651	643	616	572	505
450	573	602	614	623	625	616	597	632	647	658	666	663	656	628	582	516
400	580	606	619	628	628					658	672	672	666	637	587	523
350	582	606	620	630	626					654	675	677	672	641	587	525
300	580	602	617	627	621					646	673	678	675	641	582	524
250	573	594	610	622	613					633	669	677	674	637	572	518
200	563	582	599	613	601					616	660	671	670	629	557	509
100	529	546	567	584							632	651	652	602	513	477
0	479	494	520	542							590	617	621	558	450	
-100	414	427	460	487							534	570	577	499	368	

TABLE 11 — Hand-reach envelope — Vehicle range ($-0,24 < G < +0,24$)
Population mix : 75/25 males/females

Horizontal reach forward of the HR reference plane at stations located laterally from the centreline of operator (C/LO) and at elevations above the rearmost H-point. The envelope describes a 95 % level of performance of a driver population composed of 75 % male and 25 % female drivers wearing a three-point restraint (see clause 0).

Dimensions in millimetres

Elevation above H-point	Stations outboard of C/LO							Stations inboard of C/LO								
	400	300	250	200	100	50	0	0	50	100	200	250	300	400	500	600
800	436	485	503	517	537	544	549	549	559	563	553	541	527	489	442	
700	507	549	564	575	589	595	600	601	615	620	611	601	588	557	515	
600	559	595	608	617	626	627	626	636	652	659	655	647	637	609	567	500
500	593	624	635	644	647	641	629	654	670	679	683	679	671	643	599	532
450	603	631	643	652	652	642	622	657	672	683	692	690	683	655	607	542
400	608	635	647	656	654					682	697	697	691	662	611	547
350	610	634	648	657	651					677	698	701	696	665	609	548
300	606	630	644	654	645					667	696	701	698	663	603	546
250	599	621	637	648	635					653	690	698	696	658	591	539
200	587	608	625	638	622					634	680	692	691	649	575	528
100	551	571	592	608							650	669	671	618	527	494
0	498	518	544	565							606	633	637	572	460	
-100	430	449	483	508							547	584	591	509	374	

TABLE 12 — Hand-reach envelope — Vehicle range ($-0,24 < G < +0,24$)
Population mix : 90/10 males/females

Horizontal reach forward of the HR reference plane at stations located laterally from the centreline of operator (C/LO) and at elevations above the rearmost H-point. The envelope describes a 95 % level of performance of a driver population composed of 90 % male and 10 % female drivers wearing a three-point restraint (see clause 0).

Dimensions in millimetres

Elevation above H-point	Stations outboard of C/LO							Stations inboard of C/LO								
	400	300	250	200	100	50	0	0	50	100	200	250	300	400	500	600
800	459	507	524	538	557	564	570	570	581	584	574	562	548	511	464	
700	528	569	584	594	609	614	619	620	634	639	631	621	608	577	535	
600	579	614	626	635	644	645	643	653	669	676	672	665	655	627	585	518
500	611	642	653	661	664	657	644	669	685	695	699	695	687	660	615	548
450	621	649	661	669	669	657	636	671	686	698	707	705	698	670	623	557
400	626	652	664	673	669					696	712	712	706	676	625	562
350	626	651	664	673	666					690	712	715	711	678	622	562
300	622	646	660	670	659					679	709	715	712	676	615	559
250	614	637	653	664	649					664	702	711	709	670	602	551
200	601	624	641	653	634					644	692	704	703	660	585	539
100	564	585	607	623							661	680	682	628	535	504
0	510	532	559	579							615	643	647	579	466	
- 100	439	463	496	521							554	592	598	515	378	

TABLE 13 — Hand-reach envelope — Vehicle range ($+0,25 < G < +0,74$)
Population mix : 50/50 males/females

Horizontal reach forward of the HR reference plane at stations located laterally from the centreline of operator (C/LO) and at elevations above the rearmost H-point. The envelope describes a 95 % level of performance of a driver population composed of 50 % male and 50 % female drivers wearing a three-point restraint (see clause 0).

Dimensions in millimetres

Elevation above H-point	Stations outboard of C/LO							Stations inboard of C/LO								
	400	300	250	200	100	50	0	0	50	100	200	250	300	400	500	600
800	401	453	471	486	507	514	520	521	531	535	525	513	498	460	412	
700	474	518	534	545	561	567	572	575	590	595	586	576	563	531	489	
600	529	566	579	589	599	601	600	612	628	635	632	624	614	585	544	476
500	564	596	608	617	623	618	607	632	648	658	662	658	650	622	578	511
450	575	604	616	626	629	620	602	635	651	662	671	669	663	634	587	521
400	582	608	621	630	631					662	677	678	672	642	592	528
350	584	608	622	632	629					657	679	682	678	646	591	530
300	582	604	618	629	624					648	678	683	680	646	585	528
250	576	595	611	624	616					635	672	681	679	642	575	522
200	565	583	600	614	604					617	664	676	675	633	559	512
100	531	546	567	585							635	655	657	605	515	480
0	481	494	520	542							593	621	625	561	451	
- 100	415	426	458	486							536	573	581	501	369	

TABLE 14 — Hand-reach envelope — Vehicle range ($+0,25 < G < +0,74$)
Population mix : 75/25 males/females

Horizontal reach forward of the HR reference plane at stations located laterally from the centreline of operator (C/LO) and at elevations above the rearmost H-point. The envelope describes a 95 % level of performance of a driver population composed of 75 % male and 25 % female drivers wearing a three-point restraint (see clause 0).

Dimensions in millimetres

Elevation above H-point	Stations outboard of C/LO							Stations inboard of C/LO								
	400	300	250	200	100	50	0	0	50	100	200	250	300	400	500	600
800	440	490	508	522	542	549	555	555	566	570	560	548	534	496	449	
700	511	553	568	579	594	600	605	607	621	627	618	608	596	565	522	
600	562	599	611	621	631	632	631	641	657	665	662	654	644	616	574	507
500	596	627	639	647	652	646	635	659	675	685	690	686	678	650	605	538
450	606	634	646	655	657	647	628	661	676	688	698	696	690	661	613	548
400	611	638	650	659	656					686	703	703	698	668	616	553
350	612	637	650	660	656					681	704	707	703	671	614	554
300	609	632	646	657	650					670	701	707	704	669	607	551
250	602	623	639	650	640					656	695	704	702	664	595	544
200	590	610	627	640	626					637	685	698	697	654	579	533
100	553	571	593	610							655	675	677	623	531	499
0	500	517	544	565							610	638	643	576	464	
-100	431	448	481	508							551	589	596	514	378	

TABLE 15 — Hand-reach envelope — Vehicle range ($+0,25 < G < +0,74$)
Population mix : 90/10 males/females

Horizontal reach forward of the HR reference plane at stations located laterally from the centreline of operator (C/LO) and at elevations above the rearmost H-point. The envelope describes a 95 % level of performance of a driver population composed of 90 % male and 10 % female drivers wearing a three-point restraint (see clause 0).

Dimensions in millimetres

Elevation above H-point	Stations outboard of C/LO							Stations inboard of C/LO								
	400	300	250	200	100	50	0	0	50	100	200	250	300	400	500	600
800	464	513	530	544	564	570	576	576	587	591	581	569	555	518	471	
700	532	574	589	599	614	620	624	626	640	646	638	628	615	584	542	
600	583	618	631	640	649	650	649	659	675	682	679	672	662	634	592	525
500	615	645	657	665	669	663	651	675	691	701	706	702	694	667	622	555
450	624	652	664	673	674	663	644	677	691	703	714	712	706	677	629	563
400	629	655	668	677	674					701	718	719	713	683	631	568
350	629	654	667	677	671					695	718	722	718	685	628	568
300	625	649	663	673	664					684	715	722	718	683	620	565
250	617	639	655	666	654					668	708	718	716	677	608	557
200	605	626	643	656	640					649	698	711	710	666	590	545
100	567	586	608	624							666	687	688	634	540	509
0	512	531	558	579							620	649	653	585	471	
-100	441	461	494	521							560	598	605	521	383	

TABLE 16 — Head-reach envelope — Vehicle range (+ 0,75 < G < + 1,24)
Population mix : 50/50 males/females

Horizontal reach forward of the HR reference plane at stations located laterally from the centreline of operator (C/LO) and at elevations above the rearmost H-point. The envelope describes a 95 % level of performance of a driver population composed of 50 % male and 50 % female drivers wearing a three-point restraint (see clause 0).

Dimensions in millimetres

Elevation above H-point	Stations outboard of C/LO							Stations inboard of C/LO								
	400	300	250	200	100	50	0	0	50	100	200	250	300	400	500	600
800	404	456	475	490	511	518	524	528	539	543	533	521	506	469	421	
700	477	521	537	549	565	570	575	581	596	602	594	584	571	540	497	
600	531	569	582	592	603	605	604	617	634	641	639	631	621	593	551	483
500	566	598	610	620	626	621	611	636	652	662	668	664	657	629	584	517
450	577	606	619	628	632	623	607	639	654	666	677	676	669	641	593	527
400	584	610	623	633	634					665	682	683	678	648	596	533
350	586	610	623	634	633					660	684	688	684	651	595	535
300	584	605	620	631						650	682	689	686	651	589	533
250	578	597	613	625						636	676	686	685	646	577	526
200	567	584	601	616						618	667	680	680	637	562	516
100	533	547	568	586							638	659	661	608	516	483
0	483	493	519	542							595	624	629	563	452	435
- 100	416	424	457	485							539	577	584	503	370	372

TABLE 17 — Hand-reach envelope — Vehicle range (+ 0,75 < G < + 1,24)
Population mix : 75/25 males/females

Horizontal reach forward of the HR reference plane at stations located laterally from the centreline of operator (C/LO) and at elevations above the rearmost H-point. The envelope describes a 95 % level of performance of a driver population composed of 75 % male and 25 % female drivers wearing a three-point restraint (see clause 0).

Dimensions in millimetres

Elevation above H-point	Stations outboard of C/LO							Stations inboard of C/LO								
	400	300	250	200	100	50	0	0	50	100	200	250	300	400	500	600
800	445	495	513	528	548	555	561	562	573	577	567	556	541	504	457	
700	514	557	572	584	599	605	610	613	628	633	625	616	603	572	530	
600	566	602	615	625	635	637	636	647	663	671	668	661	651	623	581	513
500	599	630	642	651	656	651	640	664	680	690	696	692	685	657	612	545
450	609	637	650	659	661	652	634	666	681	693	704	703	696	668	619	554
400	614	640	653	662	662					691	709	710	705	674	622	559
350	615	639	653	663	660					685	709	713	709	677	619	560
300	612	634	649	660						674	706	713	711	675	612	557
250	604	625	641	653						659	700	710	708	669	600	549
200	592	611	629	642						640	690	703	703	659	583	538
100	556	572	594	611							659	680	682	628	534	503
0	503	517	544	566							614	644	648	581	467	453
- 100	433	446	479	507							556	594	602	519	382	387

TABLE 18 — Hand-reach envelope — Vehicle range ($+ 0,75 < G < + 1,24$)
Population mix : 90/10 males/females

Horizontal reach forward of the HR reference plane at stations located laterally from the centreline of operator (C/LO) and at elevations above the rearmost H-point. The envelope describes a 95 % level of performance of a driver population composed of 90 % male and 10 % female drivers wearing a three-point restraint (see clause 0).

Dimensions in millimetres

Elevation above H-point	Stations outboard of C/LO							Stations inboard of C/LO								
	400	300	250	200	100	50	0	0	50	100	200	250	300	400	500	600
800	469	518	536	550	570	577	583	582	594	597	587	576	561	525	479	
700	537	579	594	605	620	625	630	632	647	652	644	635	622	592	549	
600	586	622	635	644	655	656	655	665	681	688	686	679	669	641	599	531
500	618	649	661	670	674	669	658	680	696	706	713	709	702	674	628	561
450	627	656	668	677	679	669	651	682	697	708	720	719	713	684	635	570
400	632	658	671	680	679					706	724	725	720	690	637	574
350	632	657	670	680	676					699	724	728	724	691	634	575
300	629	651	666	676						688	721	728	725	689	626	571
250	620	641	657	669						673	714	724	723	683	613	563
200	608	627	645	658						653	703	717	717	672	595	551
100	570	587	609	626							672	693	695	640	545	515
0	515	531	558	580							626	655	660	591	476	464
- 100	443	458	492	520							566	605	612	528	389	397

TABLE 19 — Hand-reach envelope — Vehicle range ($G > + 1,25$)
Population mix : 50/50 males/females

Horizontal reach forward of the HR reference plane at stations located laterally from the centreline of operator (C/LO) and at elevations above the rearmost H-point. The envelope describes a 95 % level of performance of a driver population composed of 50 % male and 50 % female drivers wearing a three-point restraint (see clause 0).

Dimensions in millimetres

Elevation above H-point	Stations outboard of C/LO							Stations inboard of C/LO								
	400	300	250	200	100	50	0	0	50	100	200	250	300	400	500	600
800	408	460	479	494	515	522	528	534	547	551	541	529	514	477	430	
700	480	525	540	552	568	574	579	587	603	609	601	591	579	548	505	
600	533	571	585	595	606	608	608	622	639	647	645	638	629	601	558	590
500	568	600	613	622	629	625	615	640	656	667	674	671	664	636	590	523
450	579	608	621	630	635	627	611	643	658	670	683	682	676	647	598	533
400	586	612	625	635	637					668	687	689	684	654	601	538
350	588	612	625	636	636					662	689	693	690	657	599	540
300	586	607	622	633						652	686	694	691	655	592	537
250	580	598	614	627						638	680	691	690	650	580	530
200	569	585	603	617						619	671	685	685	641	564	520
100	535	547	568	587							641	663	665	611	517	486
0	485	493	519	542							598	628	633	566	453	438
- 100	418	423	455	484							541	580	588	506	371	374