



SURFACE VEHICLE RECOMMENDED PRACTICE

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Driver Hand Control Reach

RATIONALE

This document has been revised with minor editorial corrections to the definitions, and to comply with the SAE Five-Year Review policy. A recent history of changes to this document has been added to Appendix A.

SAE J287 has been reaffirmed to comply with the SAE Five-Year Review policy.

1. SCOPE

This recommended practice describes boundaries of hand control locations that can be reached by a percentage of different US driver populations in passenger cars, multi-purpose passenger vehicles, and light trucks (Class A vehicles). This practice is not applicable to heavy trucks (Class B vehicles).

1.1 Introduction

The description of driver hand control reach envelopes was developed using data acquired from test subjects performing reach tasks in test fixtures simulating a range of actual vehicle configurations [Hammond and Roe, 1972; Hammond, et al, 1975]. The test subjects included equal numbers of men and women selected to represent the (United States) driving population on the basis of stature and age, and were tested both with and without an upper torso three-point restraint (the torso restraint was a diagonal non-extending shoulder strap attached separately to the lap belt; it was not a continuous loop system). The envelopes constructed using the non-extending shoulder and lap belt are meant to define a restrained hand reach, and the envelopes constructed using the lap belt only describe an unrestrained hand reach. The hand reach envelopes are three-dimensional surfaces described in table form and can be referenced to a particular vehicle seating configuration as described in Sections 5 and 6. The tables contained in this practice describe the boundaries to which at least 95% of US drivers can reach, based on the underlying data.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

SAE J826 Devices for Use in Defining and Measuring Vehicle Seating Accommodation

SAE J1100 Motor Vehicle Dimensions

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Full document details: SAE J287_202211

For more information on this standard, visit
https://www.sae.org/standards/content/J287_202211/

Documents

Document Sharing Hub

D. Hammond and R. Roe, "SAE Controls Reach Study." Paper 720199 presented at SAE Automotive Engineering Congress and Exposition, Detroit, January 1972.

D. Hammond, D. Maurer, and L. Razgunas, "Controls Reach—The Hand Reach of Drivers." Paper 750357 presented at SAE Automotive Congress and Exposition, Detroit, February 1975.

2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

2.2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

SAE J182 Motor Vehicle Fiducial Marks and Three-Dimensional Reference System

SAE J941 Motor Vehicle Drivers' Eye Locations

SAE J1052 Motor Vehicle Driver and Passenger Head Position

3. DEFINITIONS

3.1 SAE J1100 DEFINITIONS

Accelerator Heel Point (AHP)

H-point

Actual H-point

Centerline of Occupant (C/LO, at Y-coordinate of SgRP)

Seating Reference Point (SgRP)

Steering Wheel Center

H17, Accelerator Heel Point (AHP) to Steering Wheel Center

H30-1, Seat Height (SgRP to AHP, z)

L53-1, SgRP to Heel (AHP, x)

Whenever H30 and L53 are used in this document, they apply to the driver seating position. The suffix "-1", which is used in SAE J1100 to designate the front seating row, is herein omitted from the dimension.

3.2 DRIVER HAND REACH CAPABILITY

Maximum reach capability of 95% of drivers in a simulated driving situation with the non-reaching hand on the steering wheel and the right foot on the accelerator pedal.

3.3 BASIC REACH TASK

Hand reach to a forward mounted control with the control held in a three-finger grasp. See Figure 1.

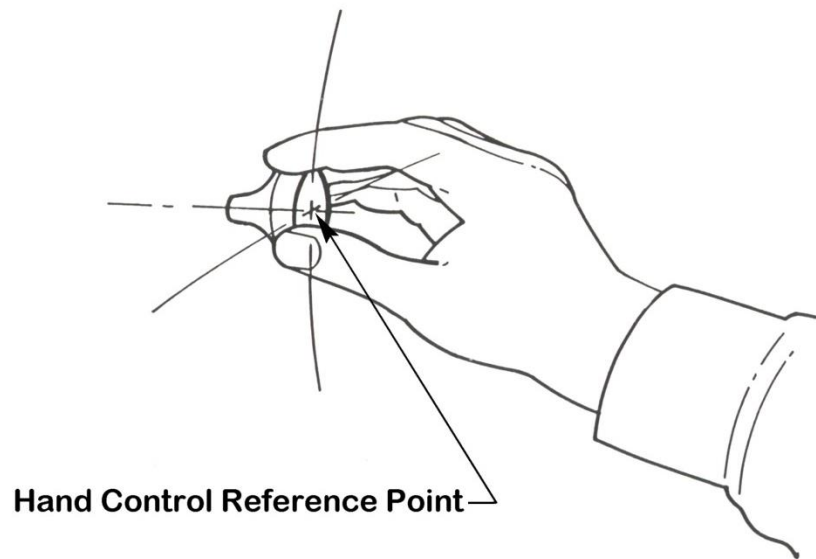


Figure 1 - three-finger grasping reach to a 25 mm diameter control knob; All measurements for the hand reach envelopes are referenced to the center of the control knob face

3.4 HAND REACH ENVELOPE

Geometric description of the hand reach capability for a specified proportion of a driver population and type of torso restraint system. The contour of the hand reach envelope refers to the geometric center 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 [Hammond and Roe, 1972].

3.5 HAND REACH REFERENCE PLANE (HR PLANE)

Vertical reference plane extending laterally across the vehicle (an X-plane) 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 depends on the value of the General Package Factor (G) as shown below:

$$HR = 786 - (99) G, \text{ mm} \quad (\text{Eq. 1})$$

3.6 GENERAL PACKAGE FACTOR (G)

Single index value that characterizes the geometry of the driver seating configuration for a particular vehicle. See Figures 2 and 3.

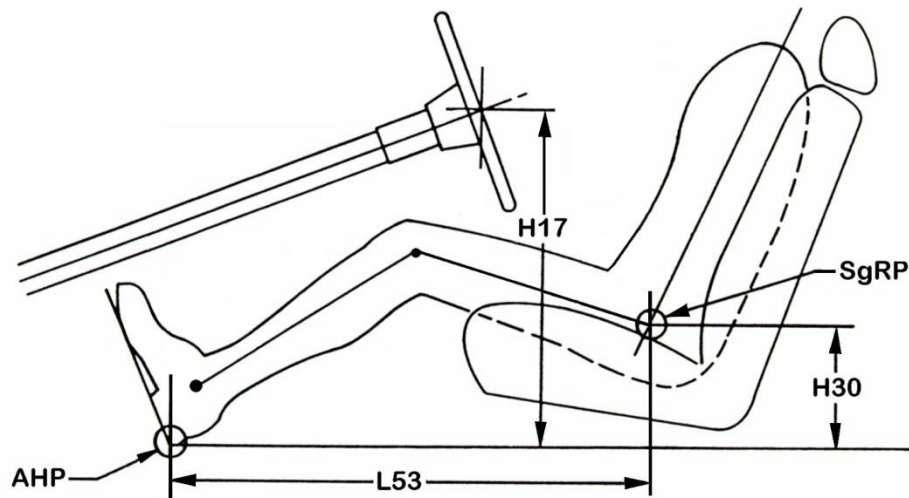


FIGURE 2 - Vehicle interior dimensions used to determine hand reach to a control

The General Package Factor (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 in millimeters into the equation

$$G = 0.00327(H30) + 0.00285(H17) - 3.21$$

Figure 3 - general package factor, G

3.7 TYPE 1 SEAT BELT ASSEMBLY

Lap belt for pelvic restraint.

3.8 TYPE 2 SEAT BELT ASSEMBLY

Combination of pelvic (lap belt) and upper torso (shoulder belt) restraints.

3.9 TYPE 2A SHOULDER BELT

Separate upper torso restraint (shoulder belt) intended to be used in conjunction with a lap belt to form a Type 2 seat belt assembly.

3.10 UNRESTRAINED REACH

Hand reach with no upper torso restraint, as provided by Type 1 seat belt assembly.

3.11 RESTRAINED REACH

Hand reach with upper torso restraint provided by a Type 2a shoulder belt. Restrained reach data were collected using a non-extending Type 2a shoulder belt under the following conditions [Hammond and Roe, 1972]:

- The subject placed his left fist, thumb inward, between the belt and the sternum, then the investigator would snug the belt
- The subject was instructed to "lean forward firmly into the belt, but do not lunge"

4. FIELD OF APPLICATION

- 4.1 This practice is primarily directed towards the initial design stages of a new vehicle program, once the Seating Reference Point (SgRP) is determined. Its application for checking purposes in actual vehicles and prototype seat models will take into account an allowable tolerance for actual H-point [SAE J826].
- 4.2 The hand reach envelopes are directly applicable to left hand drive 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.
- 4.3 The hand reach envelopes are directly applicable for a three-finger grasping reach to a forward mounted control knob of 25 mm diameter. The hand reach envelopes are also applicable to other types of reach to forward controls by using an appropriate adjustment factor that will account for the mode of operation at the control (see 4.3.1, 4.3.2, and [Roe, 1972]).

4.3.1 Controls Operated by Extended Finger

An adjustment factor of 50 mm is added to the tabled values of the reach envelope in order to describe the center of the finger pad contact surface which will be within the fingertip reach of drivers. This adjustment positions the extended finger reach envelope 50 mm farther from the HR plane (see Figure 4).

4.3.2 Controls Operated by Full Hand Grasp

An adjustment factor of 50 mm is subtracted from the tabled values of the reach envelope in order to describe the center of the face of the control knob which will be within the full hand grasp reach of drivers. This adjustment positions the full hand grasp reach envelope 50 mm closer to the HR plane (see Figure 4).

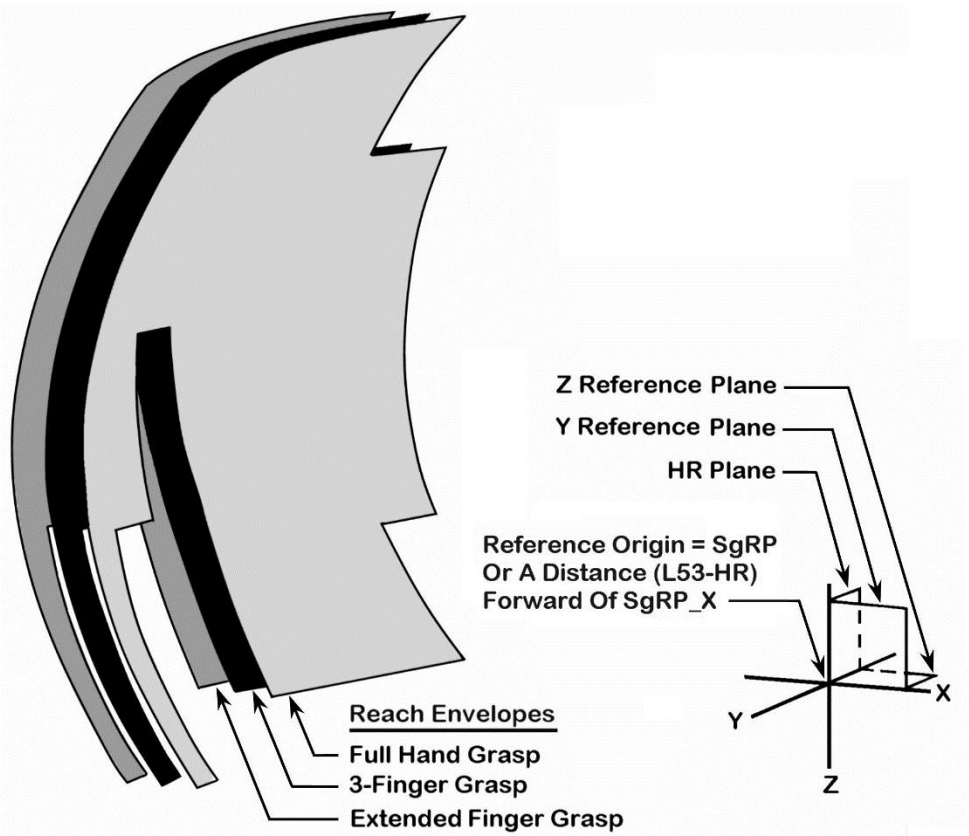


Figure 4 - Hand reach envelopes for 3-finger, extended finger, and full hand grasp of a control

5. REQUIRED CHARACTERISTICS

5.1 The ranges of the interior dimensions for which this recommended practice is applicable are described below:

Range of interior dimensions

DIMENSION		RANGE	
H30	Seat Height (SgRP to AHP, z)	127 mm	to 405 mm
H17	AHP to Steering Wheel Center, z	530 mm	to 838 mm

5.2 The reach envelopes describe the boundaries of control locations that can be reached by at least 95% of certain driver populations that include male-to-female driver population ratios of 50/50, 75/25, and 90/10. The envelopes for each of these categories are specified as an x-distance forward from the HR plane. The envelopes extend from 400 mm outboard to 600 mm inboard of the Centerline of Occupant (C/LO) and from -100 mm below SgRP to 800 mm above SgRP. See Figure 5.

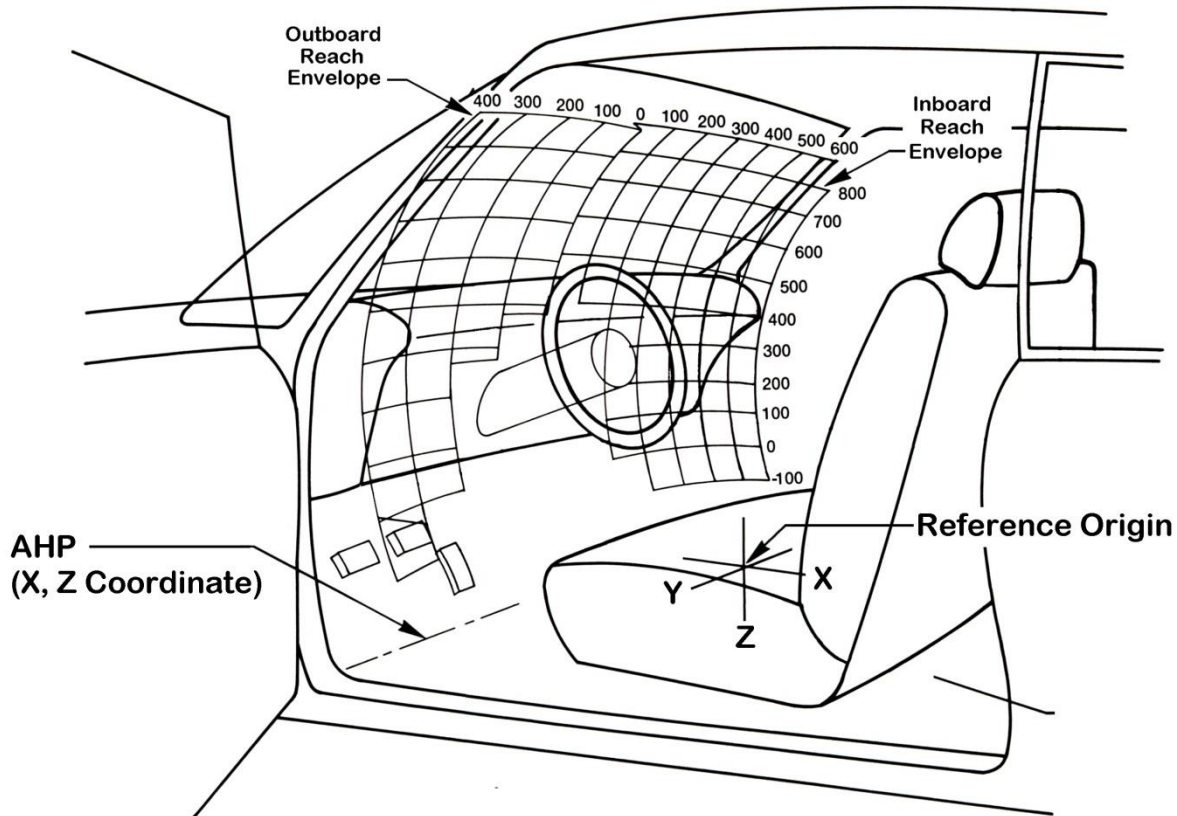


Figure 5 - hand reach envelope and reference planes shown in vehicle workspace

5.3 Hand reach envelopes are provided in the attached tables for seven different seating configurations, three male-to-female driver population ratios, and two types of restraint systems which account for: (i) drivers wearing a lap belt only (Type 1) permitting a free upper torso motion (i.e., unrestrained torso reach); and (ii) drivers wearing both a lap and a shoulder belt (Type 2) permitting only a restrained torso reach. The selection of an envelope for a vehicle is based on the calculated value of the General Package Factor (G), identification of the male-to-female driver population ratio appropriate for the vehicle, and identification of the appropriate restraint system. The General Package Factor (G) is calculated using the dimensions describing the vehicle seating configuration shown in Figures 2 and 3.

5.4 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 the reach envelopes is measured as a distance forward of the HR plane. The fore and aft location of the HR plane rearward from the AHP is determined from Equation 1.

6. PROCEDURE FOR USING THE HAND REACH ENVELOPES

6.1 Reference Planes for Reach Envelopes: The envelopes are located in the vehicle according to a set of orthogonal reference planes: a Z-plane through SgRP, the HR plane (an X-plane), and a Y-plane through the C/LO. See Figures 4 and 5.

6.2 Establish a reference X-origin.

6.2.1 Specify the dimensions describing the geometry of the vehicle seating configuration and calculate the value of the General Package Factor (G) as described in Figure 3.

6.2.2 Calculate HR from the value of the General Package Factor (G) as shown in Equation 1.

6.2.2.1 If $(HR - L53)$ is less than zero, then the hand reach reference plane is located longitudinally at a distance HR rearward of the AHP.

6.2.2.2 If $(HR - L53)$ is greater than zero, the hand reach reference plane is located longitudinally at SgRP.

6.3 Identify the appropriate hand reach envelope.

6.3.1 Referring to Tables 1-42, identify the hand reach envelope appropriate for the value of the General Package Factor (G) calculated for this vehicle, the specified driver population, and the appropriate type of restraint system.

6.3.1.1 If the General Package Factor (G) value, rounded to 2 decimal places, is equal to the limit of a range, use the reach tables associated with that range.

6.3.1.2 The reach envelopes of the 50/50 male-to-female driver population ratio are recommended to establish the maximum reach for all Class A vehicles.

6.3.1.3 For vehicles with Type 2 seat belt assemblies that allow upper torso movement, use the restrained reach envelopes (Tables 1-21) to establish the maximum reach to controls used by a driver when the vehicle is moving. For controls that are not used while driving, a considerable amount of upper torso lean may be acceptable. The unrestrained hand reach tables may be used to establish maximum reach to these controls.

6.4 Determine if the control is within reach.¹

6.4.1 Determine the lateral and vertical locations of the controls of interest. Lateral locations are described as lateral distances from the C/LO. Vertical locations are the heights of the control above the SgRP.

6.4.2 The limiting value of hand reach should be read from the appropriate table at the designated elevation and horizontal station.

6.4.2.1 Interpolation may be required if the necessary control locations are not included in the table. The preferred method is to interpolate laterally then vertically. Curvilinear interpolations, using two locations on either side of the desired control, may also be considered, but minor variations in the resulting reach envelope should be expected.

6.4.3 A surface fitted through all the points in each table may also be used to determine if the control is within reach. The fitted surface should not deviate from the table values by more than 1 mm.

6.4.4 A control is considered within reach of the specified proportion of the indicated driver population if the geometric center of the control face (in the nominal or resting position) closest to the driver is tangent to or rearward of the reach contour (reach coordinates, interpolated coordinates, or fitted surface).

¹ 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 gray shaded areas are regions where the difference between the hand reach model and the observed design limit values exceeded 25 mm. The reach values shown in these areas should be used with caution.

TABLE 1

Restrained Hand Reach				Vehicle Range: (G less than -1.25) (mm)				Population Mix: 50/50 Males to Females									
Elevation above SgRP (mm)	Horizontal reach forward of the HR reference plane at stations located laterally from the centerline of operator (C/LO) and at elevations above the Seating Reference Point (SgRP). The envelope describes a 95% level of performance of a driver population composed of 50% male and 50% female drivers wearing a Type 2a restraint.																
	Stations outboard of C/LO (mm)								Stations inboard of C/LO (mm)								
	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

Restrained Hand Reach				Vehicle Range: (G less than -1.25) (mm)				Population Mix: 75/25 Males to Females								
Elevation above SgRP (mm)	Horizontal reach forward of the HR reference plane at stations located laterally from the centerline of operator (C/LO) and at elevations above the Seating Reference Point (SgRP). The envelope describes a 95% level of performance of a driver population composed of 75% male and 25% female drivers wearing a Type 2a restraint.															
	Stations outboard of C/LO (mm)							Stations inboard of C/LO (mm)								
	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

Restrained Hand Reach		Vehicle Range: (G less than -1.25) (mm)							Population Mix: 90/10 Males to Females							
Elevation above SgRP (mm)	Horizontal reach forward of the HR reference plane at stations located laterally from the centerline of operator (C/LO) and at elevations above the Seating Reference Point (SgRP). The envelope describes a 95% level of performance of a driver population composed of 90% male and 10% female drivers wearing a Type 2a restraint.															
	Stations outboard of C/LO (mm)							Stations inboard of C/LO (mm)								
	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