

## Draft report of investigation on available range for hand controls summary version

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### 1. Objective

As part of the United Nations' Global Technical Regulations (GTR) drafting work, we have been discussing the location of hand controls. The objective of this investigation is to obtain technical data and information necessary to specify quantitative requirements on the available range for operating the hand controls.

### 2. Provisions on available range for hand controls

Japan's Safety Regulations provide a quantitative requirement for the hand controls that states the control "shall be located within 500 mm to the right and left of the center of the steering wheel." However, the literature research that we conducted found no justifications for specifying the value of 500 mm. On the other hand, in Europe and other countries, although a similar concept exists, there are no quantitative requirements; it appears that the hand control location is determined at the discretion of the reviewer of the testing laboratory of each country.

At a discussion at the UN, Canada proposed to set forth a provision that specifies the hand-reaching range for the 50th percentile male, but did not comment on any specific language of such provision. Therefore, the United Kingdom proposed to use ISO 3958 "Passenger cars - Driver hand-control reach" as reference material. This standard has been incorporated into a Japanese industrial standard as JIS D 0023. While this standard (hereafter the "ISO/JIS") contains detailed data that provide the values for specifying the range for a variety of vehicle models and seats, it was drafted more than 20 years ago and so its applicability to the current vehicles and body build of the drivers is unknown. For this reason, we conducted our original investigation using subjects to find the hand-reaching range.

### 3. Investigation Using Subjects

First, by using actual vehicles, we investigated how far the hand can reach.

The investigation was conducted on five male subjects. The body build of each subject was as follows:

Table 1 Body Build of Each Subject

Items	Participants					Average	Hybrid III
	A	B	C	D	E		
Height (cm)	163.0	179.0	168.0	177.0	168.0	171.0	175.0
Weight (kg)	65.0	68.0	80.0	78.0	62.0	70.6	77.7
Hand Reach (cm)	65.0	77.0	68.0	71.0	68.0	69.8	70.0
Shoulder Width (cm)	40.0	38.0	42.0	40.0	37.0	39.4	40.0
Seated Height (cm)	85.0	93.0	85.0	88.0	88.7	87.9	88.4

#### 3.1. Investigation Using Actual Vehicles

We used three types of vehicles: passenger car (3,000 cc), one-box car (2,000 cc), and truck (with a maximum loading weight of 4 tons). The subject was asked to be seated in the driver's seat and extend his arm so that his fingers can touch the panel. At this time, he was instructed to touch the panel on a line that is extending horizontally from the center of the steering wheel. Under this condition, the distance between steering wheel center and fingertip was measured. For the passenger car and the one-box car, the measurement was taken while the vehicle was in

motion at 40 km/h, and for the truck, the measurement was taken while the vehicle was stationary. We compared three different arm-extending styles: (1) the arm is extended while the normal driving posture is maintained as much as possible (Normal Posture), (2) the arm is extended so the hand can reach the target easily by slightly changing the posture (Changed Posture), and (3) the arm is extended by largely changing the posture, even to the limit of safety in driving (Ultimate Posture).

The result indicated that, in the case of Normal Posture, the hand cannot reach the target at 500 mm, the location specified under the Safety Regulations, in any vehicle type. On the other hand, the average hand-reaching distance of the five subjects in Changed Posture was 560 mm for the passenger car, 580 mm for the one-box car, and 500 mm for the truck. Further, the average distance in Ultimate Posture was approx. 700 mm for the passenger car, approx. 680 mm for the one-box car, and approx. 740 mm for the truck. The 500 mm provision of the Safety Regulations concerns the distance that can be reached easily by slightly changing the Normal Posture defined hereunder.

### 3.2. Measurement Using Test Seats

The ISO/JIS specifies a three-dimensional hand-reaching range, but we do not know what kind of driver posture was taken into account in the measurement of such range. Therefore, we reproduced an actual vehicle's seat in an indoor setting, and measured the range of the driver's horizontal hand reach while changing his posture (Figure 1).

We installed a dummy conforming to ISO 6549 in the driver's seat of the above-mentioned three types of vehicles to determine the driving posture factor (G value) specified in the ISO/JIS. As a result, we found that the factor for the passenger car, the one-box car, and the truck is equivalent to that given in Table 28 of the ISO/JIS (male/female ratio: 50/50), Table 35 (75/25), and Table 39 (90/10), respectively.

In each of these three types of vehicles, the hand-reaching range was measured for Normal Posture, Changed Posture, and Ultimate Posture as described in the preceding section. The horizontal plane used in the measurement was set at 240 mm above the design reference point (R point). The forward distance from the vertical plane passing through the R point was recorded as the hand-reach value and plotted as the function of the distance from the driver's central plane to the vehicle's central side. Here, we show the average value of the five subjects in the passenger car test only (Figure 2). For reference, we also plotted the ISO/JIS hand-reaching range in Figure 2. This result indicated that the ISO/JIS value can be positioned between the Changed Posture condition and the Ultimate Posture condition of this study. We obtained the similar



Fig. 1 Test setup (passenger car, Changed Posture)

Simulated Driving Table (passenger car; 240 mm above R point; average of five subjects)

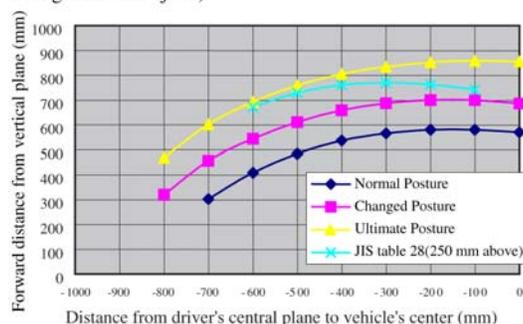


Fig. 2 Result example (passenger car)

results for the one-box car test and the truck test as well. Since the ISO/JIS value was originally developed for European people, we were afraid that there would be a large difference between the average body build of Japanese people and that of European people; however, these tests found that there is only a small difference between them.

### 3.3 Provisions on the 50th percentile male

Canada proposed to set forth a provision that specifies the hand-reaching range for the 50th percentile male. As a way to measure this range, we examined the possibility of conducting reviews using a Hybrid III dummy, which is designed with the dimensions of the 50th percentile male (Figure 3). The result found that the Hybrid III dummy's hand can only reach an area about 400 mm away from the steering wheel center. Because the dummy's shoulder joints are not as flexible as the human's, it was impossible for the dummy's arm to be extended widely in a natural position. In addition, due to a lack of flexibility of the dummy's hip joints, etc., it was impossible to take measurements for Changed Posture and Ultimate Posture. This means that a review conducted with the Hybrid III dummy will be more stringent than what the 500 mm provision of Japan's Safety Regulations requires.

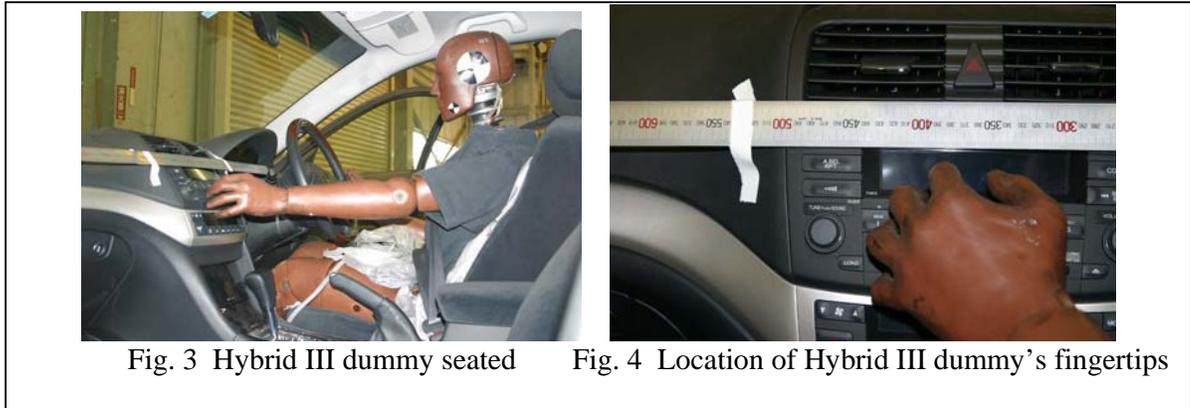


Fig. 3 Hybrid III dummy seated

Fig. 4 Location of Hybrid III dummy's fingertips

## 4. Relation Between Standards and the Subjects' Postures

The investigation thus far indicates that the available range for operating the hand controls is specified based on an assumption that the driver will change his/her posture to reach the target. Specifically, the Safety Regulations' 500 mm provision concerns the range of hand reach that is achieved easily when the driver's posture is slightly changed, and the range specified in the ISO/JIS provision takes into account a posture between slightly changed posture and ultimately changed posture. Furthermore, the result shows that under the ISO/JIS provision the driver's hand can reach the target located farther away than 500 mm from the steering wheel center as specified in the Safety Regulations (Figure 2).

Table 2 compares these three measurement methods: Safety Regulation, ISO/JIS, and the method using a Hybrid III dummy designed with the 50th percentile male dimensions.

Table 2 Comparison of measurement methods in this investigation

Standard	Driver's posture	Measurement method
Stringent	Normal Posture	← Hybrid III
	Changed Posture	← Safety Reg. (500 mm) ← ISO/JIS
Relaxed	Ultimate Posture	

## 5. Applicability of different methods to the reviewing procedures

As information related to this study, we investigated the procedures currently used to review the location of switches. Also, while Japan's current Safety Regulations specify a two-dimensional method where measurements are taken horizontally, if a three-dimensional method, such as the ISO/JIS method, is introduced in the future, we will need new reviewing procedures. We examined the possibility of such procedures.

### 5.1. Confirmation procedures under the Safety Regulations

At present, in Japan's type approval reviewing procedures, the location of switches is confirmed by checking two-dimensional CAD data submitted by the manufacturers. If a three-dimensional measurement provision is introduced in the future, the manufacturers will need to submit drawings that contain three-dimensional information.

### 5.2. Confirmation procedures under ISO/JIS using the ISO dummy

If the location of controls cannot be confirmed with drawings only, it should be checked in an actual vehicle. In this case, additional processes will be necessary, such as installing a dummy that conforms to ISO 6549 and setting the R point as well as the vertical reference plane that passes through this point. We tried confirming the location of switches by actually using these complicated procedures and found that it requires more manhours than the drawing review.

## 6. Conclusion

Based on the above results, the advantages and disadvantages of each method can be summarized as follows:

The horizontal measurement provision of the Safety Regulations concerns the range easily reachable by slightly changing the driver's posture. This method is therefore more appropriate from the perspective of physical features and ensures a higher level of safety. It is also better than the other methods in that it requires less complicated reviewing procedures because of its two-dimensional measurement. However, it has a disadvantage; i.e., since there is no provision on measurement in fore and aft directions, the regulation cannot cover the location of controls that are installed way too far in front of the driver.

The advantages of the ISO/JIS method include its having little ambiguity and being very specific. For example, it contains detailed tables based on each vehicle configuration and occupant sex. Its disadvantages are that it concerns the range reachable by a posture that is almost impossible for Japanese drivers to achieve and that the required reviewing procedures may become too complicated.

If the 50th percentile male concept is incorporated into the reviewing procedures, the location can be checked very easily: a reviewing official of the equivalent size can sit in the driver's seat and just extend his arm to reach the target. However, officials of that size are not necessarily always there. Besides, we do know that dummies of that size cannot replace the humans to do that job. Therefore, this 50th percentile male method is difficult to use in actuality.

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