

5th Percentile Female Hybrid III H-Point Machine

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ABSTRACT

Currently, no standard procedure exists for positioning the Hybrid III 5th Percentile Female Dummy in a vehicle for crash testing. Because of pending regulations proposing the use of the Hybrid III 5th Percentile Female Dummy in full vehicle crash tests, an SAE Working Group was formed to develop a standard positioning procedure. In order to support this effort, Ford Motor Company has developed a H-point machine that is the subject of this paper. This machine was modeled after the SAE J826 H-point machine except that its dimensions and mass distribution represent the Hybrid III 5th Percentile Female Dummy. The intended use of this machine is to determine a target H-point that can be used to position the Hybrid III 5th Percentile Female Dummy in a vehicle. This process is similar to that currently used to position the Hybrid III 50th Percentile Dummy in FMVSS 208. This new H-point machine has been found, based on limited testing, to be repeatable, reproducible and provides an H-point to which the 5th Percentile Hybrid III Dummy can be readily positioned. This paper describes the physical characteristics, rationale of these characteristics, repeatability and reproducibility of the 5th Percentile Female Hybrid III H-Point Machine.

INTRODUCTION

The National Highway Traffic Safety Administration (NHTSA) has issued a Notice of Proposed Rulemaking (NPRM) which would amend FMVSS 208; this NPRM contains several new tests, injury criteria, and dummies. Part of this NPRM proposes full vehicle crash testing using 5th percentile female dummies. Since this is the first regulation that proposes the use of the 5th percentile dummy, no standard procedure exists for positioning this dummy in a vehicle. In June 1997, an SAE Working Group was established to develop a procedure to position the Hybrid III 5th Percentile Female Dummy. In support of this SAE Working Group, Ford Motor Company has developed a 5th Percentile Female Hybrid III H-point Machine which could be used in this procedure.

The current FMVSS 208 regulation requires vehicle crash tests to be conducted with a 50th percentile male dummy. This regulation specifies that the SAE J826 H-Point Machine (Figure 1) is to be used to determine the location at which the Hybrid III 50th Percentile Dummy H-point is to be positioned. Since the seat pan of the J826 machine is approximately 100mm wider than the 5th Percentile Female Dummy buttocks (measured at the H-point), the J826 machine produces an H-point to which the Hybrid III 5th Percentile Female Dummy cannot always be positioned. One example of this phenomenon is in seats with side bolsters or other side-to-side contour where the wider J826 machine would sit higher than the narrower Hybrid III 5th Percentile Female Dummy. Because the J826 machine was found not to be suitable in all cases for determining an H-point to which the Hybrid III 5th Percentile Female Dummy could be positioned, a smaller H-point machine (Figure 1) was developed.



Figure 1. 5th Percentile Hybrid III H-Point Machine (left) and SAE J826 H-Point Machine (right)

H-POINT MACHINE SPECIFICATIONS

Specification Overview

The strategy used in designing the 5th percentile H-point machine was to create the device with the same dimensions and mass distribution as the Hybrid III 5th Percentile Female Dummy.

H-Point Machine Dimensions

Figure 2 shows some critical dimensions from the dummy that were used in designing the H-point machine. These include the upper and lower leg lengths and the H-point to seat pan outer surface distance in both the longitudinal and vertical directions. As can be seen in Table 1, these dimensions on the H-point machine are essentially identical to those of the dummy.

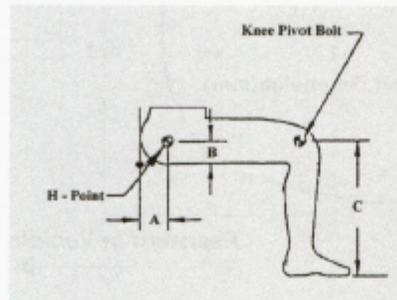


Figure 2. Dimensions

	Mannikin	Dummy
347 mm	350 mm	347 mm
Lower Leg Length (C)	402 mm	400 mm
H-Pt to Bottom of Seat Pan (B)	85 mm	84 mm
H-Pt to Back of Seat Pan (A)	132.5 mm	135 mm

Table 1. Comparison of Critical Dimensions of 5th Percentile H-Point Machine and 5th Percentile Hybrid III Dummy

To facilitate timely fabrication of the prototype, the fiberglass seat pan of the H-point machine was made by narrowing the breadth of the seat pan from a Japanese Industrial Standard seating mannikin (JIS mannikin). Figure 3 shows how the surface area occupied by the seat pan of the 5th Percentile H-Point Machine in a vehicle seat compares to the surface area occupied by the Hybrid III 5th Percentile Female Dummy in that same vehicle seat. While it can be seen that the seat pan of the 5th Percentile H-Point Machine is not identical to the seat imprint of the Hybrid III 5th Percentile Female Dummy, the shapes of the H-point machine's and dummy's seats are very similar. The surface area occupied by the H-point machine in a vehicle seat is seen to be within 5 % of the area occupied by the dummy. As mentioned, the 5th Percentile H-Point Machine's seat pan was fabricated by modifying the seat pan of an existing JIS seating mannikin to expedite fabrication. Since, as will be described, the H-point machine performed adequately in a variety of different vehicles, it was felt that this seat pan was acceptable. Although no such situation has been discovered thus far, if it is found that the minor differences between the shape of the H-point machine's seat pan and the dummy's seat create issues in certain vehicle applications, a new seat pan can be fabricated to be identical to the Hybrid III 5th Percentile Female Dummy.

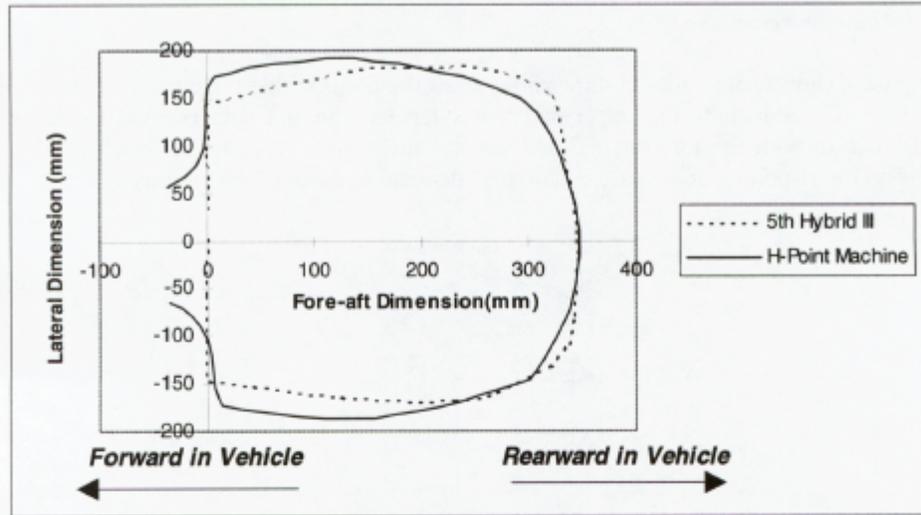


Figure 3. Comparison of the 5th Percentile H-Point Machine and 5th Percentile Female Hybrid III Dummy Seated Surface Area

The back pan of the 5th percentile H-point machine is identical to that of the JIS seating mannikin. This back pan is very similar (although not identical) to Hybrid III 5th Percentile Female Dummy. Although no problems regarding the 5th percentile H-point machine's back pan have been encountered thus far in a variety of different vehicles, if such problems are encountered, a new back pan can be fabricated that is identical to the dimensions of Hybrid III 5th Percentile Female Dummy's back. This is the same philosophy that was discussed regarding the seat pan.

H-Point Machine Masses and Mass Distribution

The mass distributions of the various body segments of Hybrid III 5th Percentile Female Dummy are shown in Table 2. Also seen in Table 2 is the comparison of the dummy mass distributions to the H-Point machine mass distributions. It can be seen that the dummy's mass distributions were replicated very closely in the 5th percentile H-point machine. The head, neck and arm masses of the dummy were all combined into the chest mass since the H-point machine has no head, neck or arms.

Body Region	H-Pt Mannikin (lbs.)	Hybrid III Dummy (lbs.)
Upper Torso	47.5	45.6
Lower Torso	29.9	30.4
Upper Legs	14.8	13.8
Lower Legs	14.1	14.4
Feet	3.2	3.2
Total	109.5	107.4

Table 2. Comparison of Mass Distributions of 5th Percentile H-Point Machine and the 5th Percentile Female Hybrid III Dummy

COMPARISON OF THE 5TH PERCENTILE H-POINT MACHINE VS. THE SAE J826 H-POINT MACHINE

The 5th Percentile H-point Machine was patterned after the SAE J826 H-point Machine, but there are some differences. The length of the 5th Percentile Female Dummy's legs are such that the dummy's calves typically interact with the forward edge of the seat cushion. To properly create this condition in the 5th Percentile H-point Machine, it was necessary to add Delrin™ calf inserts to the back of the lower leg segments as shown in Figure 4. Because of the interference condition between the calf and the seat, it was not possible to have a hanging weight on the lower leg of the 5th Percentile H-point Machine as is found on the J826 machine. Instead, a permanently mounted weight was added to each lower leg segment of the 5th Percentile H-point Machine as seen in Figure 5.

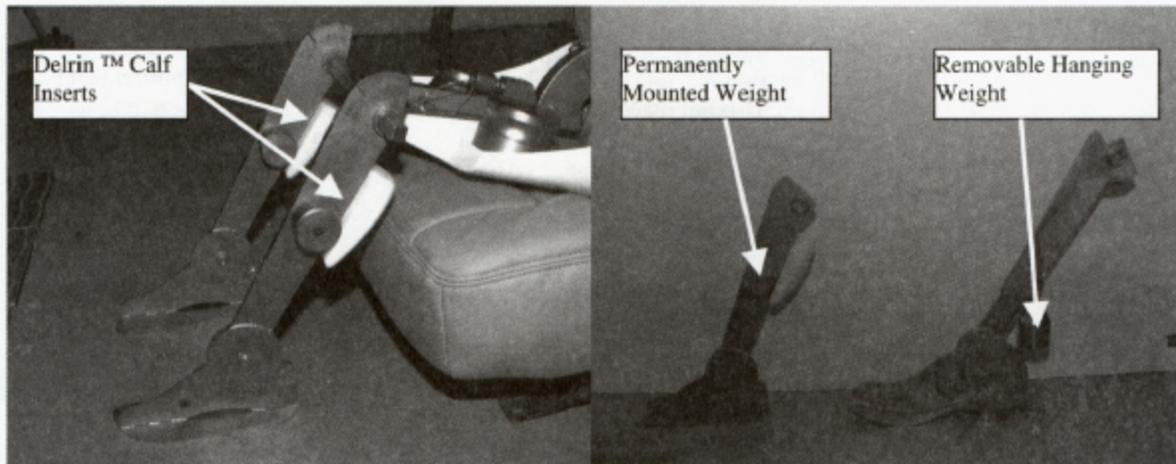


Figure 4. Lower Leg Segment of 5th Percentile H-Point Machine

Figure 5. Comparison of 5th Percentile H-point Machine (left) and J826 (right) Lower Legs

The major difference between the SAE J826 H-point machine and the 5th Percentile Female H-point Machine is that the 5th Percentile H-point Machine was designed to be as similar as possible, in both dimensions and mass distribution, as the dummy with which it is to be used. The SAE J826 H-point machine was designed from different anthropometry information than the 50th Percentile Male Hybrid III Dummy. However, as has been described, the anthropometry information used to develop the 5th Percentile H-Point Machine was the anthropometry of the Hybrid III 5th Percentile Female Dummy. This minimizes the risk of any performance problems that would result from differences in dimensions or mass distribution between the H-point machine and Hybrid III 5th Percentile Female Dummy.

PERFORMANCE OF THE 5TH PERCENTILE H-POINT MACHINE

Repeatability and Reproducibility

A series of experiments were performed on the H-point machine to study its repeatability and reproducibility. The machine was positioned in several vehicles using the SAE J826 APR 80 procedure modified as appropriate to accommodate the 5th Percentile H-point Machine. These modifications included placing the seat cushion in its full forward fore-aft position and in its mid height position vertically (if vertically adjustable), and placing the seat back in its full upright position. This is not necessarily the recommended or typical seating position for a 5th percentile female. These locations were chosen somewhat arbitrarily as more representative of where a 5th percentile female would sit in comparison to the seat position specified in SAE J826. Other modifications that were made to the SAE J826 procedure to make the procedure applicable to the 5th Percentile H-point Machine are:

SAE J826 APR 80 Section 4.3.5: Replace this entire section with: "Use the 5th percentile H-point machine's fixed lower leg segment length and 350mm for the 5th percentile H-point machine's thigh segment length."

SAE J826 APR80 Section 4.3.7.4: Change "set the H-point machine's feet approximately 10 in (254 mm) apart" to "set the H-point machine's feet approximately 6.5 in (165 mm) apart"

SAE J826 APR80 Section 4.3.8: Change "Apply lower leg and thigh weights" to "Apply thigh weights". (The 5th percentile H-point machine's lower leg weights are permanently mounted on the lower legs and, therefore, are permanently applied.)

SAE J826 APR 80 Section 4.3.10: Change "Apply a 22 lb. (10 kg) load" to "Apply a 13.2 lb. (6 kg) load"

The experiments performed consisted of positioning the H-point Machine in 4 vehicles: a small car, a mid-sized car, a large car, and a light truck. To test repeatability, the H-point machine was positioned in the driver seat three times and in the passenger seat three times for each vehicle. Four different operators (not all experienced in using the SAE J826 H-point machine) were randomly assigned throughout this process to test for reproducibility. The data collected are shown in Tables 4 - 7. It is seen in these tables that, in these tests, the results were repeatable and reproducible as evidenced by the small standard deviation values. Table 8 summarizes all the results by combining the driver and passenger results for each vehicle and calculating a standard deviation for all 6 tests performed on each vehicle. Each individual reading was zeroed by subtracting its corresponding mean value to enable combining driver and passenger data.

Small Car - Driver	Trial 1	Trial 2	Trial 3	Mean	Std. Dev.
H-Pt Long (mm)	2084.8	2085.6	2080.5	2083.6	2.8
H-Pt Vert (mm)	290.7	291.4	290.3	290.8	0.6
Mannikin Back Angle (deg)	14.0	14.0	14.7	14.2	0.4
Small Car - Passenger					
H-Pt Long (mm)	2077.2	2075.8	2077.0	2076.6	0.7
H-Pt Vert (mm)	295.4	295.4	294.3	295.0	0.6
Mannikin Back Angle (deg)	14.5	14.0	14.5	14.3	0.3

Table 4. Results of 5th Percentile H-Point Machine Tests in a Small Car

Mid Size Car - Driver					
	Trial 1	Trial 2	Trial 3	Mean	Std. Dev.
H-Pt Long (mm)	2847.8	2848.6	2848.4	2848.3	0.4
H-Pt Vert (mm)	692.3	690.5	691.6	691.5	0.9
Mannikin Back Angle (deg)	18.0	18.0	18.0	18.0	0.0
Mid Size Car - Passenger					
	Trial 1	Trial 2	Trial 3	Mean	Std. Dev.
H-Pt Long (mm)	2846.3	2845.3	2845.8	2845.8	0.5
H-Pt Vert (mm)	700.0	700.5	700.0	700.2	0.3
Mannikin Back Angle (deg)	16.5	16.5	16.5	16.5	0.0

Table 5. Results of 5th Percentile H-Point Machine Tests in a Mid-Sized Car

Large Car - Driver					
	Trial 1	Trial 2	Trial 3	Mean	Std. Dev.
H-Pt Long (mm)	2956.5	2961.8	2960.6	2959.6	2.8
H-Pt Vert (mm)	728.8	727.5	728.0	728.1	0.6
Mannikin Back Angle (deg)	17.5	17.5	17.4	17.5	0.1
Large Car - Passenger					
	Trial 1	Trial 2	Trial 3	Mean	Std. Dev.
H-Pt Long (mm)	2966.2	2968.2	2969.5	2967.9	1.7
H-Pt Vert (mm)	702.8	702.5	700.0	701.8	1.5
Mannikin Back Angle (deg)	17.2	17.5	17.0	17.2	0.3

Table 6. Results of 5th Percentile H-Point Machine Tests in a Large Car

Light Truck - Driver					
	Trial 1	Trial 2	Trial 3	Mean	Std. Dev.
H-Pt Long (mm)	2776.7	2773.1	2774.7	2774.8	1.8
H-Pt Vert (mm)	957.0	955.4	957.8	956.7	1.2
Mannikin Back Angle (deg)	21.0	21.5	21.0	21.2	0.3
Light Truck - Passenger					
	Trial 1	Trial 2	Trial 3	Mean	Std. Dev.
H-Pt Long (mm)	2757.3	2763.7	2765.5	2762.1	4.3
H-Pt Vert (mm)	960.5	962.1	960.7	961.1	0.9
Mannikin Back Angle (deg)	24.0	23.0	23.5	23.5	0.5

Table 7. Results of 5th Percentile H-Point Machine Tests in a Light Truck

		Small Car	Mid Size Car	Large Car	Light Truck
Sample Size		6	6	6	6
H-Pt	Long (mm)	1.8	0.4	2.1	3.0
	Vert (mm)	0.5	0.6	1.1	1.0
Back Angle	degrees	0.3	0.0	0.2	0.4

Table 8. Comparison of Standard Deviations of All Vehicles Tested

A major design issue encountered with the 5th percentile H-point Machine is that the H-point Machine back angle indicator contacted the lower rim of the steering wheel in some vehicles, thus impeding full execution of the H-point determination procedure with the seat in its full forward position. This issue can be resolved by replacing the current mechanical back angle indicator with a rotary potentiometer that would be integral to the H-point Machine's H-point pivot joint. This would permit elimination of the additional hardware that constitutes the current mechanical back angle indicator (see Figure 6) which would eliminate the interference condition between the H-point machine and the steering wheel.

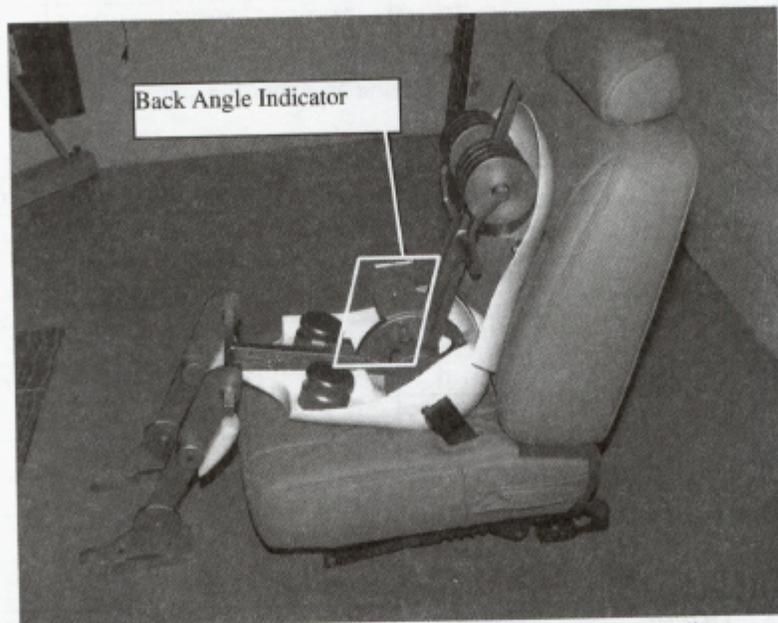


Figure 6. 5th Percentile H-Point Machine Back Angle Indicator

Suitability for Intended Purpose

The intended purpose for the 5th Percentile Female Hybrid III H-Point Machine was to produce a target H-point to which the Hybrid III 5th Percentile Female Dummy could be positioned. To evaluate the H-point machine's capability toward this objective, the machine was used to determine target H-points in 3 vehicles: a small car, a mid-sized car, and a light truck. These results can be found in Table 9. Again, the H-point machine was placed in the vehicle following the modified J826 procedure described previously. Time did not permit utilizing a large car for this experiment. After a target H-point had been established, a Hybrid III 5th Percentile Female Dummy was positioned in the vehicle following a procedure similar to that specified in FMVSS 208 for positioning a 50th percentile male dummy with modifications as appropriate to accommodate the 5th female dummy. The modifications to the FMVSS 208 seating procedure included placing the seat cushion in its full forward fore-aft position and in its mid height position vertically (if vertically adjustable), and placing the seat back in its full upright position. As stated previously, this is not necessarily the recommended or typical seating position for a 5th percentile female; these locations were chosen somewhat arbitrarily as being more representative of where a 5th percentile female would sit in comparison to the seat position specified in FMVSS 208 for the 50th percentile male

Hybrid III dummy. Other modifications made to the FMVSS 208 seating procedure to make it applicable to the 5th percentile female Hybrid III dummy are:

FMVSS 208 S10.4.2.1: Replace this entire section with: "The H-points of the driver and passenger test dummies shall coincide within ½ inch in the vertical dimension and ½ inch in the horizontal dimension to the position of the H-point determined using the 5th Percentile H-point Machine and the procedure described in the section of this paper entitled 'Repeatability and Reproducibility'."

FMVSS 208 S10.4.2.2: Change "22 ½ degrees plus or minus 2 ½ degrees" to "20 degrees plus or minus 2 ½ degrees". This is based on information provided to the SAE Working Group that indicated a pelvis angle range of 20 plus or minus 2 ½ degrees will allow the 5th Percentile Female Hybrid III Dummy's head to be level.

FMVSS 208 S10.5: Change "10.6 inches" to "6.5 inches".

Driver Side		Small Car	Mid Size Car	Light Truck
H-Pt Difference	Long (mm)	-5.1	0.0	2.9
(machine-dummy)	Vert (mm)	7.6	-2.5	4.5
HIII Pelvic Angle	degrees	20.0	24.2	18.4
Passenger Side				
		Small Car	Mid Size Car	Light Truck
H-Pt Difference	Long (mm)	7.6	5.1	-10.6
(machine-dummy)	Vert (mm)	2.5	10.2	-6.6
HIII Pelvic Angle	degrees	22.0	21.1	19.2

Table 9. Comparison of 5th Percentile H-Point Machine and 5th Percentile Female Hybrid III Dummy H-point Locations

It is seen that, in the tested cases, the dummy's H-point was within the plus or minus ½ inch (12.5 mm) window of the target H-point established using the 5th Percentile H-Point Machine. Also, the pelvic angle fell within the 20 +/- 2.5 degree window in these cases except for the driver dummy on the mid-sized car. This was because that particular vehicle was being used in an actual crash test to evaluate the NHTSA dummy positioning procedure specified in the NPRM which specifies a 22.5 +/- 2.5 degree tolerance. Since the dummy was within the NHTSA proposed tolerance, the crash test was performed with the 24.2 degree pelvic angle obtained from the original positioning. Because the H-point longitudinal dimension was exactly on target, it was judged that the dummy could have been adjusted to obtain a pelvic angle within 20 +/- 2.5 degrees while still maintaining the H-point within the plus or minus ½ inch (12.5 mm) tolerance and also maintaining the head level.

CONCLUSIONS AND RECOMMENDATIONS

In response to a potential need to develop a procedure for positioning the Hybrid III 5th Percentile Female Dummy in a vehicle for crash testing, an H-point machine has been developed. The mannikin is intended to provide a target H-point for positioning the dummy. This H-point machine has been designed to have similar dimensions and mass distribution as the 5th percentile

female Hybrid III dummy. Limited experimentation has shown that this H-point machine may be repeatable and reproducible in a variety of vehicles. Also, it has been shown that Hybrid III 5th Percentile Female Dummy can be readily positioned to the target H-point established by the H-point machine in a variety of vehicles. The procedures used are similar to those described in FMVSS 208 for positioning the Hybrid III 50th Percentile Dummy.

Recommendations for next steps are:

Replace the H-point machine's mechanical back angle indicator with an electronic transducer to eliminate the interference condition with the steering wheel described in the section of this paper entitled "Repeatability and Reproducibility".

Establish an agreed upon appropriate seat track and seat back position for Hybrid III 5th Percentile Female Dummy so the H-point machine and dummy positioning procedures can be finalized.

Allow any interested government, industry, and research organizations to evaluate the 5th Percentile Female Hybrid III H-Point Machine and provide feedback and additional recommendations.