Study on Characteristics of Event Data Recorders Using J-NCAP Data

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Abstract - The aim of this study was to evaluate the performance and accuracy of Event Data Recorders (EDRs). The analysis was based on J-NCAP crash tests from 2006–2007, with the corresponding EDR datasets. The pre-crash velocity, maximum delta-V and delta-V versus time history data recorded in the EDRs were compared with the reliable crash test data. The difference between the EDR pre-crash velocity and the laboratory test speed was less than 4 percent. In contrast, in several cases the maximum delta-V and delta-V versus time history data obtained from the EDRs showed uncertainty of measurement in comparisons with the reliable delta-V data. The difference in maximum delta-V in these comparisons was more than 5 percent in 10 of 14 tests and more than 10 percent in 4 of 14 tests. The EDRs underestimated the maximum delta-V in almost all tests. It was also concluded that the calculated acceleration from the EDR delta-V versus time history data showed good agreement with the instrumented accelerometer signal during the collision in almost all tests.

INTRODUCTION

In August 2006, National Highway Traffic Safety Administration (NHTSA) in the USA published a final rule on Event Data Recorders (EDRs) which are devices installed in motor vehicles to record vehicle and occupant information for a brief period of time before, during and after a crash or a near-crash event [1]. In January 2008, NHTSA published a revised final rule on EDRs and responded to several petitions for reconsideration of the August 2006 rule [2]. In March 2008, the Japanese Ministry of Land, Infrastructure, Transport and Tourism (J-MLIT) decided on the technical requirements for the application of EDRs to light vehicles (3500 kg GVWR or less) [3]. This rule—the so called J-EDR technical requirement—is comparable to the US regulation (49 CFR Part 563). EDRs are now being installed as standard equipment by several automakers in the USA and in Japan.

The EDR is a promising device for accident reconstruction. It directly records such details as delta-V (ΔV), vehicle speed, engine speed, information on brake and accelerator pedals, and seat positions and seat-belt use in the case of drivers and front passengers. However, if EDRs are to be utilized for accident investigation, then it is first necessary to examine the reliability and accuracy of EDR readout data.

The characteristics of EDRs were evaluated in this study in order to assess the devices' ability to improve accident reconstruction through the supply of more reliable and accurate crash information.

ANALYSIS

The analysis was based on data obtained from J-NCAP full-lap frontal barrier (FLB) tests at 55 km/h and 40 percent overlap offset frontal deformable barrier (ODB) tests at 64 km/h from 2006–2007, with the corresponding EDR datasets in 14 separate crash tests involving 7 vehicle models. Pre-crash velocity recorded in each EDR (V_{EDR}) was compared with the data from an optical speedometer placed in front of the barrier (V_{OP}). The maximum delta-V and delta-V versus time history data recorded in EDRs were compared with the J-NCAP test data from three accelerometers—on the left-side sill (A-L), right-side sill (A-R), and centre floor (A-C)—and from a high-speed video

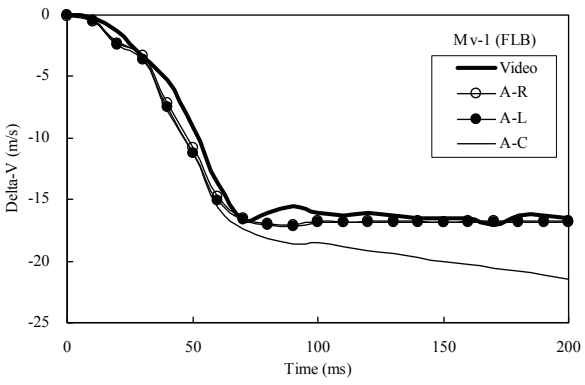

Figure 1. Delta-V time history curves obtained from Video and accelerometers

camera (Video).
Figure 1 is an example of a curve comparing delta-V time histories obtained from the accelerometers with that from Video. In several tests the delta-V time history curves obtained from the accelerometers differed markedly from the reliable Video results. Even a small error in the accelerometer signal can cause marked deviation in the velocity after integration of the acceleration.
Accordingly, after an intensive analysis of the J-NCAP crash test data, reliable J-NCAP data for use in the comparisons with the EDR data were chosen, as follows:

- For the maximum delta-Vs, the data obtained from the Video were chosen as reference values.
- For the delta-V time histories, the data obtained from the centre-floor accelerometer (A-C) and the Video were chosen.
- However, when the delta-V time history from the A-C differed markedly from the Video result, the average of the delta-V time history from the accelerometers at the left-side sill (A-L) and right-side sill (A-R) was used.

RESULTS AND DISCUSSIONS

Table 1 compares the results for pre-crash velocity. In all cases, the difference between the EDR pre-crash velocity (V_{EDR}) and the J-NCAP test speed (V_{OP}) was less than 4 percent (average: about 2 percent). The EDR pre-crash velocities were very accurate and reliable, but generally lower than the optically derived ones (V_{OP}).
Table 2 compares the results for post-crash maximum delta-V. The maximum delta-Vs recorded by the EDR (Max ΔV_{EDR}) showed uncertainty of measurement in several cases when compared with the Video results (Max ΔV_{Video}) or the reference values. The difference was more than 5 percent in 10 of 14 tests and more than 10 percent in 4 of 14 tests. The average difference in maximum delta-V was about 7 percent. The EDR maximum delta-V values were generally lower than the Video ones (Max ΔV_{Video}).
We examined the degree of deviation of the maximum delta-Vs recorded by the EDR or calculated by accelerometer signals (A-C, Ave. A-R and A-L) from the Video results in FLB tests and ODB tests, as shown in Figure 2. The deviation of the maximum delta-V calculated from the accelerometer signals was more than 10 percent in 4 tests. Accordingly, the accuracy and reliability of the EDR maximum delta-V seemed to be of the same order as those of the data obtained from the accelerometers in the crash tests. The accelerometers utilized in EDRs could have the same performance as the instrumented accelerometers used in crash tests. The maximum delta-Vs recorded by the EDRs were slightly lower than the Video results in the FLB and OBD tests (see Table 2, Fig. 2): that is, the EDRs underestimated the maximum delta-V in almost all tests.
We compared the delta-V time history curves obtained by EDR with those from accelerometers and Video in the FLB and ODB tests (Fig. 3). In the case of the passenger car-1 (PC-1), the delta-V time history from EDR was very comparable with those from the accelerometers and Video in both the FLB test and the ODB test. In other cases, there was an apparent difference between the EDR data and the results from the accelerometers and Video. However, when we focused on the initial short time window of the delta-V curve, the EDR data were very comparable with those from the accelerometers. This initial short time window was up to about 60 ms in the FLB test and about 100 ms in the ODB test. This result suggests that the acceleration calculated by the EDR data agrees well with the accelerometer signal in these short time windows.
Figure 4 compares the calculated EDR acceleration and the accelerometer signal. The calculated EDR acceleration agreed well with the accelerometer signal for the entire period of 200 ms. Even in the worst cases (PC-3(FLB) , Mv-1(FLB), Mv-2(FLB) and Mv-2(ODB)), in which the EDR maximum delta-V (Max ΔV_{EDR}) differed by more than 10 percent from the Video results (Max ΔV_{EDR}), the calculated EDR acceleration plots were almost comparable with the accelerometer signals (Fig. 4).
A previous study [4] of EDRs reached conclusions similar to ours. For pre-crash velocity the difference was less than 1 mph in all cases (average difference: 1.1 percent). The average difference in maximum delta-V was about 6 percent, and in nearly all cases the maximum delta-V recorded by the EDRs was less than the reliable delta-V, for which instrumented accelerometers were used. These authors explained that EDR data loss caused this difference, since in their study the majority of the

EDRs did not record the entire event. In contrast, even though the EDRs used in our study could record the entire event up to 200 ms, the EDRs still underestimated the maximum delta-V in almost all tests.

Table 1 Comparison results of pre-crash velocity

Test	Model	V_{OP} m/s	V_{EDR} m/s	Difference m/s	Difference %
FLB	PC-1	15.3	15.0	-0.3	-2.0
	PC-2	15.3	15.6	0.3	2.0
	PC-3	15.3	15.0	-0.3	-2.0
	PC-4	15.3	15.0	-0.3	-2.0
	PC-5	15.3	15.0	-0.3	-2.0
	Mv-1	15.3	15.0	-0.3	-2.0
	Mv-2	15.3	14.9	-0.4	-2.6
ODB	PC-1	17.9	17.2	-0.7	-3.9
	PC-2	17.8	17.8	0.0	0.0
	PC-3	17.8	17.2	-0.6	-3.4
	PC-4	17.8	17.2	-0.6	-3.4
	PC-5	17.8	17.2	-0.6	-3.4
	Mv-1	17.9	17.8	-0.1	-0.6
	Mv-2	17.7	17.1	-0.6	-3.4
		Average		-0.3	-1.8

Table 2 Comparison results of post-crash maximum delta-V

Test	Model	Max ΔV_{Video} m/s	Max ΔV_{EDR} m/s	Difference* m/s	Difference* %	Max ΔV_{A-C} m/s	Difference* m/s	Difference* %	Max $\Delta V_{Ave.\ A-R\ and\ A-L}$ m/s	Difference* m/s	Difference* %
FLB	PC-1	17.2	16.5	-0.7	-4.1	17.0	-0.2	-1.2	17.7	0.5	2.8
	PC-2	16.9	15.3	-1.6	-9.5	17.1	0.2	1.2	17.8	0.9	5.1
	PC-3	17.1	14.9	-2.2	-12.9	16.4	-0.7	-4.3	18.1	1.0	5.5
	PC-4	17.3	16.2	-1.1	-6.4	17.9	0.6	3.4	18.5	1.2	6.5
	PC-5	17.0	16.7	-0.3	-1.8	18.8	1.8	9.6	17.6	0.6	3.4
	Mv-1	17.1	14.7	-2.4	-14.0	21.4	4.3	20.1	17.1	0.0	0.0
	Mv-2	17.0	15.2	-1.8	-10.6	18.1	1.1	6.1	17.5	0.5	2.9
ODB	PC-1	20.3	19.1	-1.2	-5.9	19.0	-1.3	-6.8	19.3	-1.0	-5.2
	PC-2	19.4	19.2	-0.2	-1.0	22.1	2.7	12.2	19.4	0.0	0.0
	PC-3	20.0	18.4	-1.6	-8.0	21.7	1.7	7.8	19.4	-0.6	-3.1
	PC-4	20.7	18.7	-2.0	-9.7	20.2	-0.5	-2.5	19.9	-0.8	-4.0
	PC-5	20.1	18.7	-1.4	-7.0	19.4	-0.7	-3.6	19.4	-0.7	-3.6
	Mv-1	18.4	18.5	0.1	0.5	22.4	4.0	17.9	20.8	2.4	11.5
	Mv-2	19.9	17.5	-2.4	-12.1	18.8	-1.1	-5.9	20.1	0.2	1.0
			Average	-1.3	-7.3	Average	0.9	3.9	Average	0.3	1.6

*: Reference value is Max ΔV_{Video}.

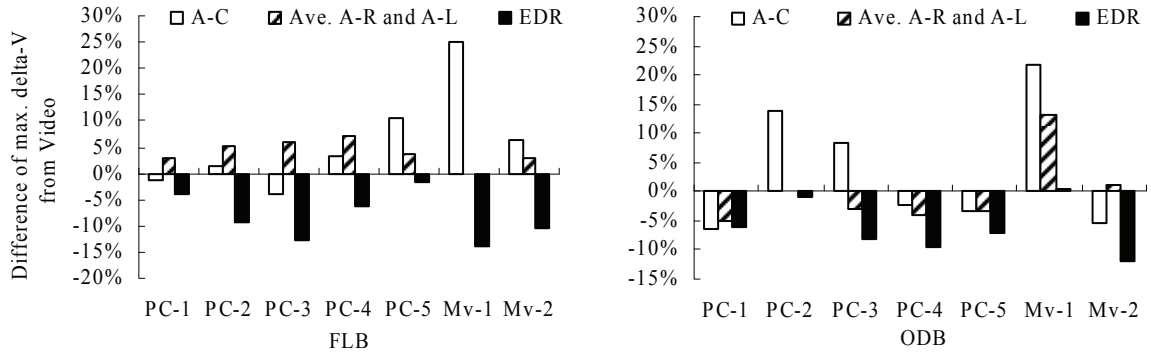

Figure 2. Deviation of the maximum delta-Vs recorded by the EDR or calculated by accelerometer signals (A-C, Ave. A-R and A-L) from the reliable Video results (Max ΔV_{Video}) in FLB and ODB tests.

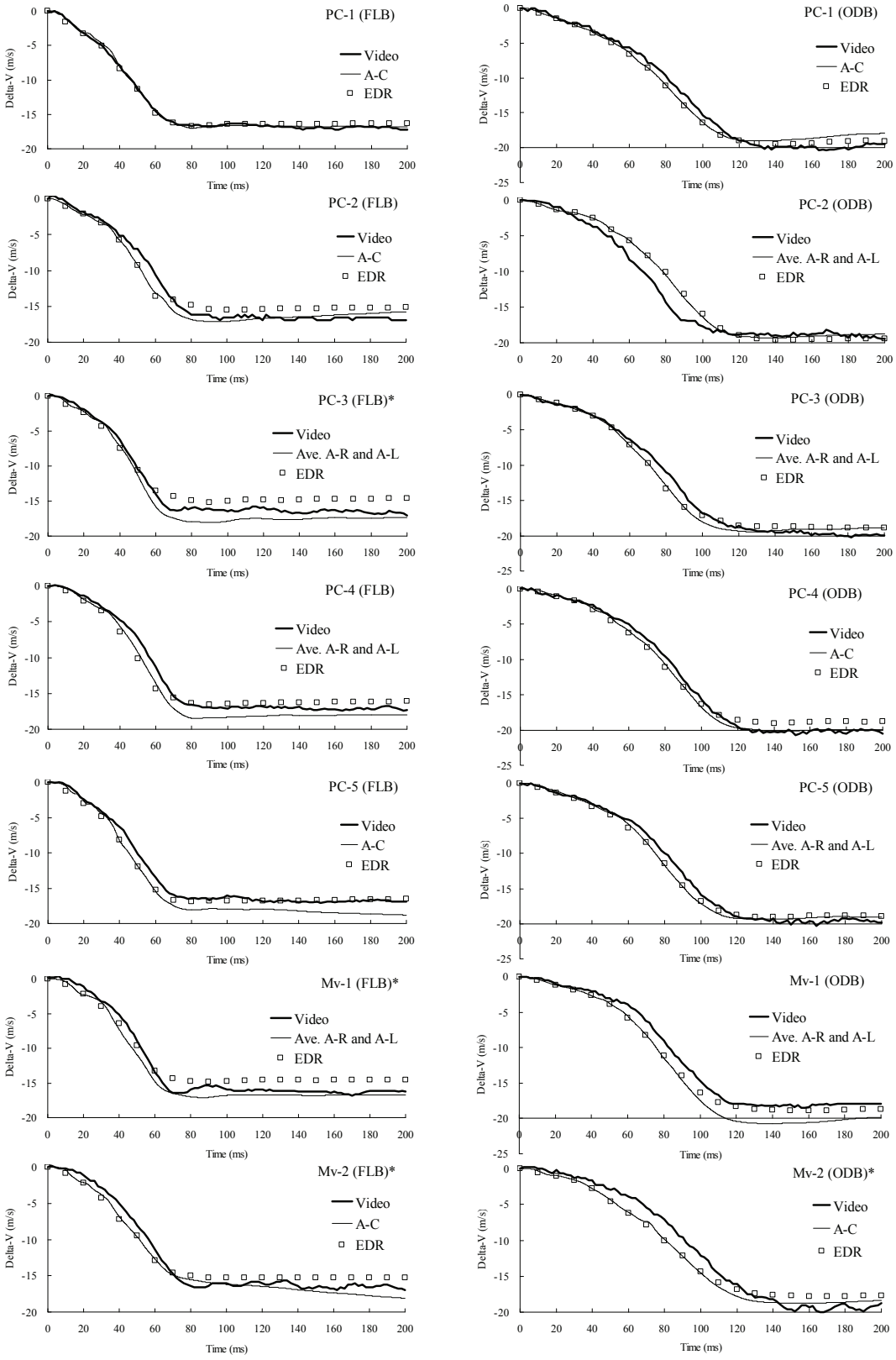

Figure 3. Comparison of delta-V time histories from EDR, Video and Accelerometer. (*: Max ΔV_{EDR} differed more than 10 percent compared with Max ΔV_{Video}.)

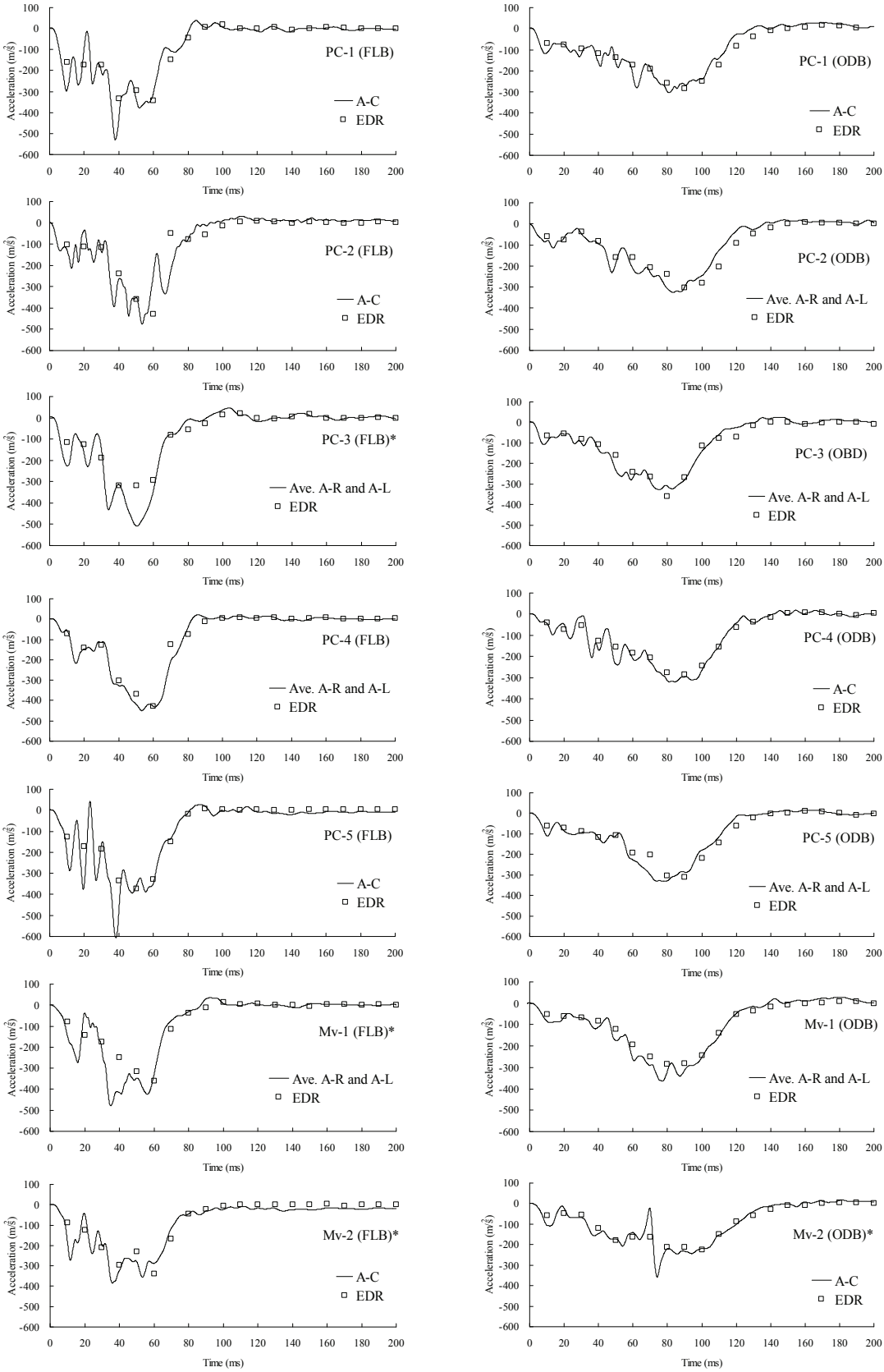

Figure 4. Comparison of acceleration time histories from EDR and Accelerometer.
(*: Max ΔV_{EDR} differed more than 10 percent compared with Max ΔV_{Video}.)

CONCLUSIONS

The pre-crash velocity, maximum delta-V and delta-V versus time history data recorded in EDRs were compared with those of the data obtained from the 2006–2007 J-NCAP crash tests in order to evaluate the performance and accuracy of EDRs. The EDR datasets of 14 separate crash tests involving 7 vehicle models were used in this study. Conclusions are summarized as follows:

- The EDR pre-crash velocities were very accurate and reliable. The difference between the EDR recording value and the laboratory test speed was less than 4 percent (average: about 2 percent).
- The maximum delta-V and delta-V versus time history data obtained from the EDRs showed uncertainty of measurement in several cases in comparisons with the reliable delta-V data. The difference in maximum delta-V was more than 5 percent in 10 of 14 tests and more than 10 percent in 4 of 14 tests (average: about 7 percent).
- The EDRs underestimated the maximum delta-V in almost all tests.
- The delta-V time history curves from EDRs were very comparable with those from the instrumented accelerometers when we focused on the initial short time window of the delta-V curves. This initial short time window was up to about 60 ms in the FLB test and about 100 ms in the ODB test.
- The calculated acceleration from the EDR delta-V versus time history data agreed well with the instrumented accelerometer signal for the entire period of 200 ms in almost all tests.

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