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16. Abstract

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PENDULUM TESTS ON TRANSFORMER BASES

FOR LUMINAIRE SUPPORTS

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Research Report Number 146-9

Studies of Field Adaptation of Impact Attenuation Systems
Research Study Number 2-8-68-146

Sponsored by
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TEXAS TRANSPORTATION INSTITUTE
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ABSTRACT

Energy absorbing characteristics of four cast aluminum transformer bases for luminaire supports were determined using a 2000 lb pendulum. Complete luminaire supports including the base, pole, mast arm, and simulated luminaire were tested. Velocity of the pendulum at impact was 20 mph. High-speed photography was used as the primary source of data acquisition. Change in momentum of the pendulum during impact was used to characterize the behavior of the bases. Details of the data analysis procedure and their influence on the results are discussed.

SUMMARY

Four full-scale luminaire supports with cast aluminum transformer bases were impact tested with a 2000 lb pendulum traveling at 20 mph. High-speed motion cameras were used to obtain displacement-time data for the pendulum and the base of the luminaire support. An accelerometer was mounted on the pendulum to measure deceleration. Velocity-displacement curves for the pendulum were constructed from the high-speed photography data and change in momentum values for the pendulum were obtained from these curves. Three of the four luminaire supports tested failed to meet the Federal Highway Administration tentative criteria of 400 lb-sec maximum change in momentum. Peak forces obtained from the accelerometer data were about 60,000 lbs or 30 g's deceleration of pendulum.

Key Words: Highway Safety, Luminaire Supports, Transformer base, Cast Aluminum, Pendulum tests, Momentum change.

IMPLEMENTATION STATEMENT

Tentative guidelines for allowable momentum changes of a 2000 lb impacting pendulum for test of luminaire supports are given in FHWA Notice dated November 16, 1970, entitled "Application of Highway Safety Measures -- Breakaway Luminaire Supports", (see Appendix page 52). A maximum change in momentum of 400 lb-sec is specified. Three of the four luminaire supports with cast aluminum transformer bases tested with the pendulum in this study exceeded the limit, but one of these was by a very narrow margin. Replication of the tests were not made and test variability is not known. Additional research in this area is needed to more precisely define the test method, data collection, and method of analysis, and to develop guidelines for reporting the test results.

DISCLAIMER

INTRODUCTION

Cast aluminum transformer bases for luminaire supports have been shown to perform satisfactorily in vehicle crash tests (1). A large number of these transformer bases have been installed on the highways and in several instances these have not performed satisfactorily when struck by a vehicle traveling at medium to low speeds.

Existing State specifications place requirements on the hole pattern at the top and bottom of the base, height dimensions, and the type of material to be used. They do not specify the wall thickness of the base nor other details of other geometry. A wide variety of transformer bases that meet existing specifications are being produced and installed. This creates the possibility of different energy absorption characteristics for different transformer bases.

For these reasons, it was decided to conduct pendulum tests on some of these bases. Two bases that had been removed from field installations and two bases from a THD warehouse were tested. An interim test procedure for pendulum tests of full-sized supports is contained in FHWA Notice, TO-20. This procedure requires the use of a 2000 lb pendulum with an impact velocity of 20 mph. Luminaire supports producing pendulum change in momentum values of 400 lb-sec or less are considered satisfactory. No details as to the type of instrumentation that should be employed or the procedure for calculating the change in momentum are given in the tentative procedure. One of the major questions that arises concerns the point where the final velocity is to be determined. Significantly different change in momentum values are obtained depending upon which point is selected.

The fact that these and other details have not been clearly defined prompted a study of the velocity change phenomena and an investigation of methods for analyzing results of pendulum tests.

TESTING PROGRAM

Four cast aluminum transformer bases for luminaire supports were tested with a free swinging pendulum as the impacting mass to determine their energy absorption characteristics. The total weight of the pendulum was 2000 lb. It was fitted with a 4 in. diameter bumper and the point of impact was 19 in. above the bottom of the base. The radius of curvature of the path of the pendulum was 37.75 ft. Figure 1 is a photograph of the entire pendulum test facility with luminaire support just prior to testing.

Each base was mounted to a steel adapter plate beneath the superstructure as shown in Figure 2. All bases were oriented in the direction shown in this Figure. The center of the base was located at the bottom of the pendulum arc. A 35 ft pole was used for tests I-20, I-35, and S-40. This pole including mast arm and simulated lamp weighed 498 lb. For the fourth test with base S-50, a 45 ft pole was used. This pole including mast arm and simulated lamp weighed 709 lb. Detailed drawings of these bases are found in Figures 3, 5, 7, and 9. Photographs of these bases before and after impact are found in Figures 4, 6, 8, and 10.

The pendulum was released from a height of 14 ft above the bottom of its arc. This height gives a pendulum impact velocity of 20.5 mph. High speed motion picture cameras operating at approximately 400 frames per second were used to obtain time-placement data. One camera was focused on the lower portion of the support, the other recorded the entire scene. A tape switch was placed on the front of the transformer base to record the exact time of impact. The acceleration of the pendulum in the longitudinal direction was measured with a strain-gage type accelerometer mounted on the rear of the pendulum and was recorded with a Honeywell visicorder.

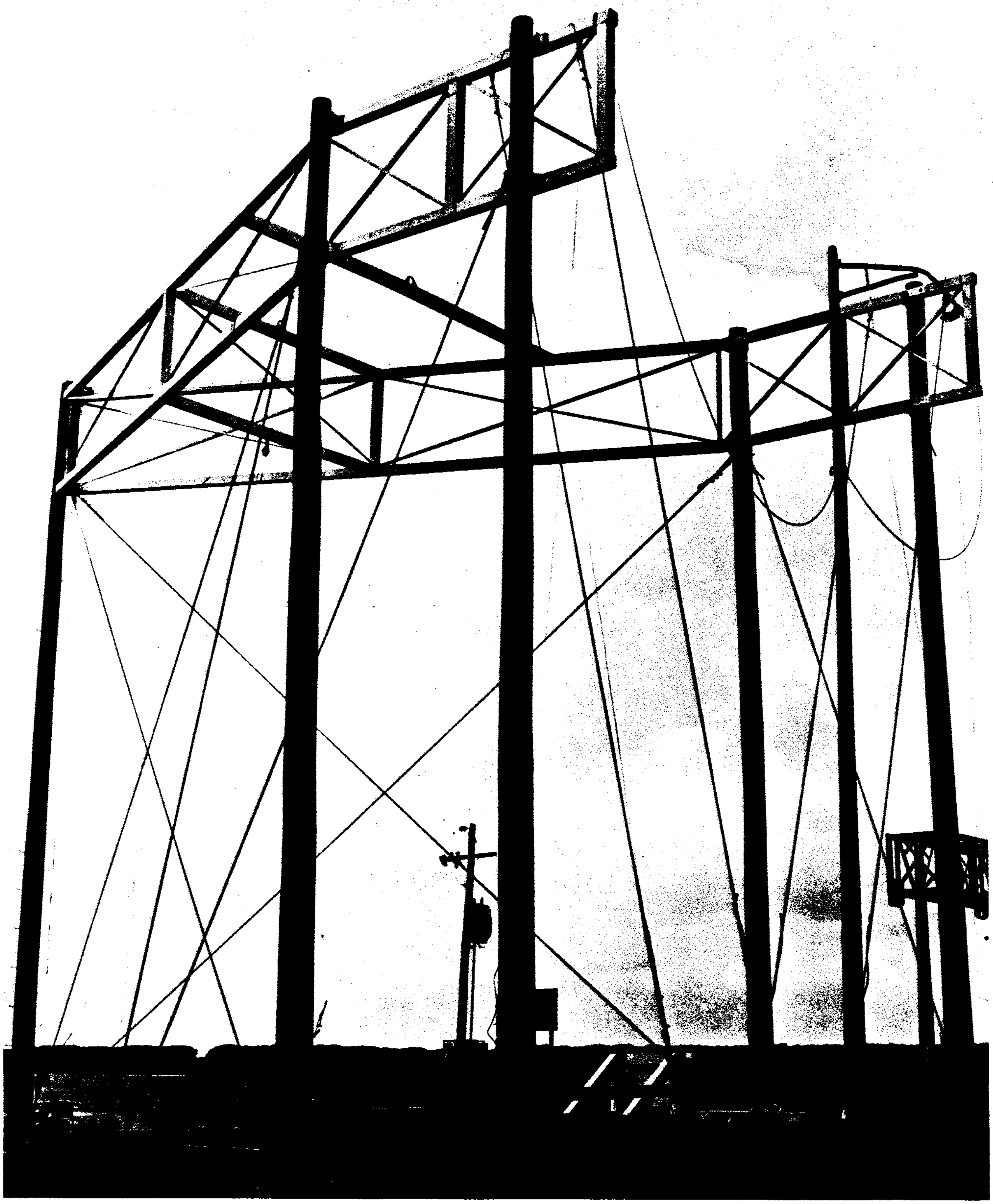


Figure 1. Pendulum Test facility with luminaire support mounted for impact testing.

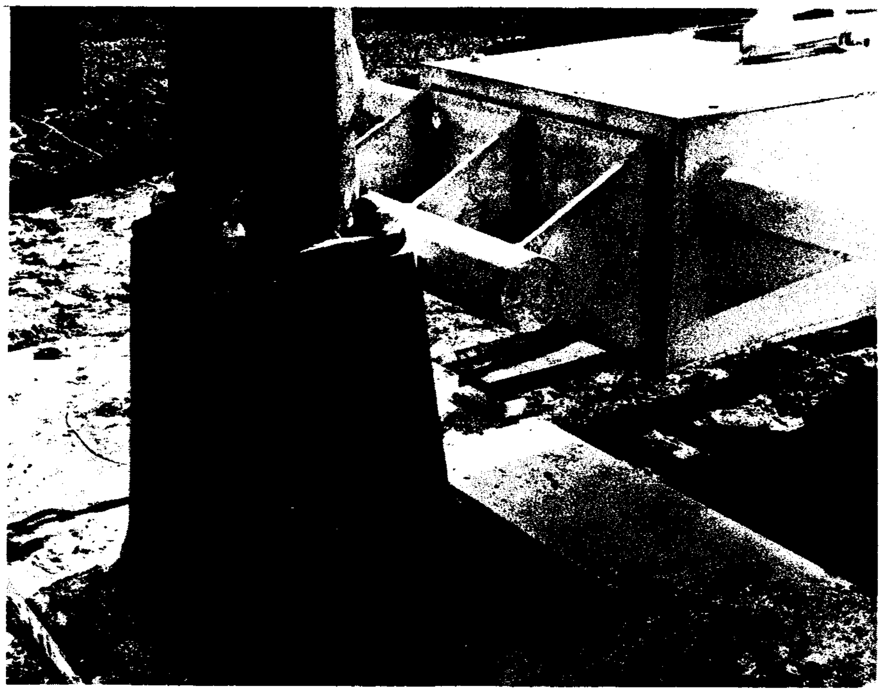


Figure 2. Close-up view of transformer base showing bumper and adapter plate.

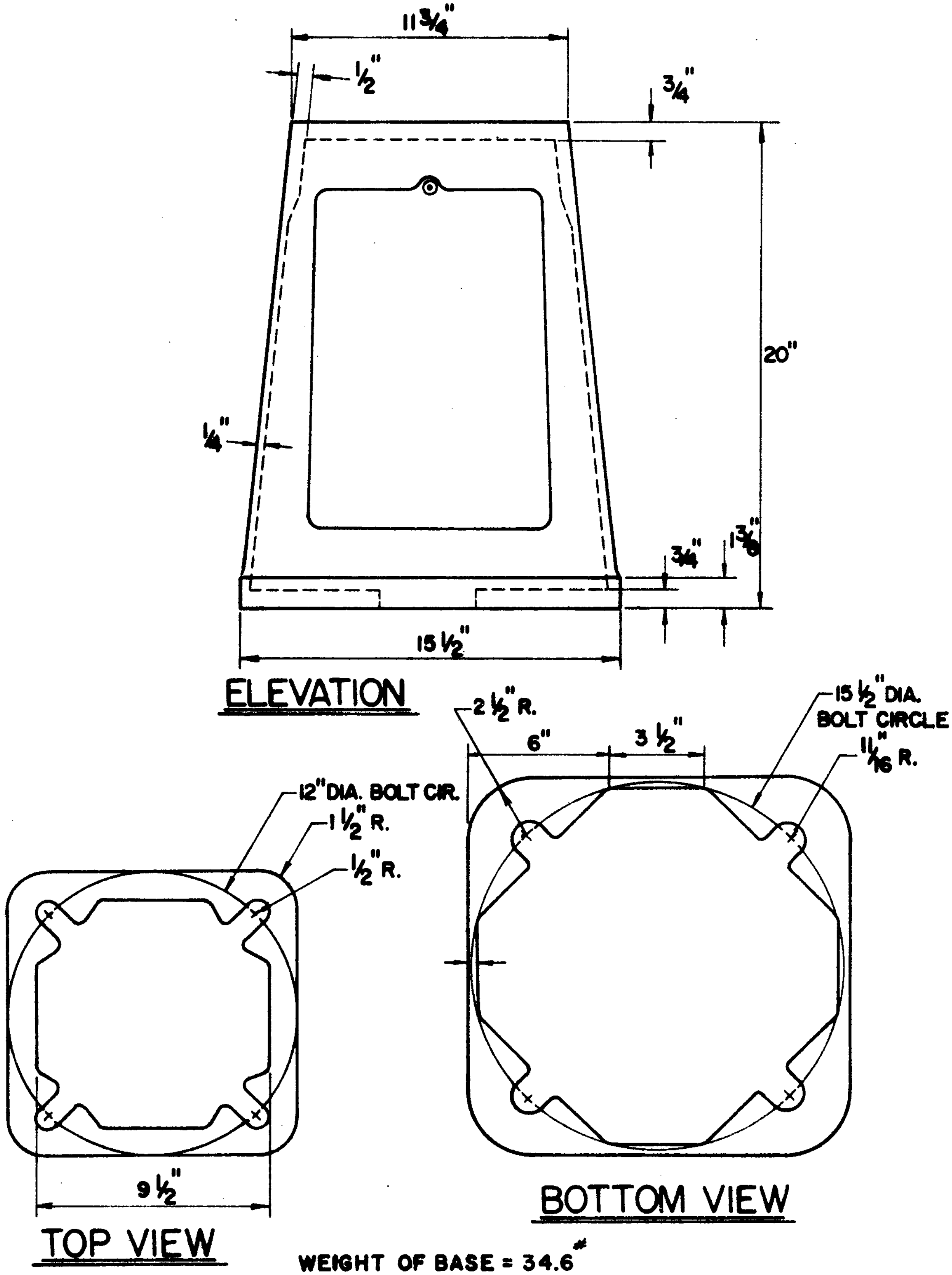


Figure 3. Details of base I-20.

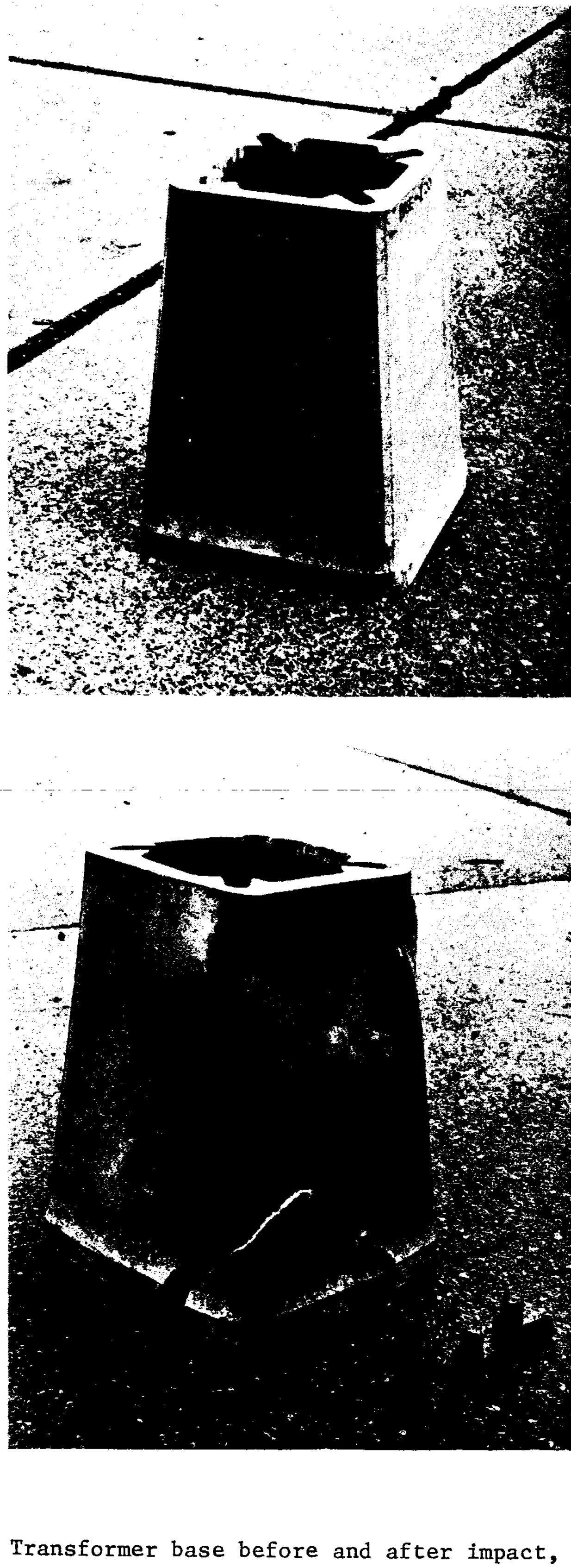


Figure 4. Transformer base before and after impact, Test I-20.

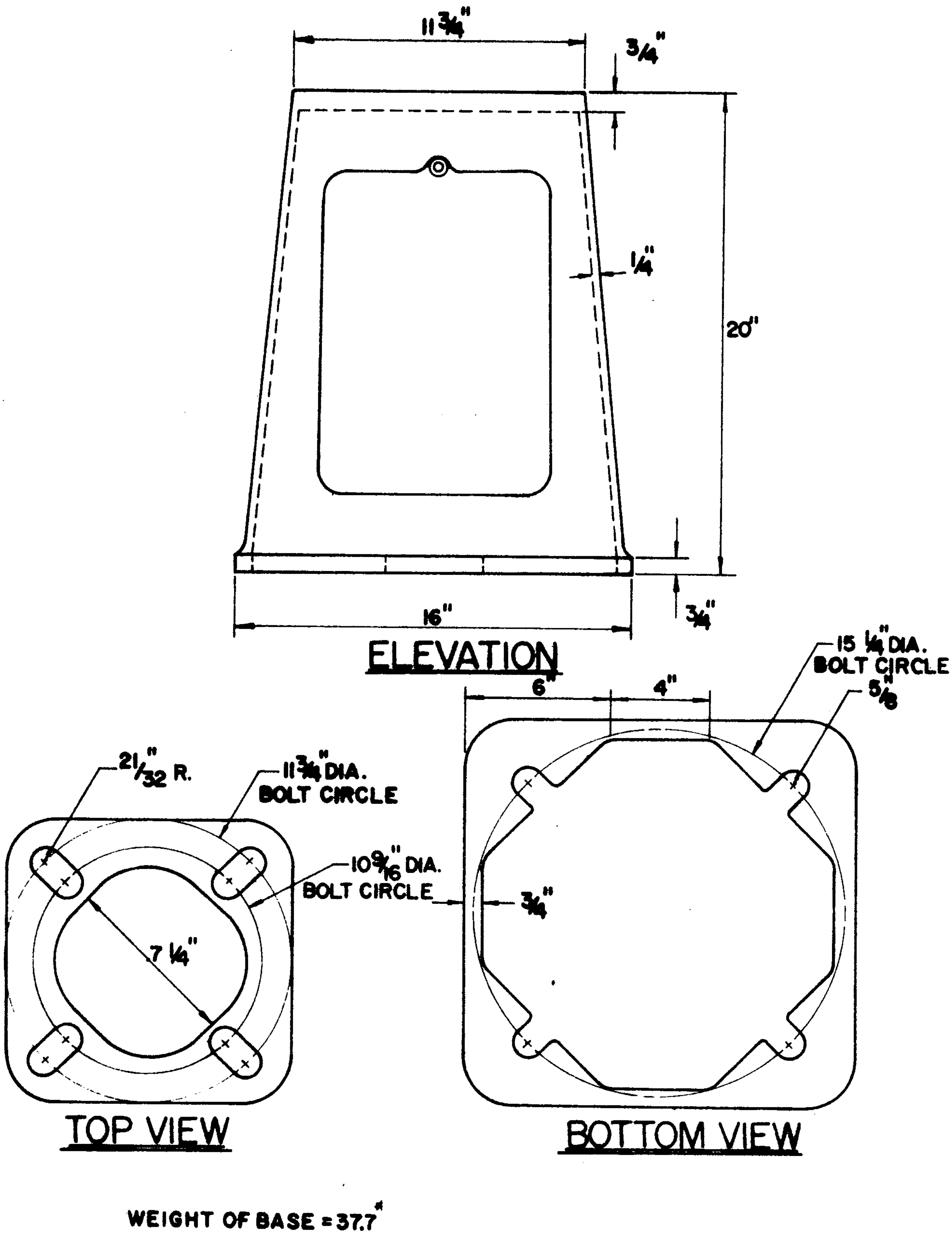


Figure 5. Details of base I-35.

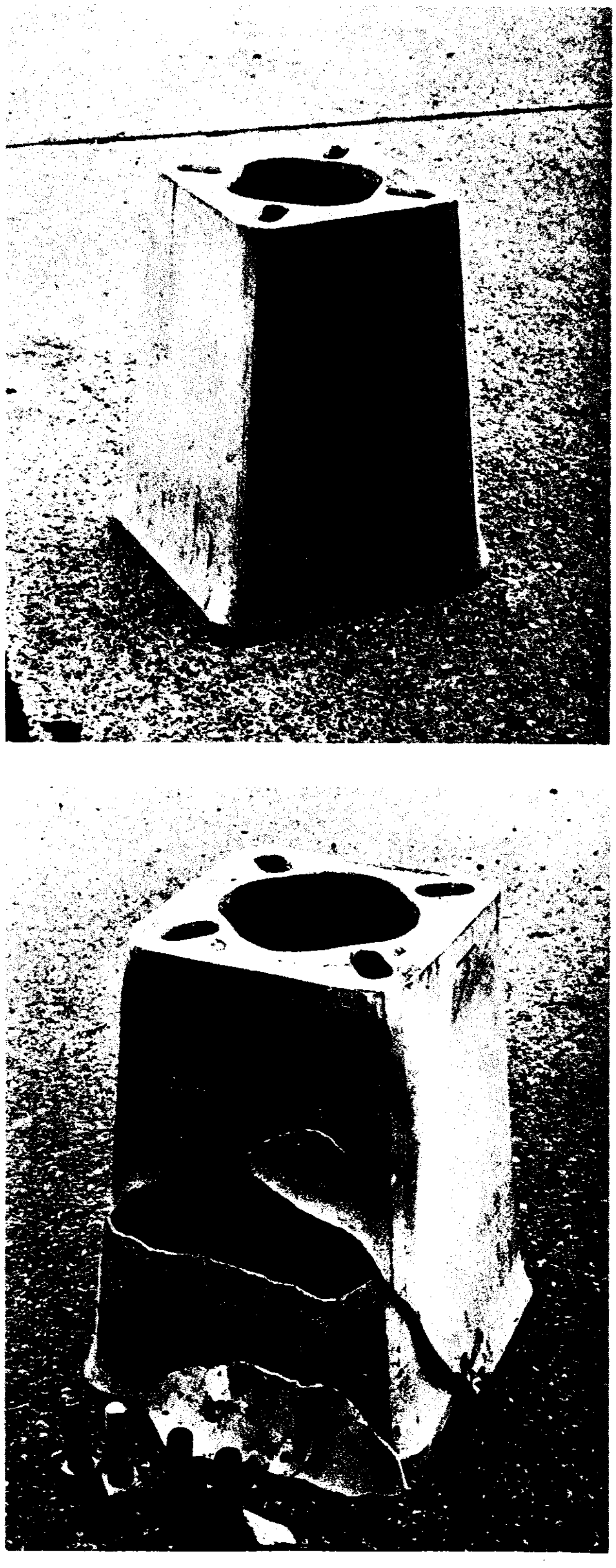


Figure 6. Transformer base before and after impact, Test I-35.

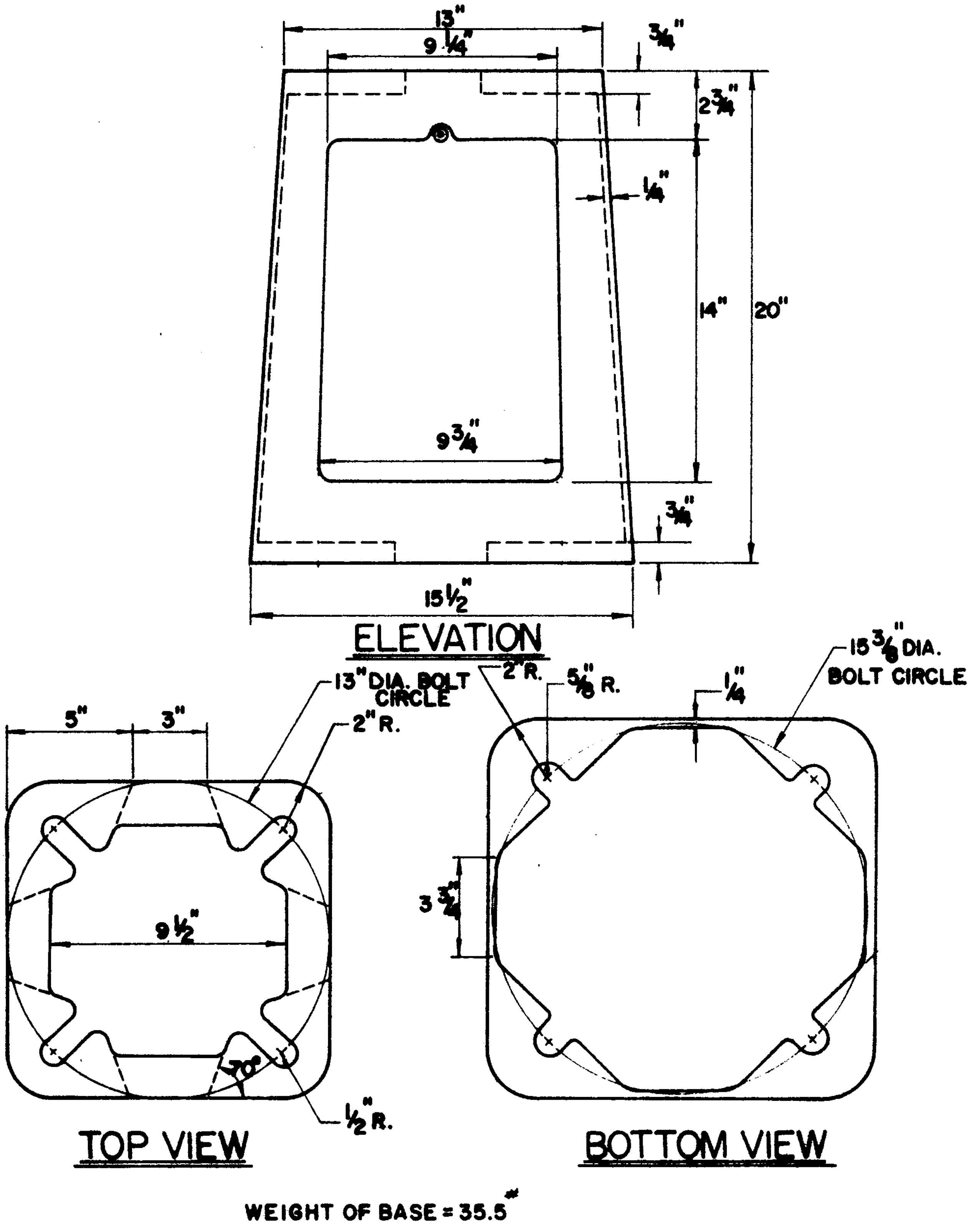


Figure 7. Details of base S-40.

Figure 8. Transformer base before and after impact, Test S-40.

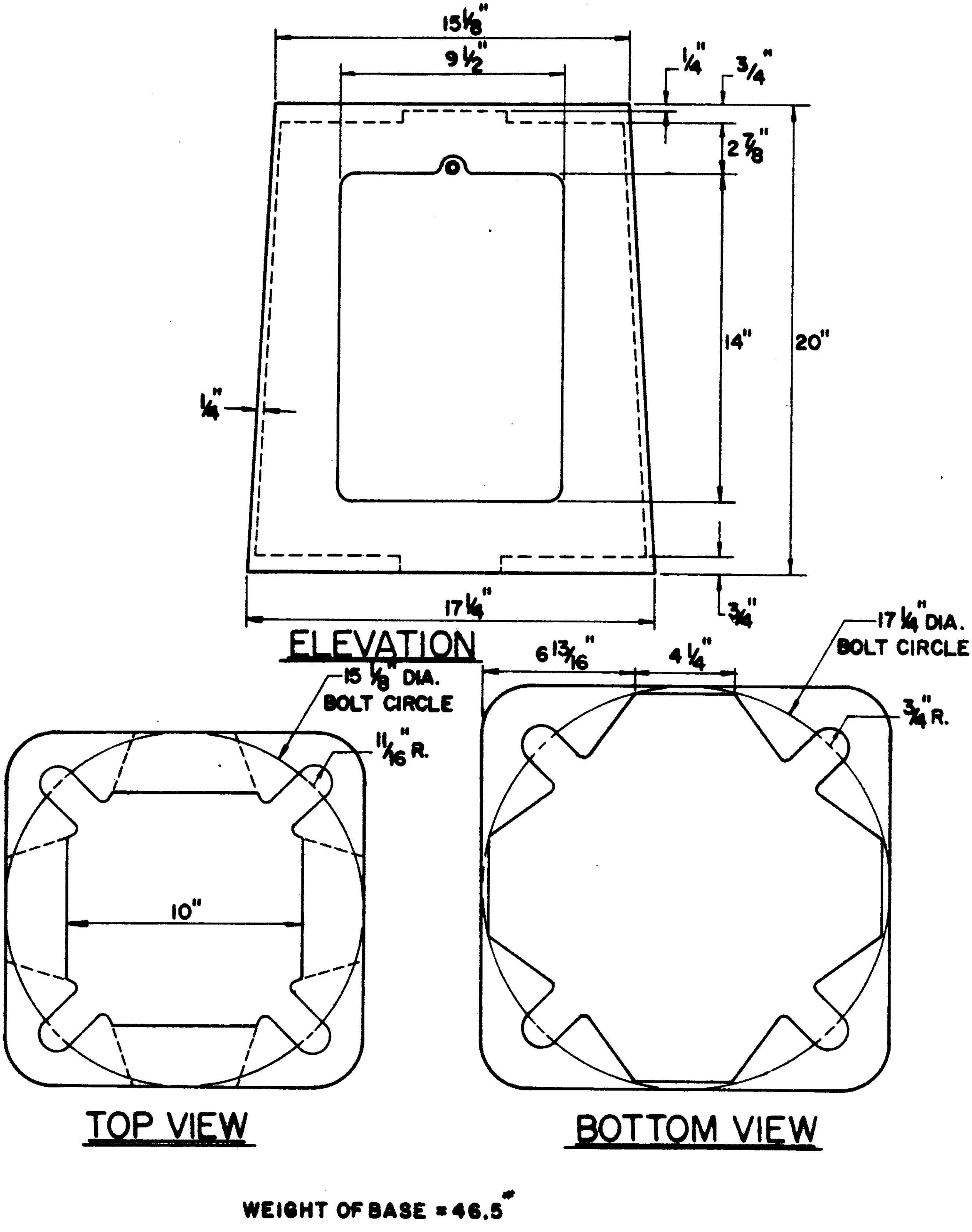


Figure 9. Details of base S-50.

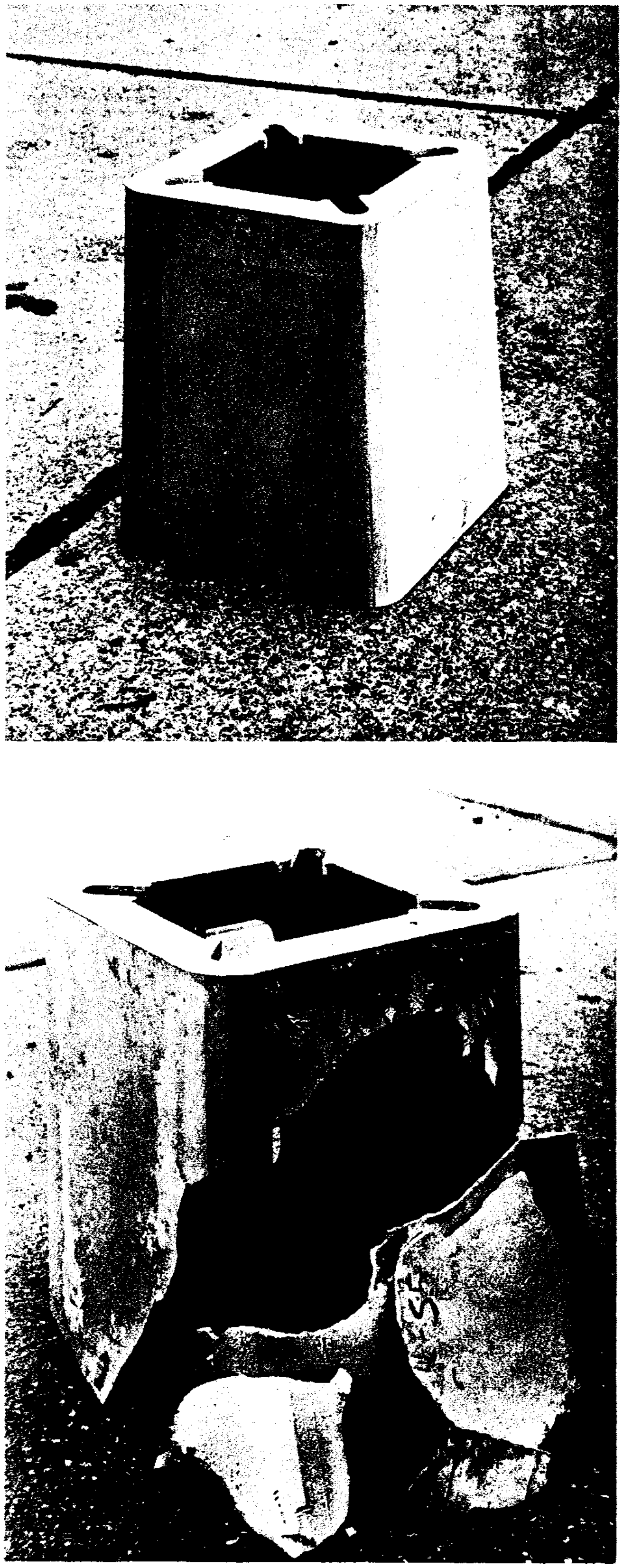


Figure 10. Transformer base before and after impact, Test S-50.

ANALYSIS OF RESULTS AND DISCUSSION

The methods employed to measure the energy absorbing characteristics and the forces developed in a pendulum test and the manner in which the data are analyzed have a strong influence on the results obtained. The change in momentum of the pendulum during impact can vary by as much as 50 to 100 percent, depending on the point where the final velocity of the pendulum is determined. Standards that accurately reflect behavior during impacts by vehicles on the roadway have not been established. For this reason, velocity-displacement curves for both the pendulum and the base of the luminaire support are developed and analyzed over the full range of events from the point of impact to the point where the luminaire support loses contact with the pendulum.

Displacement-time data for the pendulum and the base and accelerometer traces for the pendulum are given in the Appendix. Displacement-time data points were obtained from analysis of the high-speed motion film. Smooth curves were then drawn through the data points as shown in Figures 11 through 14. Velocity vs. displacement curves for both the pendulum and the base of the luminaire support were obtained by plotting the measured slope of the displacement-time curves. These curves are given in Figures 15 through 18. It is observed that even though the pendulum velocity changes in a somewhat erratic manner during fracture of the base, a point is reached where the pendulum velocity curve becomes essentially parallel to that of a free-swinging pendulum but at a reduced velocity. The initial velocity of the pendulum was determined from the displacement-time data for an interval of 3 to 4 feet immediately prior to impact. This gives an average velocity for that interval instead of the instantaneous velocity at impact, but the error involved is 0.1 fps or less.

For change in momentum determinations, the change in velocity of the pendulum was read directly from the velocity-displacement curves in Figures 15 thru 18 and are tabulated in Table 1. The displacement at which the change in momentum was determined was selected as the point where the pendulum velocity curve had become essentially parallel to the free-swinging velocity curve and was not necessarily the same displacement in all tests. The corresponding change in momentum values are given in Table 1. Peak forces, obtained from the accelerometer traces, are also tabulated there.

Three of the four luminaire supports tested did not satisfy the tentative guideline of 400 lb-sec change in momentum, although one exceeded the limit by only a narrow margin. No test replications were performed, and the expected variability of results for this type of testing has not been established. Furthermore, the 400 lb-sec limitation is based on a limited amount of information relating pendulum test results to full-scale vehicle test results and significant data scatter exists in this relationship.

The peak decelerations indicated by the accelerometers were about 30 g's (see Table 1), which is (30 g's x 2000 lbs) 60,000 peak force. Extension of these data to a full-scale vehicle impacting a luminaire support will point out the importance of consideration of peak forces.

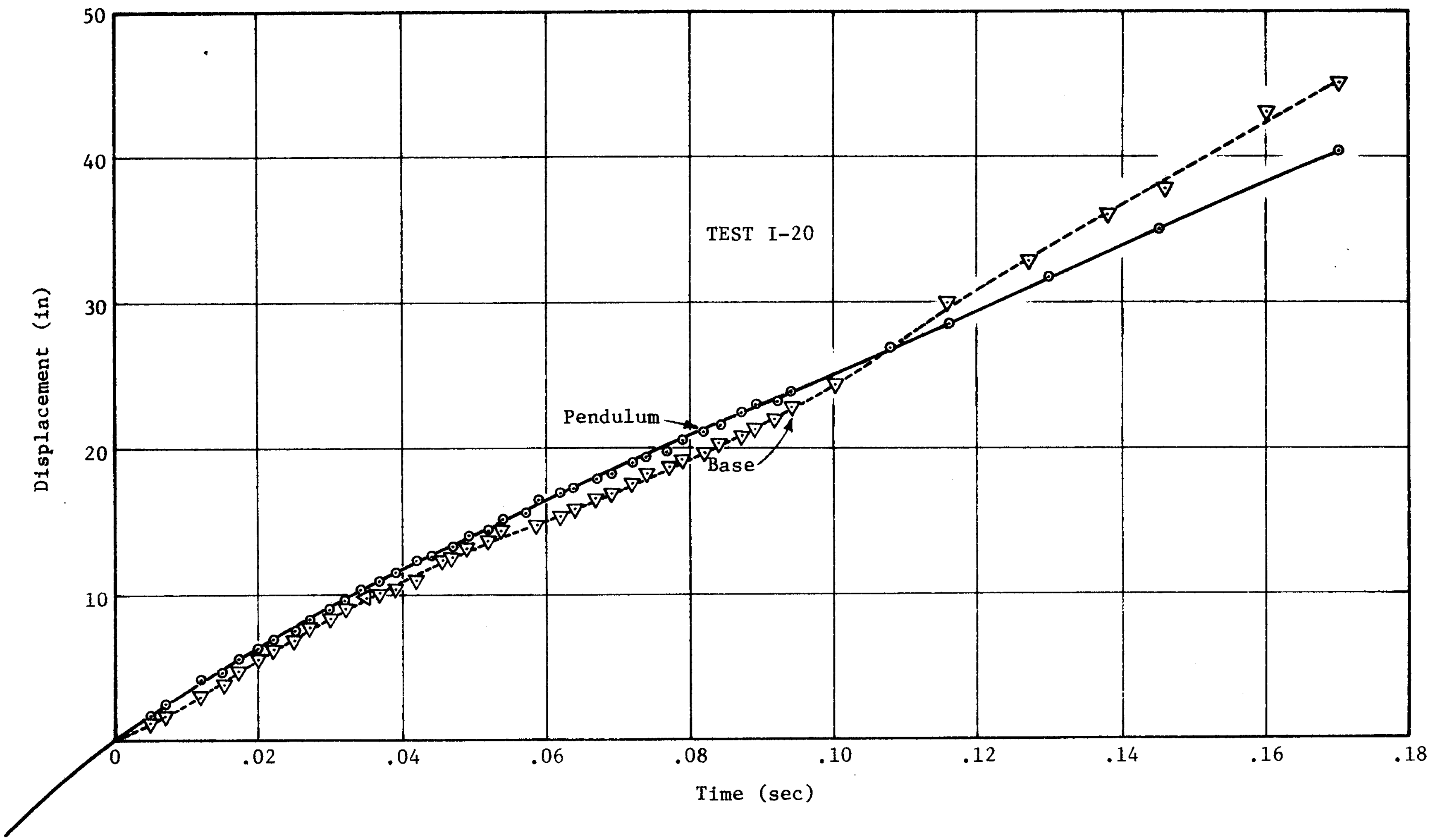


Figure 11 . Displacement-time curves for test I-20.

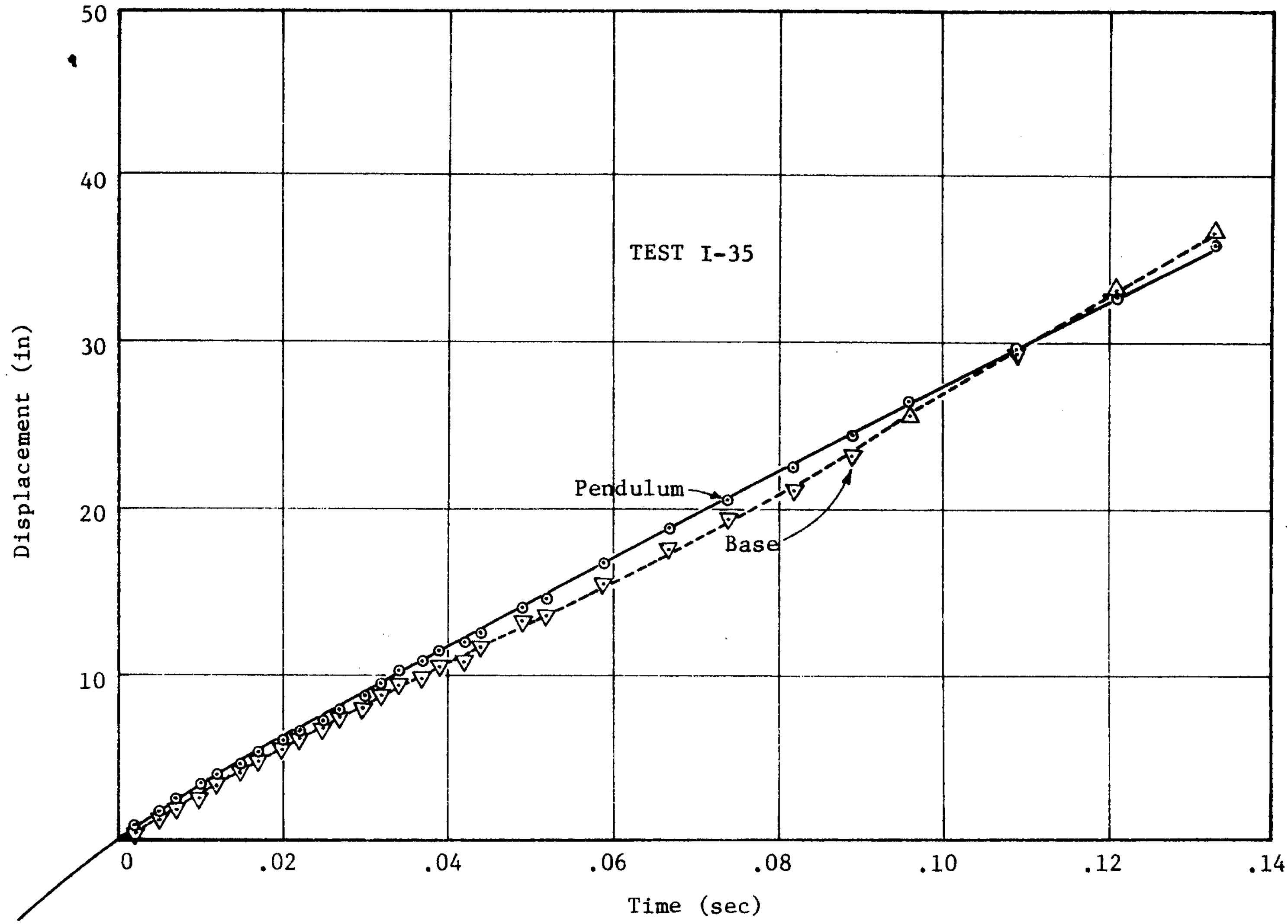


Figure 12 . Displacement-time curves for test I-35.

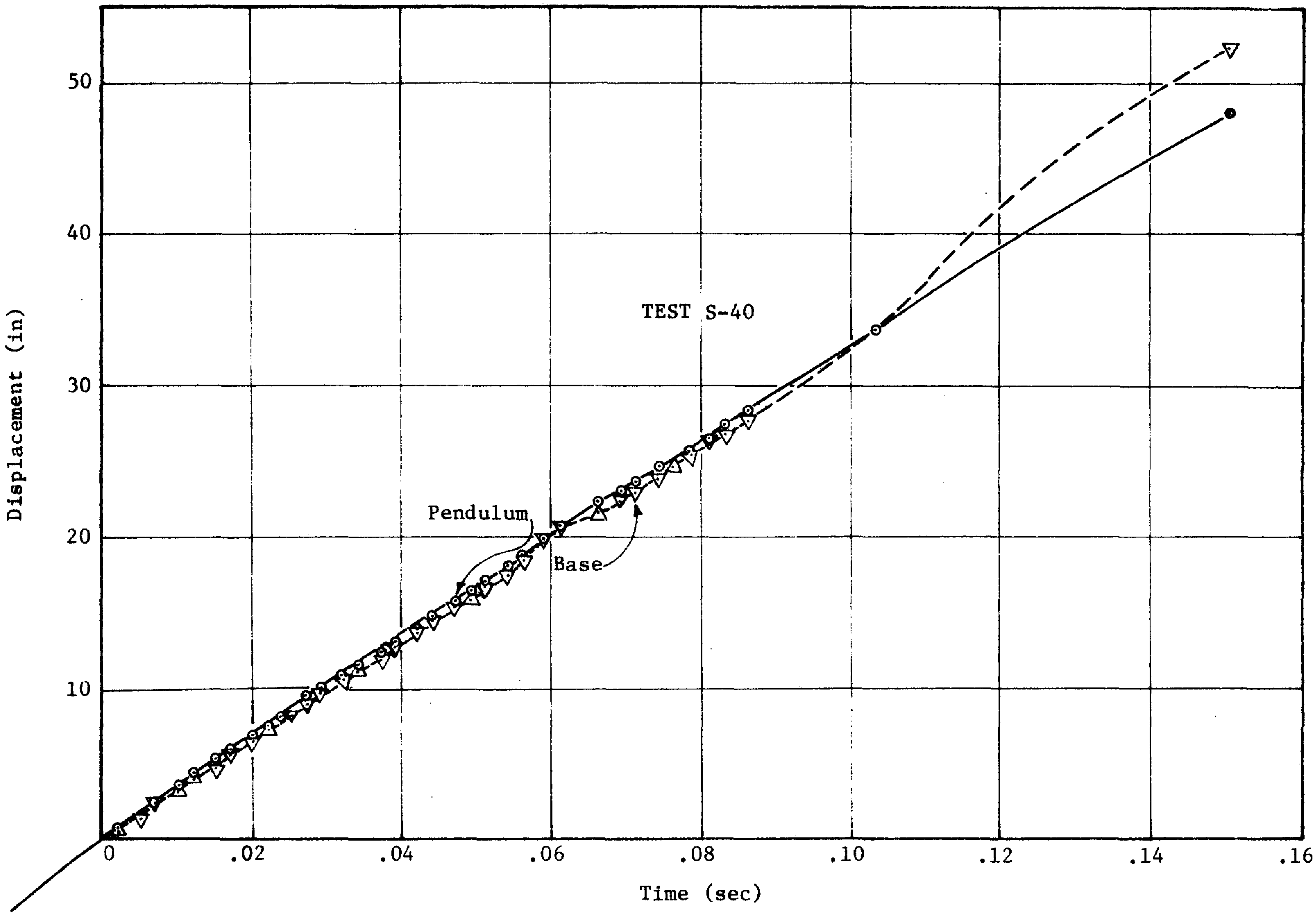


Figure 13. Displacement-time curves for test S-40.

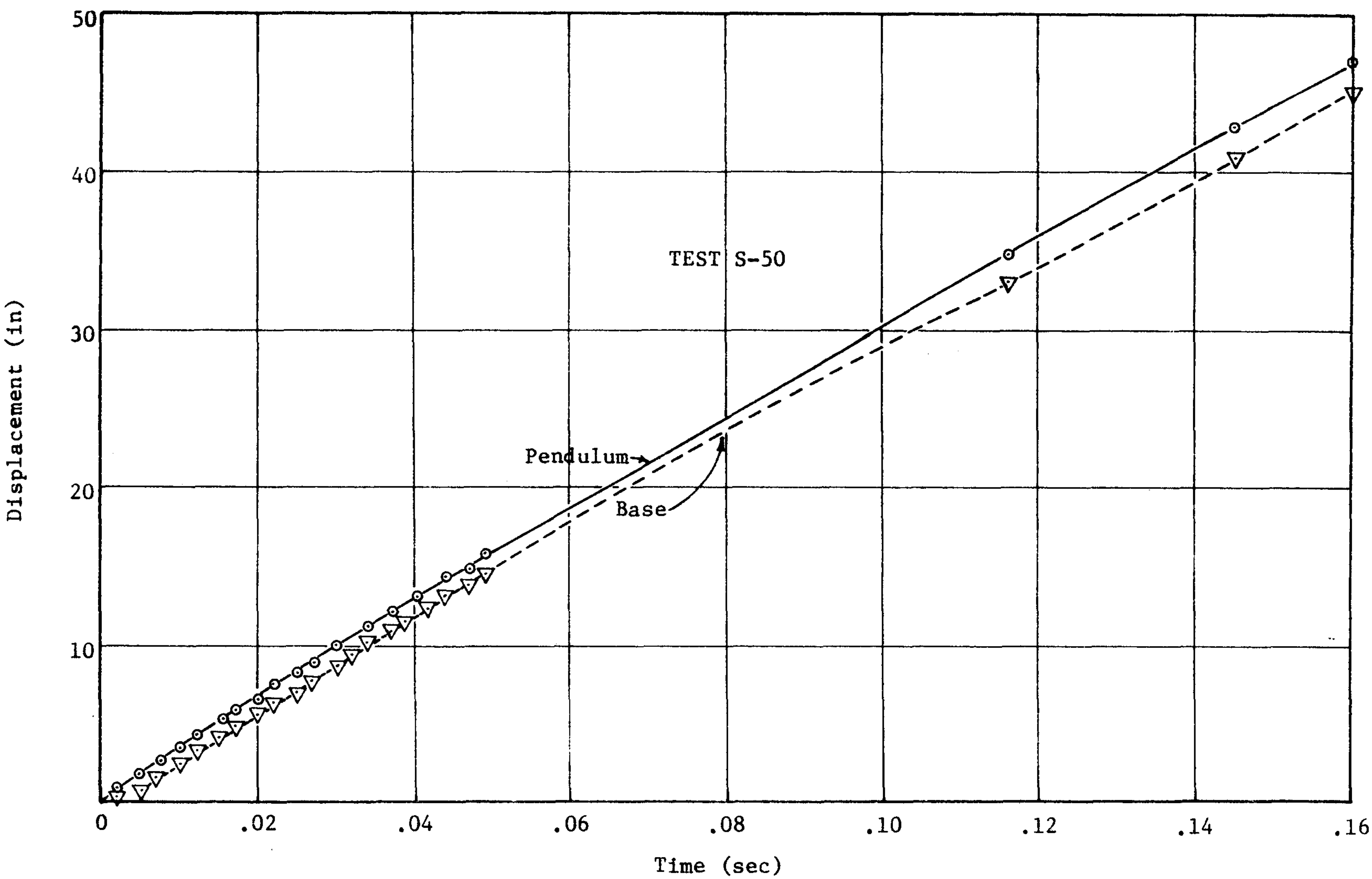


Figure 14. Displacement-time curves for test S-50.

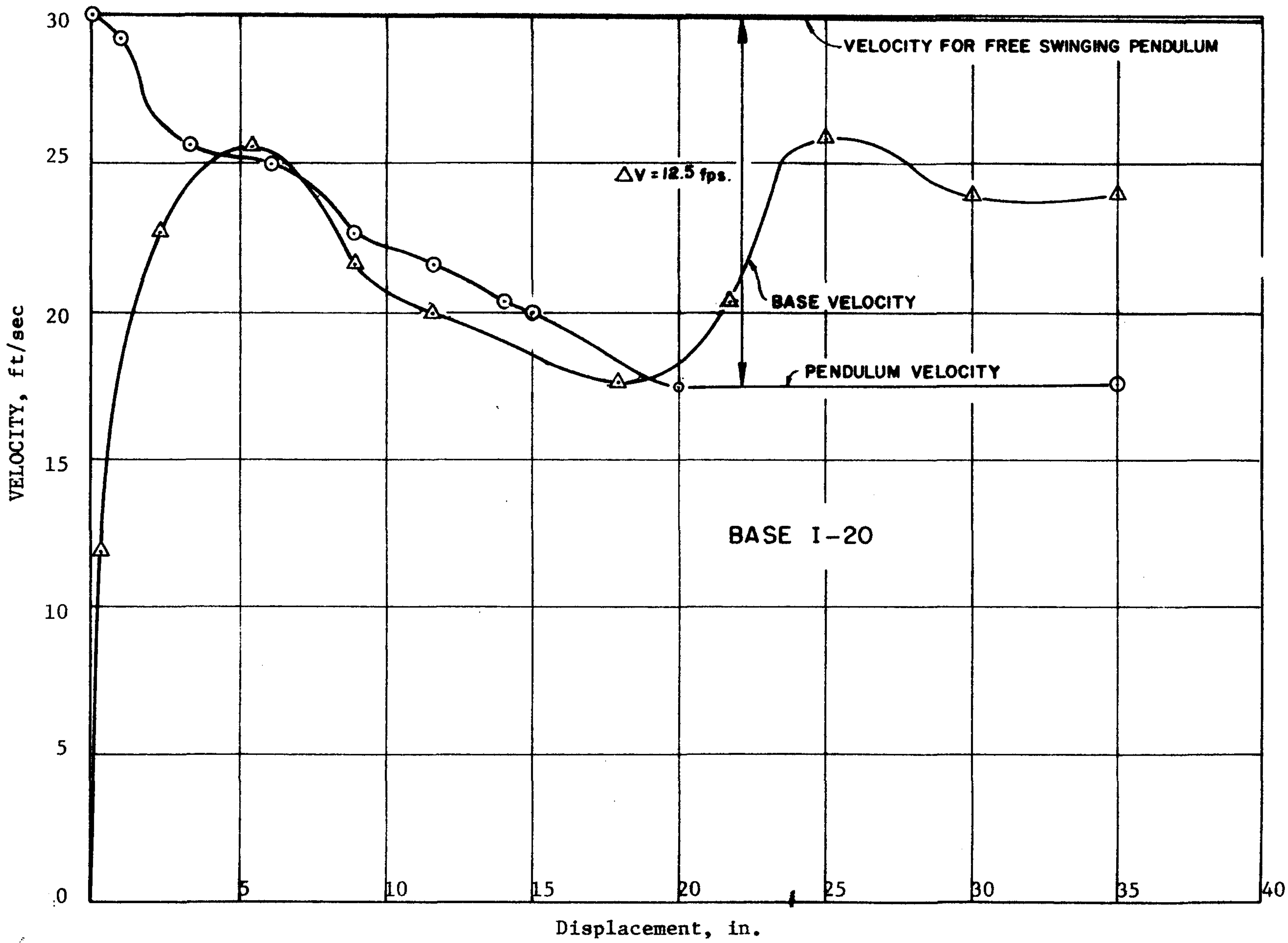


Figure 15. Velocity-displacement curves for test I-20.

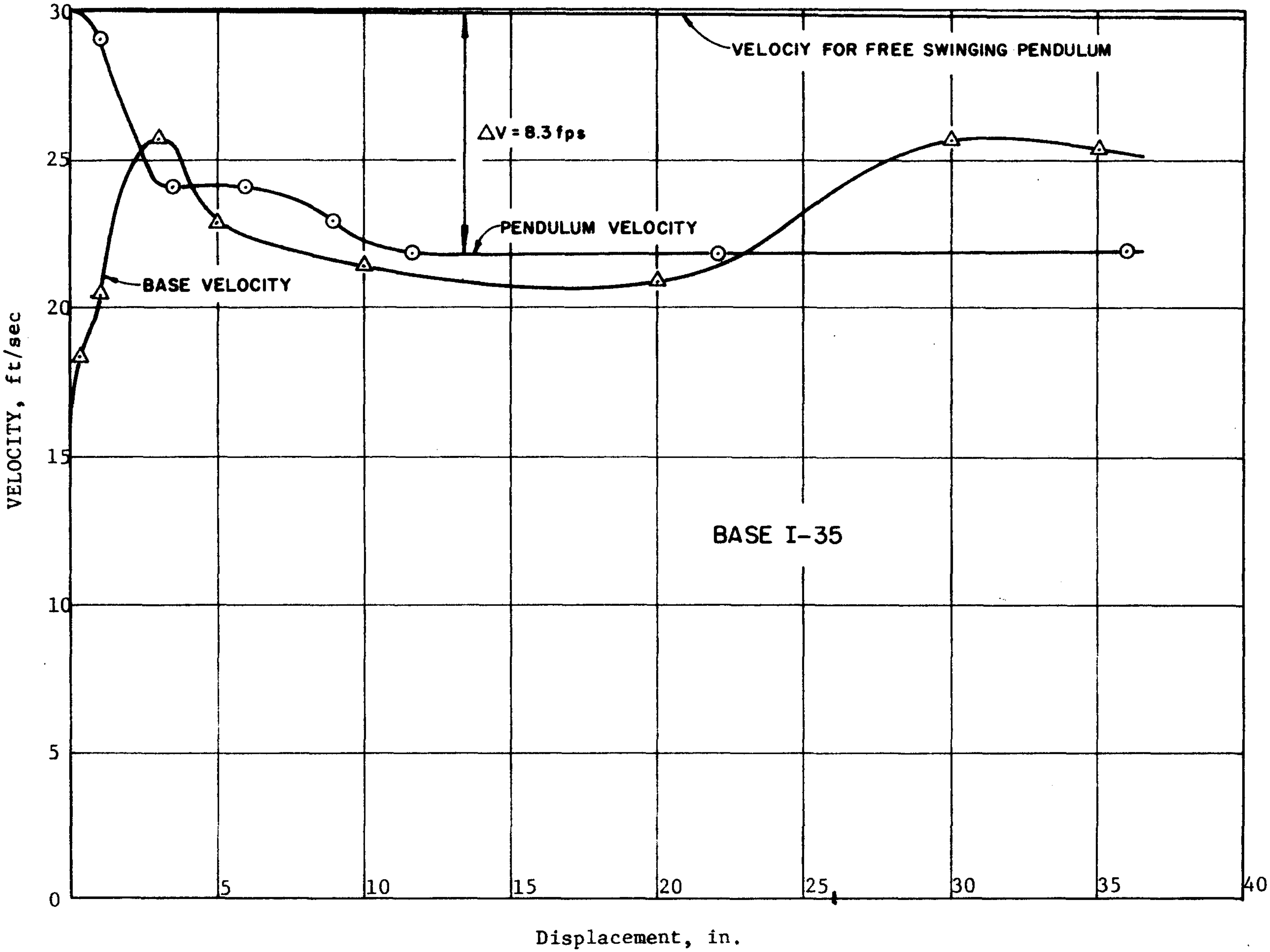


Figure 16. Velocity-displacement curves for test I-35.

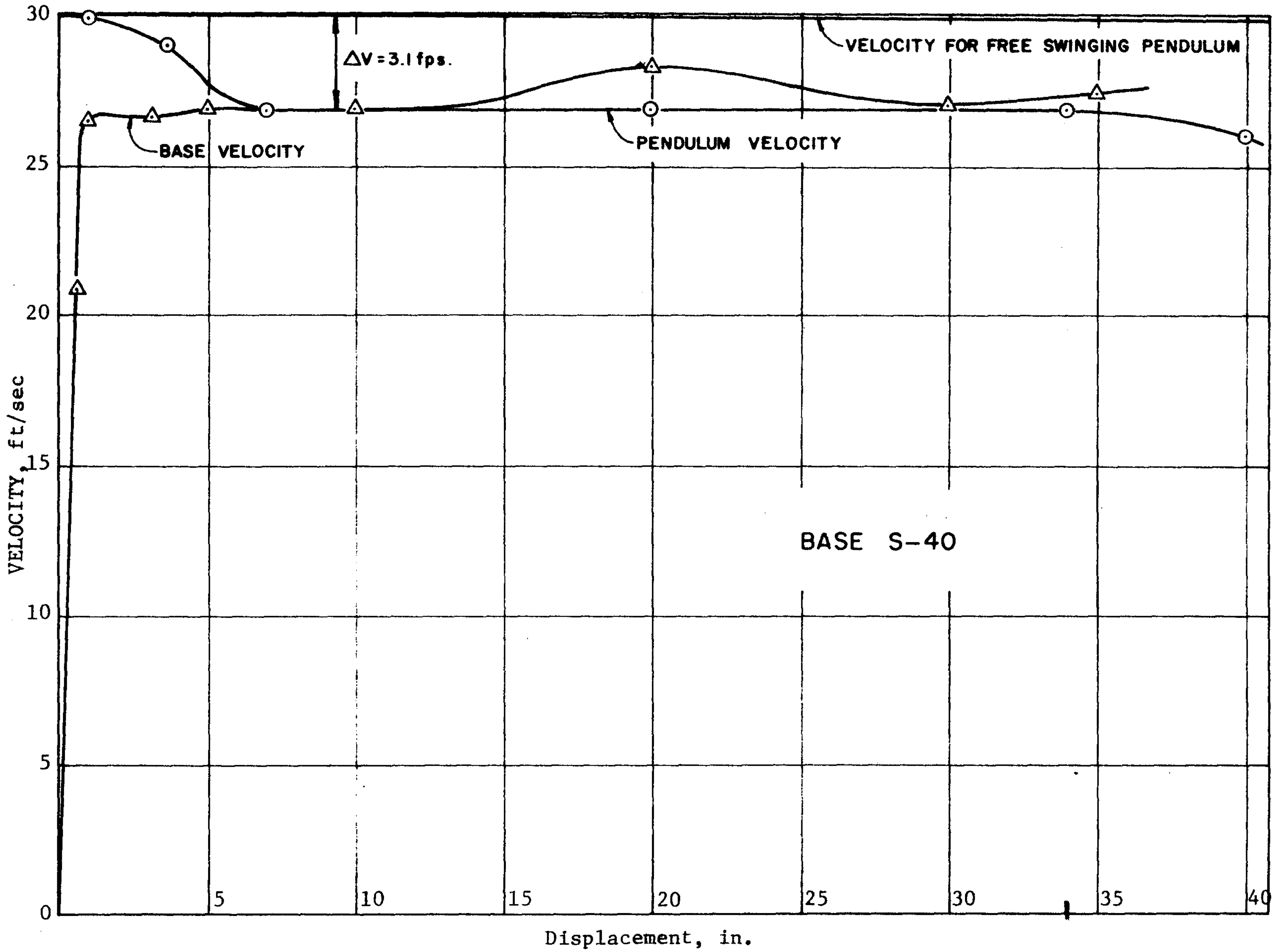


Figure 17 . Velocity-displacement curves for test S-40.

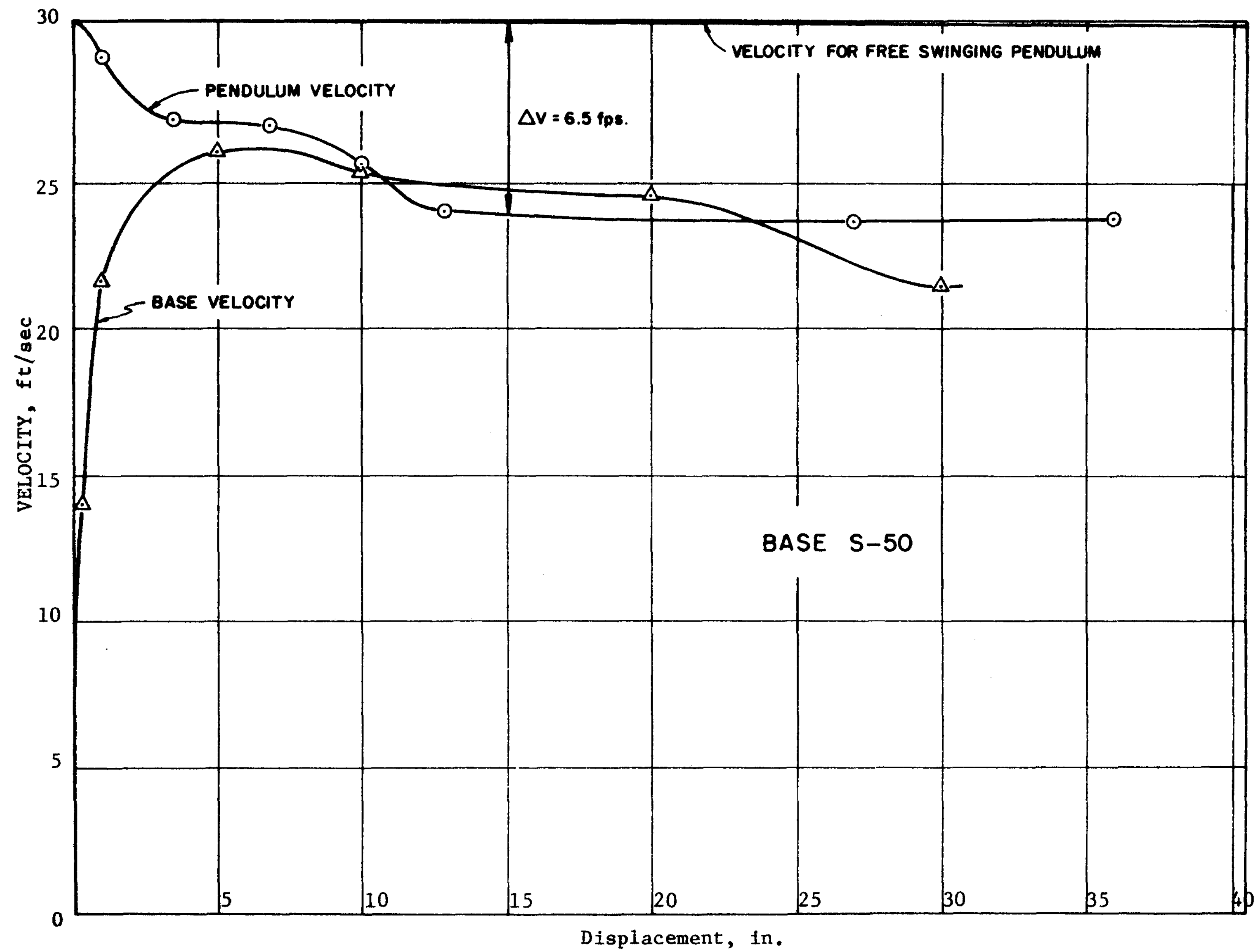
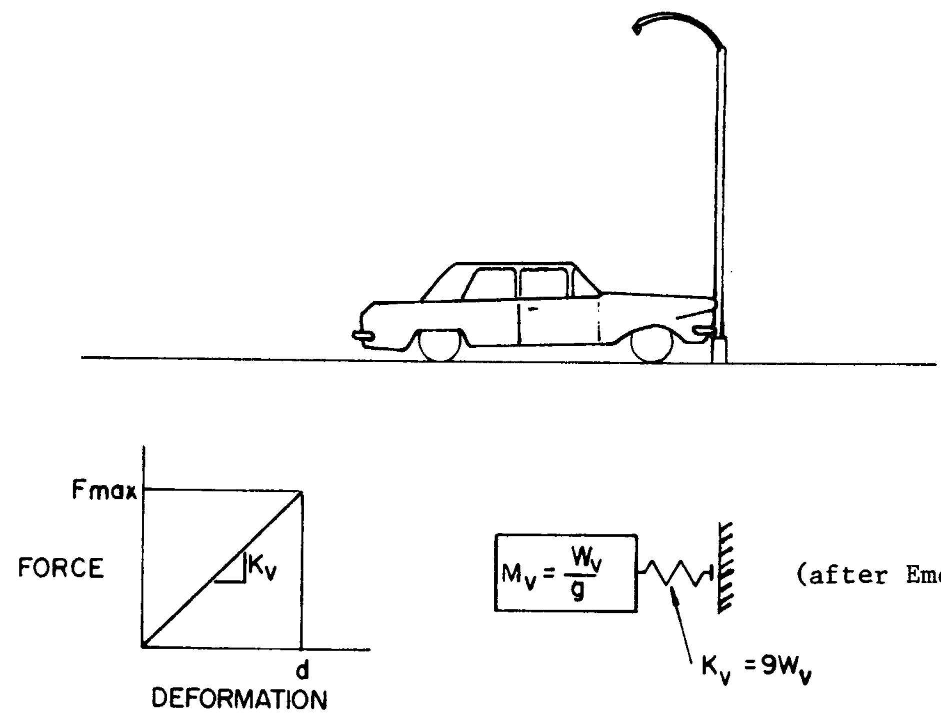


Figure 18. Velocity-displacement curves for test S-50.

TABLE 1. SUMMARY OF RESULTS

Test no.	Change in pendulum velocity, ΔV fps	Change in momentum, ΔMV lb-sec	Max Force from accelerometer, Kips
I-20	12.5	780	60
I-35	8.3	515	60
S-40	3.1	190	56
S-50	6.5	405	62

The peak force measured in the pendulum test arises from two sources; that required to fracture the base and that required to set the luminaire support into motion. These two sources are present in a vehicle impact, although not necessarily in the same proportions. The vehicle also undergoes crushing and deformation which consumes some of the energy of the vehicle. The fact that energy is absorbed in the crushing of the vehicle makes it possible for a vehicle to impact a luminaire support at or below some critical velocity which will not cause the luminaire support to breakaway. The minimum or critical velocity can be computed using the idealization shown in Figure 19.



(after Emori, Ref. 2)

Figure 19. Idealization of vehicle-luminaire support impact at or below minimum velocity to cause breakaway.

The energy of the vehicle is $\frac{W_v V_v^2}{2g}$, and the energy absorbed by the vehicle on impact (without breakaway) is $\frac{F^2_{max}}{2K_v}$. By equating these two expressions, one can compute the minimum velocity of the vehicle required to cause breakaway.

$$\frac{W_v V^2_{min}}{2g} = \frac{F^2_{max}}{2K_v} \qquad \text{where } K_v = 9\, W_v$$

or

$$Vmin = \frac{Fmax}{W_v} 1.89 \quad \text{ft/sec}$$

$$Vmin = \frac{Fmax}{W_v} 1.29 \quad \text{mph}$$

If it is assumed that F_{max} = 60,000 lbs, the following minimum velocities are obtained:

W_v	V_{min}
2000 lbs	38.8 mph
3000 lbs	25.8 mph
4000 lbs	19.5 mph

If vehicles of the indicated weights impact such a luminaire support at or below the minimum velocity, the final velocity will be zero. All of the energy will be consumed in crushing of the vehicle and some rather significant velocity changes will occur. One could argue that the 60,000 lb maximum force is not appropriate for use in the above equation since it reflects fracturing of the base as well as acceleration of the support. However, if a maximum force of only 30,000 lbs is used, the minimum velocity required to breakaway the base remains rather high.

CONCLUSIONS

The following conclusions are drawn from the results of this investigation.

1. Data describing velocity changes of the pendulum and base of the luminaire support were found to be qualitatively similar in each of the four tests conducted. During impact, the pendulum velocity first changed in a somewhat erratic manner, but then "stabilized" at a reduced value. The displacement at which the pendulum velocity "stabilized" was not the same in each test, but once this point was reached, the velocity-displacement curve in each test was essentially parallel to that of the pendulum during a free-swing.
2. Three of the four full-scale luminaire supports tested with a 2000 lb pendulum traveling at 20 mph failed to meet the FHWA tentative guideline of 400 lb-sec maximum change in momentum. In two of the tests, the momentum change exceeded the limit by a significant amount.
3. Only one specimen of each type luminaire base was tested. Several specimens of each type base should be tested to establish the statistical variability of results for such specimens and the test procedure.
4. A more thorough description of the test method and the method of collecting, analyzing and reporting of the results of pendulum tests are needed if the test is to be standardized as an acceptance

test method. Parameters such as the displacement or time at which the final velocity of the pendulum are to be determined are not controlled in the present tentative guidelines.

5. The peak force required to cause a luminaire support to breakaway can be significantly high even though the change in momentum as measured in the test is at an acceptable level. In this case, a lightweight car traveling at a slow to moderate velocity will not develop enough force to breakaway the support and a rather high change in velocity of the vehicle will occur.

REFERENCES

1. Edwards, T. C. et al., "Development of Design Criteria for Safer Luminaire Supports", NCHRP Report 77, National Academy of Sciences - National Academy of Engineering, 1969.

2. Emori, Richard I., "Analytical Approach to Automobile Collisions", paper 680016, Society of Automotive Engineering, January 1968.

APPENDIX

Time Displacement Data and
Accelerometer Traces

TABLE A1

TIME-DISPLACEMENT DATA FOR PENDULUM

2146 Test I-20

V_1 = 360 in./sec.
30.0 fps
20.5 mph

Time (sec)	Displacement (in.)	Comments
-0.135	-48.6	
-0.012	- 4.8	
0	0	Impact
0.002	0.8	Pendulum denting base
0.005	1.8	Base moving with pendulum
0.007	2.6	
0.010	3.4	
0.012	4.2	
0.015	4.6	
0.017	5.6	Base free
0.020	6.2	
0.022	7.0	
0.025	7.6	
0.027	8.4	
0.030	9.0	
0.032	9.4	
0.034	10.2	
0.037	11.0	Base motion hesitates
0.039	11.6	
0.042	12.2	
0.044	12.6	

TABLE A1 (continued)

Time (sec)	Displacement (in.)	Comments
0.047	13.2	
0.049	14.0	
0.052	14.4	
0.054	15.2	
0.057	15.6	
0.059	16.4	
0.062	17.0	
0.064	17.4	
0.067	18.0	
0.069	18.4	
0.072	19.0	
0.074	19.6	
0.077	19.8	
0.079	20.6	
0.082	21.2	
0.084	21.6	
0.087	22.4	
0.089	23.0	
0.092	23.2	
0.094	23.8	Pendulum loses contact
0.171	40.8	

TABLE A2

TIME-DISPLACEMENT DATA FOR BASE

2146 Test I-20

Time (sec)	Displacement (in.)	Comments
0	0	Impact
0.002	0.3	Pendulum denting base
0.005	1.1	Base moving with pendulum
0.007	1.7	
0.010	2.3	
0.012	3.0	
0.015	3.8	
0.017	4.6	Base free
0.020	5.4	
0.022	6.1	
0.025	6.9	
0.027	7.8	Base loses contact with pendulum
0.030	8.5	
0.032	9.1	
0.034	9.6	
0.037	9.8	
0.039	10.2	Base regains contact with pendulum
0.042	10.7	
0.044	11.8	
0.047	12.7	
0.049	13.1	

TABLE A2 (continued)

Time (sec)	Displacement (in.)	Comments
0.052	13.7	
0.054	14.3	
0.059	14.8	
0.062	15.4	
0.064	15.8	
0.067	16.4	
0.069	16.8	
0.072	17.6	
0.074	18.3	
0.077	18.7	
0.079	19.2	
0.082	19.7	
0.084	20.2	
0.087	20.8	
0.089	21.3	
0.092	21.9	
0.094	22.6	Pendulum loses contact with base
0.171	47.0	

TABLE A3

TIME-DISPLACEMENT DATA FOR PENDULUM

2146 Test I-35

V_1 = 359 in./sec
29.9 fps
20.4 mph

Time (sec)	Displacement (in.)	Comments
-0.113	-40.6	
-0.012	- 4.8	
0	0	Impact
0.002	1.0	Base denting
0.005	1.8	Base is moving, larger dent
0.007	2.6	
0.010	3.4	
0.012	4.0	Crack appears in base
0.015	4.6	
0.017	5.4	Base is free
0.020	6.0	
0.022	6.6	
0.025	7.2	
0.027	8.0	
0.030	8.8	
0.032	9.4	
0.034	10.2	
0.037	10.8	
0.039	11.6	
0.042	12.0	
0.044	12.6	

TABLE A3 (continued)

Time (sec)	Displacement (in.)	Comments
0.047	13.4	
0.049	14.0	
0.052	14.6	
0.059	16.8	
0.067	18.8	
0.074	20.6	
0.082	22.4	
0.089	24.4	
0.096	26.4	Pendulum loses contact
0.109	29.4	
0.121	32.8	
0.133	36.0	

TABLE A4

TIME-DISPLACEMENT DATA FOR BASE

2146 Test I-35

Time (sec)	Displacement (in.)	Comments
0	0	Impact
0.002	0.4	Base denting
0.005	1.2	Base moving, larger dent
0.007	1.9	
0.010	2.7	
0.012	3.3	Crack appears in base
0.015	4.1	
0.017	4.7	Base free
0.020	5.4	
0.022	6.2	
0.025	6.8	
0.027	7.4	
0.030	8.0	
0.032	8.9	
0.034	9.3	
0.037	9.8	
0.039	10.5	
0.042	10.9	
0.044	11.7	
0.047	12.5	
0.049	13.2	

TABLE A4 (continued)

Time (sec)	Displacement (in.)	Comments
0.052	13.6	
0.059	15.5	
0.067	17.5	
0.074	19.3	
0.082	21.0	
0.089	23.0	
0.096	25.6	Pendulum loses contact with base
0.109	29.2	
0.121	33.1	
0.133	36.6	

TABLE A5

TIME-DISPLACEMENT DATA FOR PENDULUM

2146 Test S-40

V_1 = 360 in./sec.
30 fps
20.4 mph

Time (sec)	Displacement (in.)	Comments
-0.106	-38.0	
-0.010	- 3.6	
0	0	Impact
0.002	0.8	Pendulum denting base
0.005	1.6	Base cracking
0.007	2.6	Base is free
0.010	3.6	
0.012	4.4	
0.015	5.2	
0.017	6.0	
0.020	6.8	
0.022	7.6	
0.025	8.6	
0.027	9.4	
0.029	10.0	
0.032	10.6	
0.034	11.4	
0.037	12.2	
0.039	13.0	
0.042	13.8	
0.044	14.6	

TABLE A5 (continued)

Time (sec)	Displacement (in.)	Comments
0.047	15.6	
0.049	16.4	
0.051	17.0	
0.054	18.0	
0.056	18.6	
0.059	19.6	
0.061	20.4	
0.064	21.2	
0.066	22.2	
0.069	23.0	
0.071	23.6	
0.074	24.6	
0.076	25.0	
0.078	25.6	
0.081	26.4	
0.083	27.4	
0.086	28.2	
0.103	33.8	Pendulum and base lose contact
0.150	48.0	

TABLE A6

TIME-DISPLACEMENT DATA FOR BASE

2146 Test S-40

Time (sec)	Displacement (in.)	Comments
0	0	Impact
0.002	0.6	Pendulum denting base
0.005	1.4	Base cracking
0.007	2.4	Base free
0.010	3.0	
0.012	4.0	
0.015	4.7	
0.017	5.6	
0.020	6.5	
0.022	7.3	
0.025	8.0	
0.027	8.9	
0.029	9.7	
0.032	10.4	
0.034	11.1	
0.037	11.9	
0.039	12.7	
0.042	13.5	
0.044	14.4	
0.047	15.2	
0.049	15.9	

TABLE A6 (continued)

Time (sec)	Displacement (in.)	Comments
0.051	16.6	
0.054	18.2	
0.056	19.2	
0.059	19.8	
0.061	20.7	
0.066	21.4	
0.069	22.2	
0.071	22.9	
0.074	23.7	
0.076	24.6	
0.078	25.5	
0.081	26.3	
0.083	26.8	
0.086	27.7	
0.103	33.6	Pendulum loses contact with base
0.150	52.3	

TABLE A7

TIME-DISPLACEMENT DATA FOR PENDULUM

2146 Test S-50

	Time (sec)	Displacement (in.)	Comments
V_1 = 365 in./sec. 30.4 fps 20.7 mph	-0.122	-44.6	
	0	0	Impact
	0.002	1.0	
	0.005	1.8	Base cracking
	0.007	2.6	
	0.010	3.2	
	0.012	4.2	
	0.015	5.0	
	0.017	5.8	
	0.020	6.4	
	0.022	7.4	Base completely free
	0.025	8.2	
	0.027	8.8	
	0.030	9.4	
	0.032	10.4	
	0.034	11.2	
	0.037	12.0	
	0.039	12.8	
	0.042	13.4	
	0.044	14.2	
	0.047	14.8	

TABLE A7 (continued)

Time (sec)	Displacement (in.)	Comments
0.049	15.8	
0.089	27.0	
0.116	34.8	
0.145	42.8	
0.160	47.0	Pendulum loses contact with bas
0.269	76.0	

TABLE A8

TIME-DISPLACEMENT DATA FOR BASE

2146 Test S-50

Time (sec)	Displacement (in.)	Comments
0	0	Impact
0.002	0.3	
0.005	0.8	Base cracking
0.007	1.7	
0.010	2.4	
0.012	3.3	
0.015	4.1	
0.017	4.9	
0.020	5.7	
0.022	6.5	Base free
0.025	7.0	
0.027	7.9	
0.030	8.6	
0.032	9.4	
0.034	10.1	
0.037	10.9	
0.039	11.5	
0.042	12.2	
0.044	13.0	
0.047	13.8	
0.049	14.5	

TABLE A8 (continued)

Time (sec)	Displacement (in.)	Comments
0.089	26.0	
0.116	33.0	
0.145	40.9	
0.160	45.1	Pendulum loses contact
0.269	75.7	

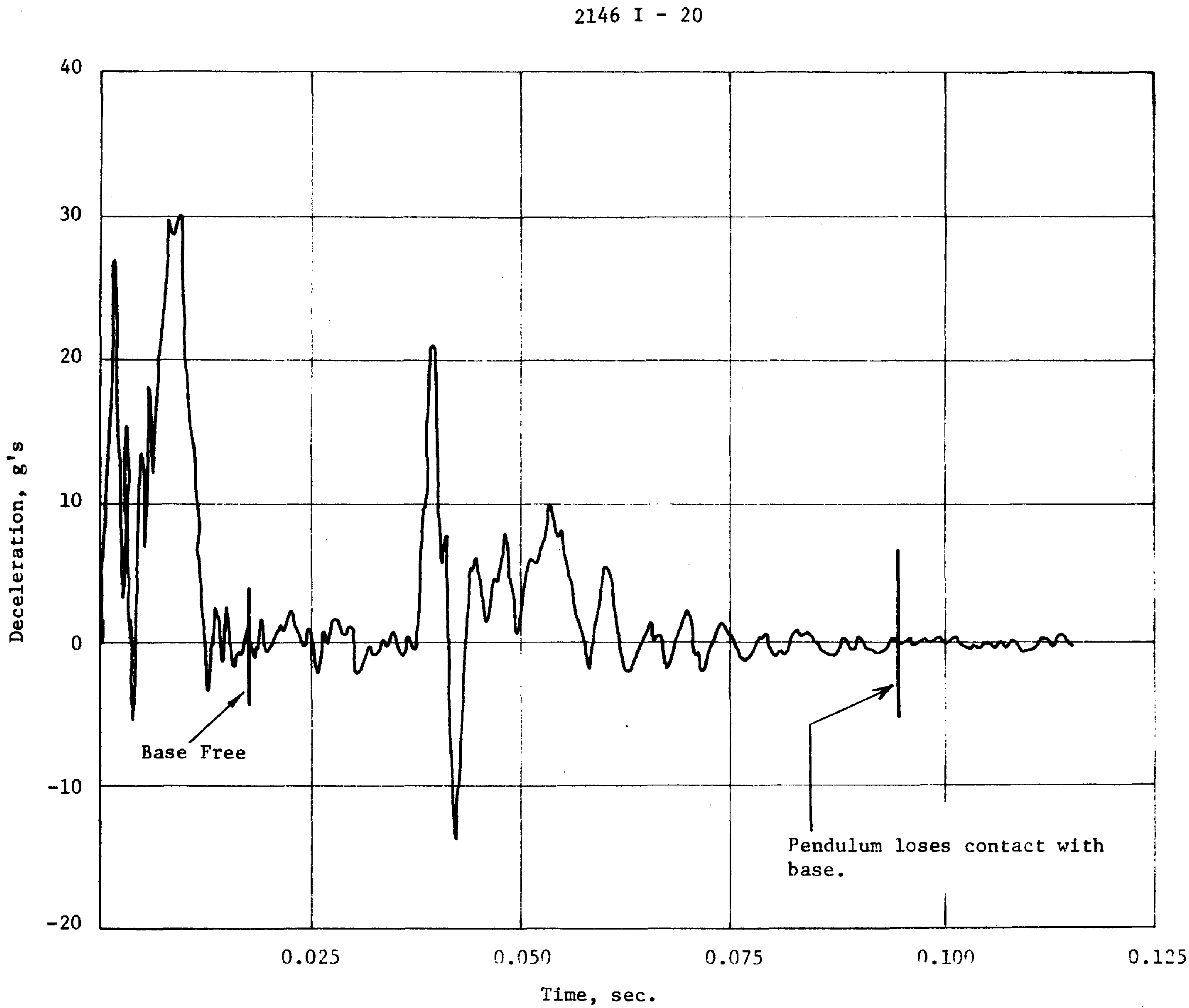


Figure A1. Test 2146 I - 20. Accelerometer Data

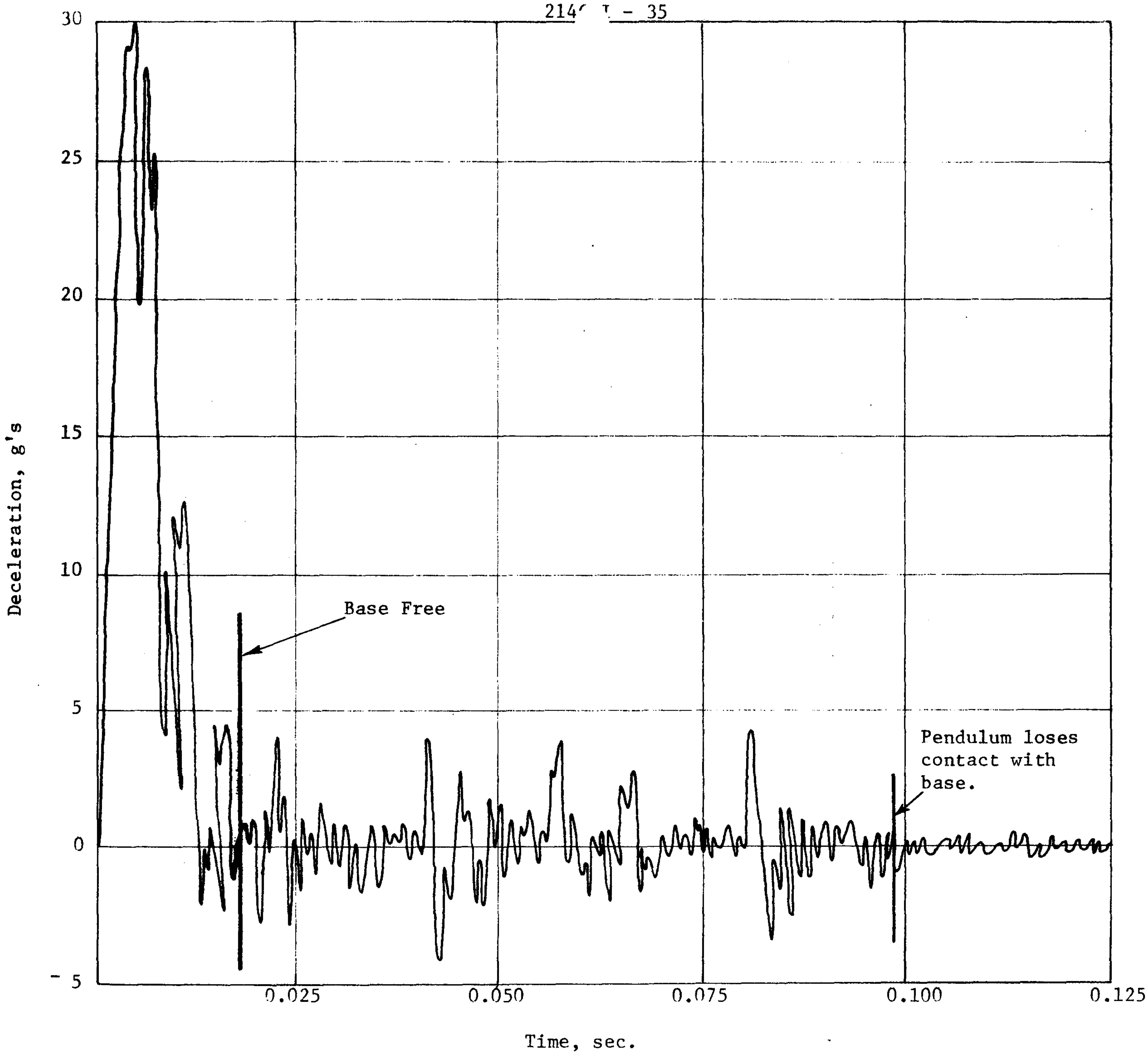


Figure A2 Test 2146 I - 35 Accelerometer Data

2146 S - 40

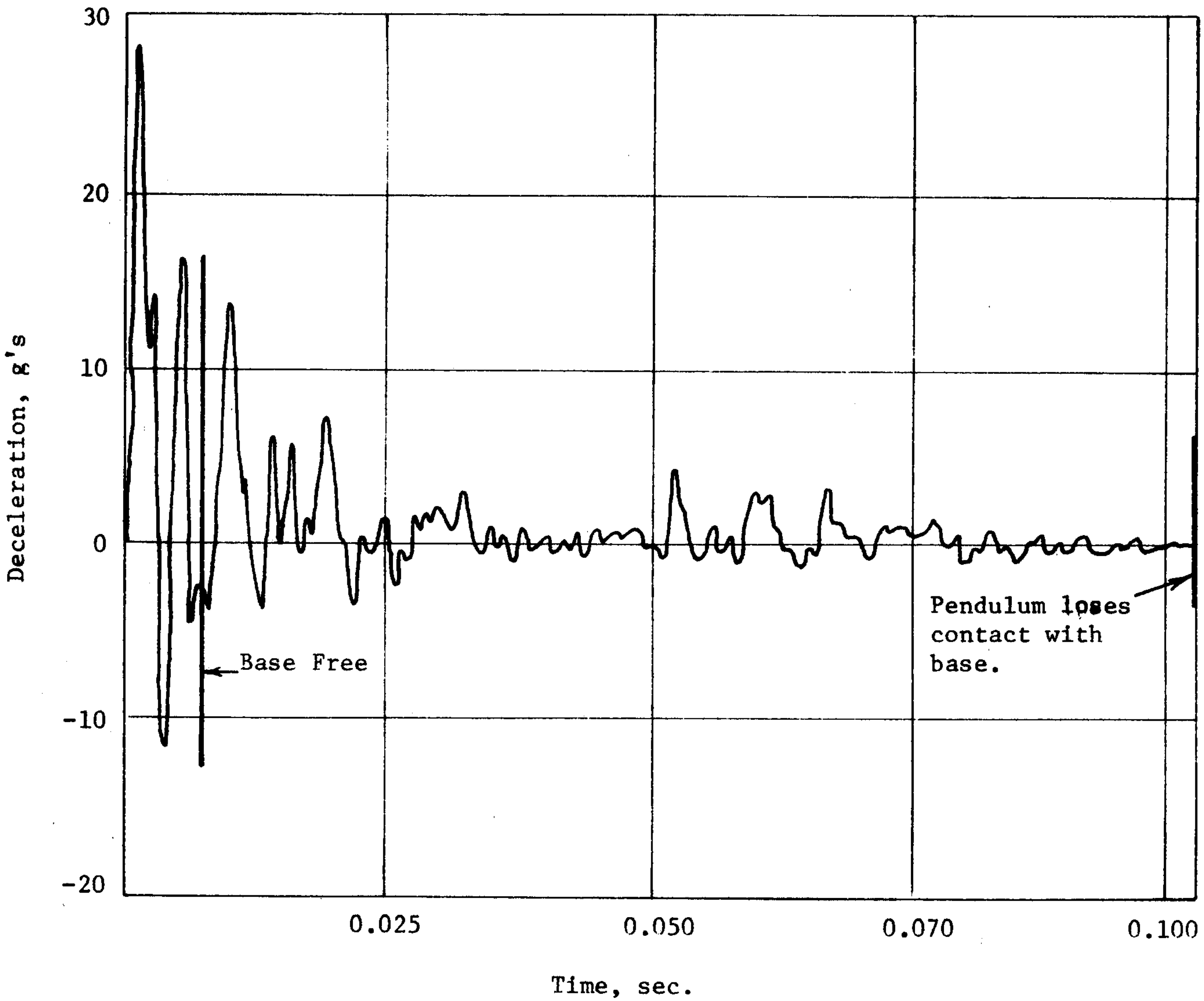


Figure A3. Test 2146 S — 40. Accelerometer Data

2146 S - 50

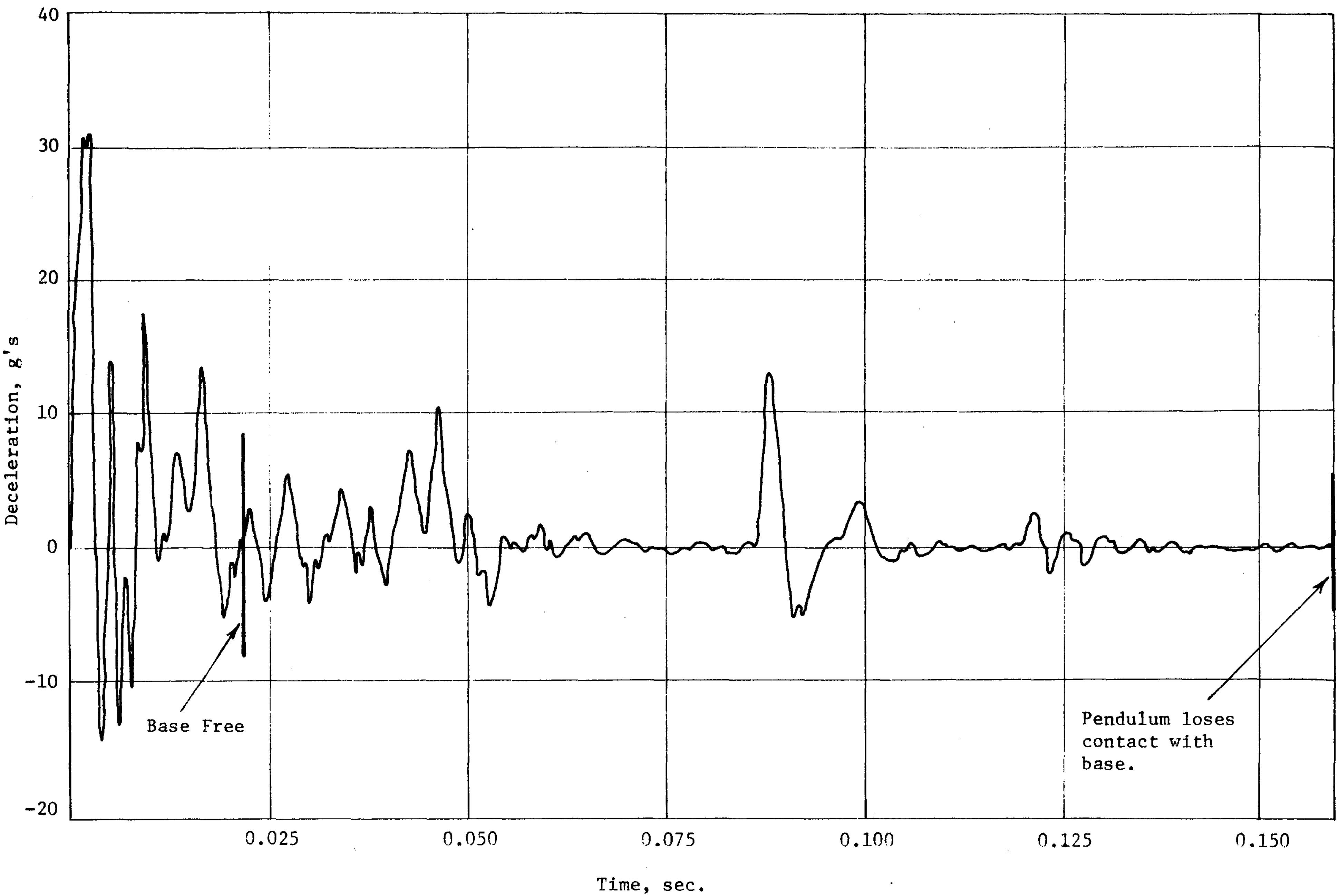


Figure A4. Test 2146 S - 50. Accelerometer Data

U.S. DEPARTMENT OF TRANSPORTATION

FEDERAL HIGHWAY ADMINISTRATION

SUBJECT Application of Highway Safety Measures -- Breakaway Luminaire Supports	FHWA NOTICE

November 16, 1970

TO-20

In the June 5, 1968, Circular Memorandum on the above subject, an interim acceptance criterion was set for luminaire supports. This criterion, which was based on full-scale vehicle impact tests, considered a pole which yields or breaks away with a change in vehicle momentum of 1100 pound-seconds or less to have acceptance breakaway features and therefore may be approved for Federal-aid participation. Since then dynamic laboratory tests have been found to give repeatable results at a lesser cost than full-scale vehicle impact testing. However, in the limited number of cases in which data are available on the same poles from both dynamic laboratory tests and full-scale impact tests, change in momentum values obtained from dynamic laboratory tests have been found to be substantially less than the values obtained from vehicle impact tests. This is in part due to vehicle crush characteristics which, in addition, may vary greatly from vehicle to vehicle.

Dynamic laboratory testing may be used in lieu of full-scale impact testing to determine the acceptability of the breakaway characteristics of luminaire supports. Poles producing a change in impacting weight momentum of 400 pound-seconds or less shall be considered evidence of acceptable breakaway features if tested in accordance with the following interim test procedure:

> Dynamic laboratory tests will be conducted on a full-sized pole mounted on its supporting base with a ballistic pendulum, or other equivalent means. The pendulum weight shall be 2000 pounds and the pendulum velocity at impact shall be 20 MPH. The impact point shall be 20 inches from the mounting base. A striking block not to exceed six inches in length as measured along the long axis of the pole may be attached to the poles to prevent localized failure at impact, however, it shall be attached in such a way as to avoid strengthening the pole.

Poles producing a change in impacting weight momentum exceeding 400 pound-seconds shall be considered to have acceptable breakaway features if when subjected to full-scale dynamic vehicle testing they produce an

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1100 pound-second or less change in vehicle momentum. Poles with mounting heights exceeding 50 feet, poles such as those with large bases which might hook or snag an impacting vehicle, and poles heavier than 700 pounds shall likewise be subjected to full-scale vehicle impact testing.

As new information becomes available, modifications and refinements in these interim test procedures and performance criteria may be expected.

Luminaire supports and other roadside structures such as signs, guardrails, and energy absorption barriers that conform to existing established performance criteria are considered "safe." From time to time, though, technological advances make safer structures possible. Because it is the policy of the Federal Highway Administration to provide a roadside that is as safe as possible, new advances in safety are to be promoted. New types of structures or adjustments to existing structures that will noticeably increase safety by reducing impact severity to occupants of all size vehicles at both high and low speeds shall be fostered consistent with other engineering considerations. Therefore, even though luminaire supports that just conform to the above interim criteria are acceptable, serious effort should be made to adopt other supports with lower change in momentum so as to provide an extra margin of safety for occupants of all vehicles including light weight and low speed vehicles.

Thos. W. Kuser

For M. F. Maloney
Acting Associate Administrator for
Engineering and Traffic Operations