

Test Report
of a
Breakaway Luminaire Support
Tested at the
Hapco Outdoor Impact Test Facility (HOITF)

July 1, 1992

Manufacturer: Hapco Division
P. O. Box 547
Abingdon, Virginia 24210
Device Tested: Base Model: B72785
Pole Model: B21-855 (35 ft mounting
height with 6 ft bracket)

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Submitted to:
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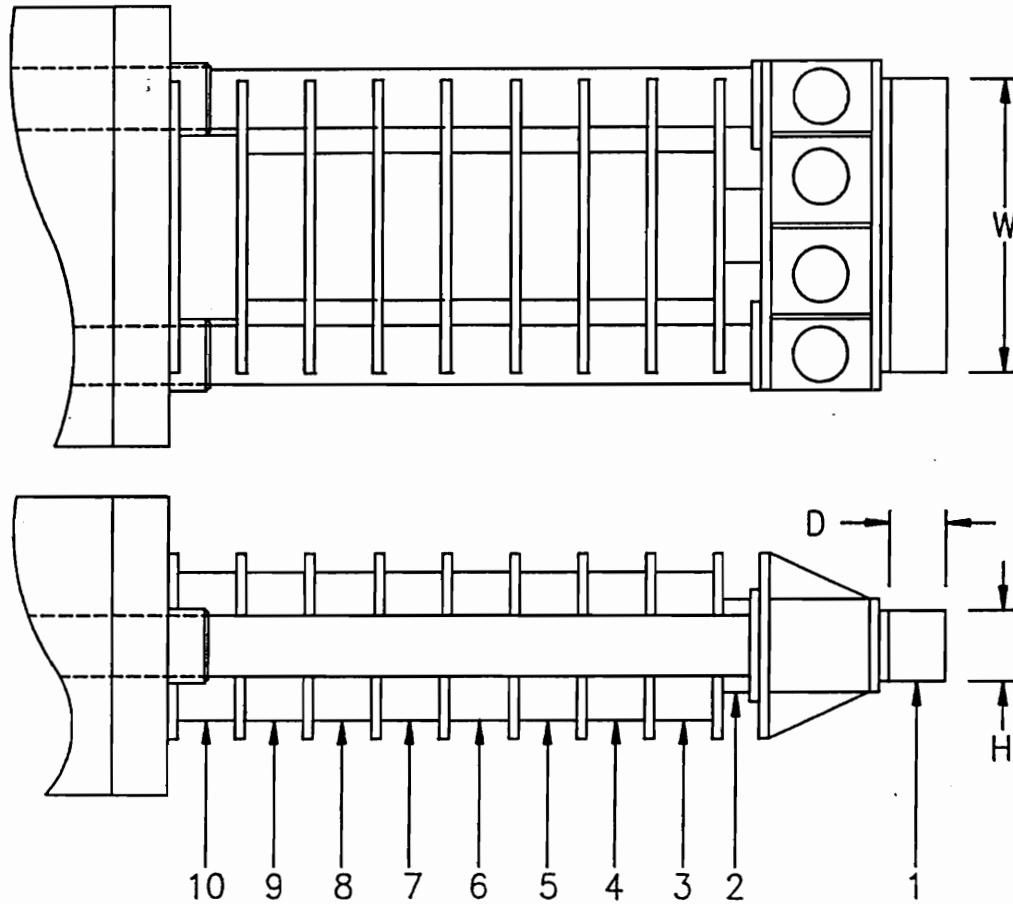
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1.0 SCOPE: This document contains the results of a test performed at the Hapco Outdoor Impact Test Facility (HOITF) on April 23, 1992 on a luminaire support using an 1800 lb class surrogate test vehicle. The luminaire support was manufactured by Hapco Division, P. O. Box 547, Abingdon, Virginia 24210. The luminaire support consisted of pole model number B21-855 complete with 6 ft. mast arm model number A47005, and breakaway anchor base model number B72785. The luminaire mounting height was 35 ft with the 6 ft mast arm attached. A 50 lb steel weight was attached to the end of the mast arm to simulate the luminaire mass. A 20 mph impact test was performed and the data has been extrapolated for the 60 mph impact case.

2.0 SURROGATE TEST VEHICLE: The surrogate test vehicle was the HOITF reusable, 1800 lb pendulum. The 1800 lb pendulum was constructed per Ensco, Inc. Drawing No. 1870-D-100 which was provided by The Federal Highway Administration and is identical to the pendulum used at the Federal Outdoor Impact Laboratory (FOIL) except the sweeper plate has been omitted.

From reference (1), the crushable nose of the pendulum was set up to represent the crush characteristics of a 1979 Volkswagon Rabbit 2-door sedan's left front quarter point, approximately 12.5 inches left of the vehicles's centerline. Figure (1) presents the pendulum's crushable front nose configuration showing each honeycomb cartridge. Figure (2)

Figure (1)
HOITF Pendulum Nose Configuration



Cartridge Number	Honeycomb Type	Static Crush Strength (psi)	Size (H x W x D)
1	3/16-5052-.001	130	2 3/4 x 16 x 3
2	3/8-5052-.0007	25	4 x 5 x 2
3	3/16-5052-.001	130	8 x 8 x 3 /21*
4	1/4-5052-.002	230	8 x 8 x 3 /15*
5	1/4-5052-.002	230	8 x 8 x 3 /6*
6	1/4-5052-.002	230	8 x 8 x 3
7	3/16-5052-.002	390	8 x 8 x 3 /21*
8	3/16-5052-.002	390	8 x 8 x 3 /12*
9	3/16-5052-.002	390	8 x 8 x 3
10	3/16-5052-.002	390	8 x 10 x 3

* Indicates square inches removed from center of cartridge.

presents a photograph of the 1800 lb pendulum with crushable front nose prior to the test.

3.0 TEST HARDWARE: The luminaire support consisted of a breakaway, anchor base welded to the Hapco 21-855 aluminum lighting standard. Figure (3) presents Hapco drawing number B21-855 showing the pole design which was tested. Figure (4) presents Hapco drawing number B72785 showing the breakaway, anchor base which was being evaluated.

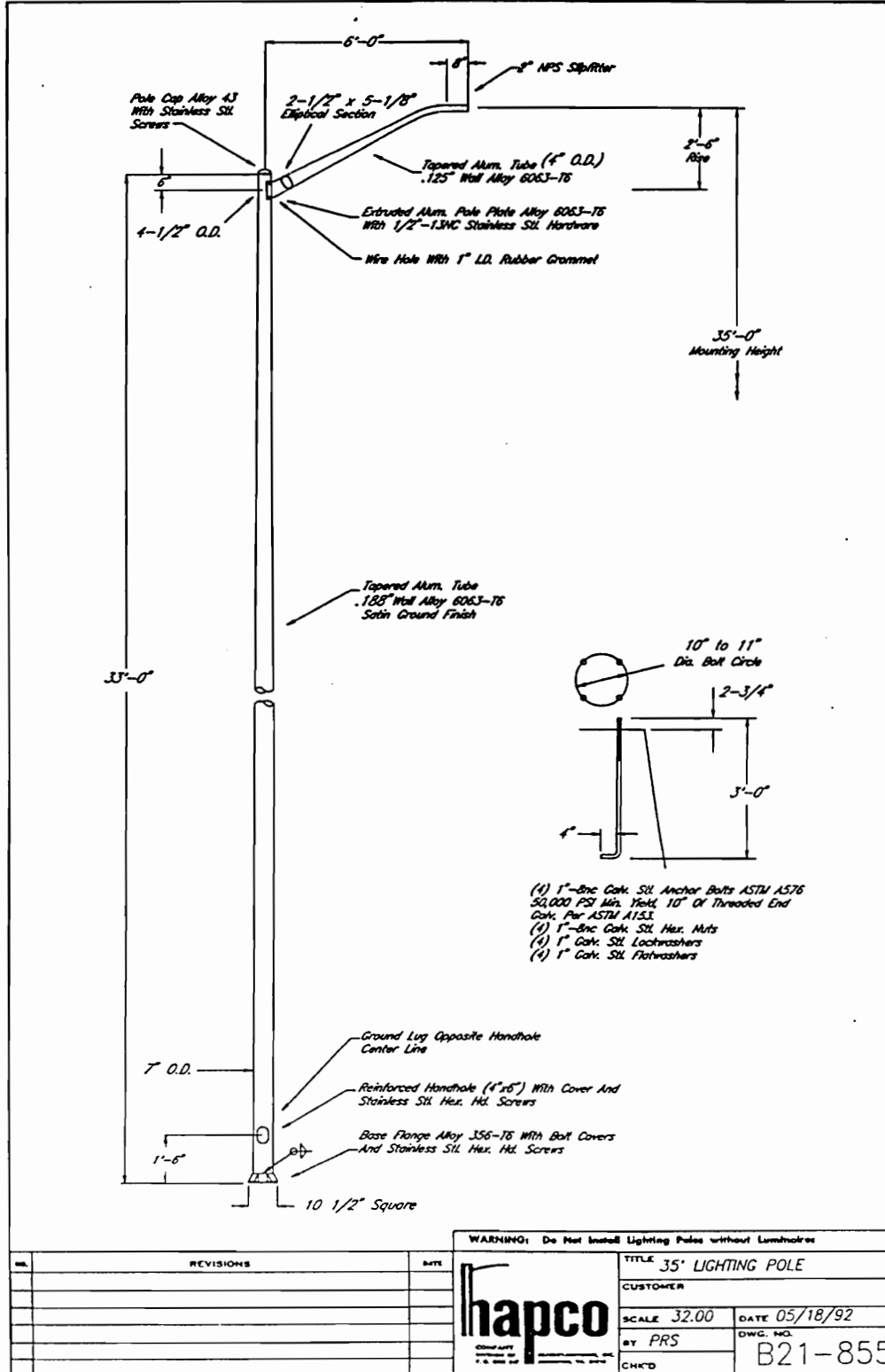
The anchor base was cast aluminum alloy 356 and was supplied to Hapco in the -F temper. The base end of the aluminum alloy 6063-T4 shaft tube was inserted into the anchor base to a depth of 1 3/4" and was joined by means of two complete circumferential fillet welds. A 1/4" circumferential fillet weld externally at the top of the anchor base and a 3/16" circumferential fillet weld internally at the bottom of the shaft tube secured the anchor base to the shaft tube. The entire shaft assembly was then heat treated after welding. The resulting shaft tube temper was -T6 and the resulting anchor base temper was -T5. After heat treatment a reinforced 4" x 6" handhole was installed in the shaft tube as shown in figure (3).

A 6' tapered elliptical arm was attached near the top of the shaft using stainless steel fasteners and a 50 lb steel block was fitted to the arm's end to simulate the mass of a luminaire. The lighting pole assembly was then bolted into position using 1" diameter steel bolts on a 11" diameter bolt

Figure (2)
Pre-test Photograph, HOITF Pendulum

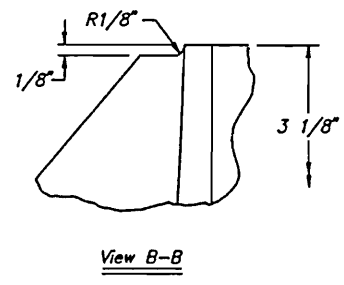
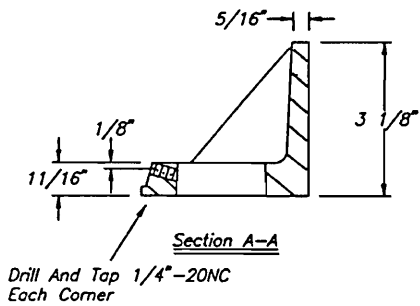
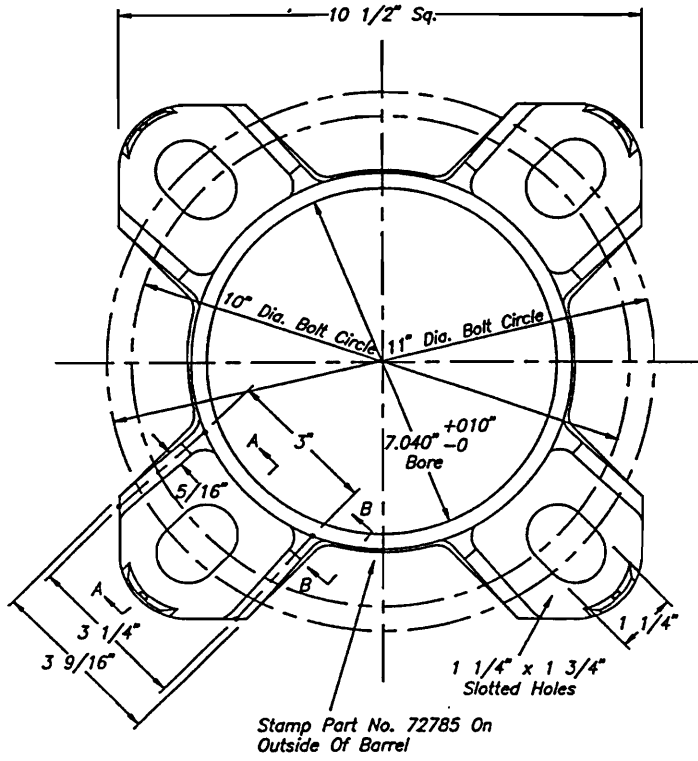


Figure (3)
Hapco Drawing No. B21-855,
35' Lighting Pole



B21-855

Figure (4)
Hapco Drawing No. B72785,
Breakaway Anchor Base



- Notes:
- (1) Material: Cast Alum. Alloy 356-F (ASTM B108)
 - (2) This Is 44543 Base Flange (7") Modified To Meet AASHTO, 1985 Edition Specification For Breakaway.

B72785

WARNING: Do Not Install Lighting Poles without Lumbermen		
REVISIONS		TITLE BREAKAWAY BASE FLANGE
NO.	DATE	CUSTOMER
1	05/11/92	SCALE 2.00
2	05/11/92	BY LW
3	05/11/92	DWG. NO.
4	05/11/92	B72785
5	05/11/92	CHKD TE

circle as shown in the pre-test photograph presented in figure (5). A steel "eye-bolt" was placed in the lighting pole approximately 10 ft from the shaft top to which one end of a nylon safety strap was fastened. The other end of the safety strap was attached to a crane to prevent the lighting pole from damaging the pendulum test vehicle after the initial impact. Some slack was left in the strap so to minimize it's affect on the dynamics of the pole immediately after impact. See the pre-test photograph presented in Figure (6) for the orientation of the lighting pole, test vehicle, and safety strap.

4.0 DATA SYSTEMS:

4.1 ACCELEROMETER: The pendulum was instrumented with an accelerometer to measure the change in the pendulum's velocity due to impact. The accelerometer used was a Sensotec model JTF 3629-02, low impedance strain gage type transducer. Figure (7) presents the Calibration Certificate for the accelerometer used.

The excitation voltage to the strain gage accelerometer, and output signal conditioning was provided with a Vishay Model 2310 Amplifier. The low pass filter was set to 100 Hz. The output was recorded on a Gould 220 2-Channel Brush Recorder. Both channels of the recorder were connected to the one output signal; however, the different sensitivities were used.

Prior to the impact test a measurement system

Figure (5)
Pre-test Photograph, Lighting Pole
Bolted Into Position, Test No. 3237

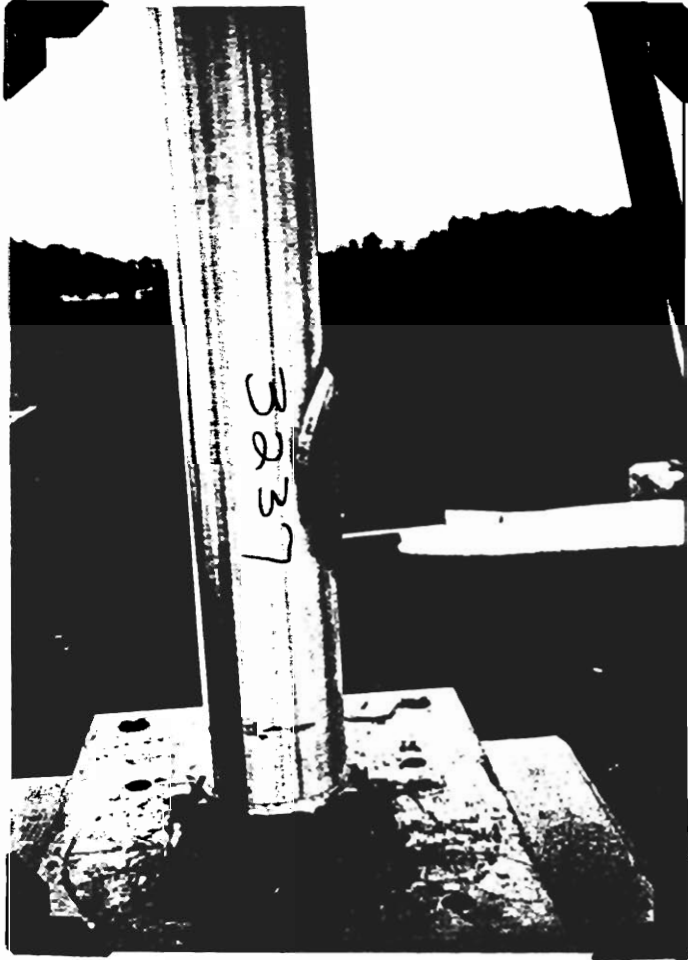


Figure (6)
Pre-test Photograph, Orientation of
Lighting Pole, Pendulum, & Safety
Strap, Test No. 3237

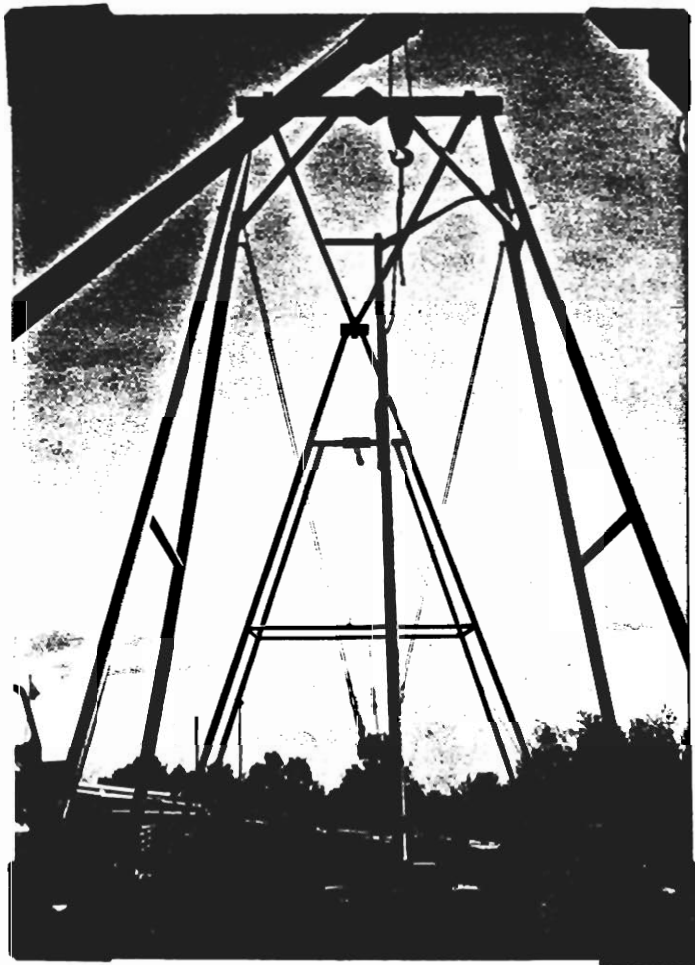


Figure (7)
Accelerometer Calibration Certificate

087-0205-00

transducers
and instrumentation by

SENSOTEC

1200 Chesapeake Ave. Columbus, Ohio 43212 (614) 486-7723

Calibration Certificate

MODEL JTF 3629-02
SERIAL NUMBER 300466
SENSITIVITY 3.013 MV/G.
EXCITATION VOLTAGE 5.0 VDC
RANGE +/- 50 "G" PEAK

CABLE CONNECTION

RED +INPUT POWER
BLACK or BROWN -INPUT POWER
WHITE or ORANGE +OUTPUT
GREEN or YELLOW -OUTPUT

DATE 8-29-91

Bonnie Roach

SIGNATURE

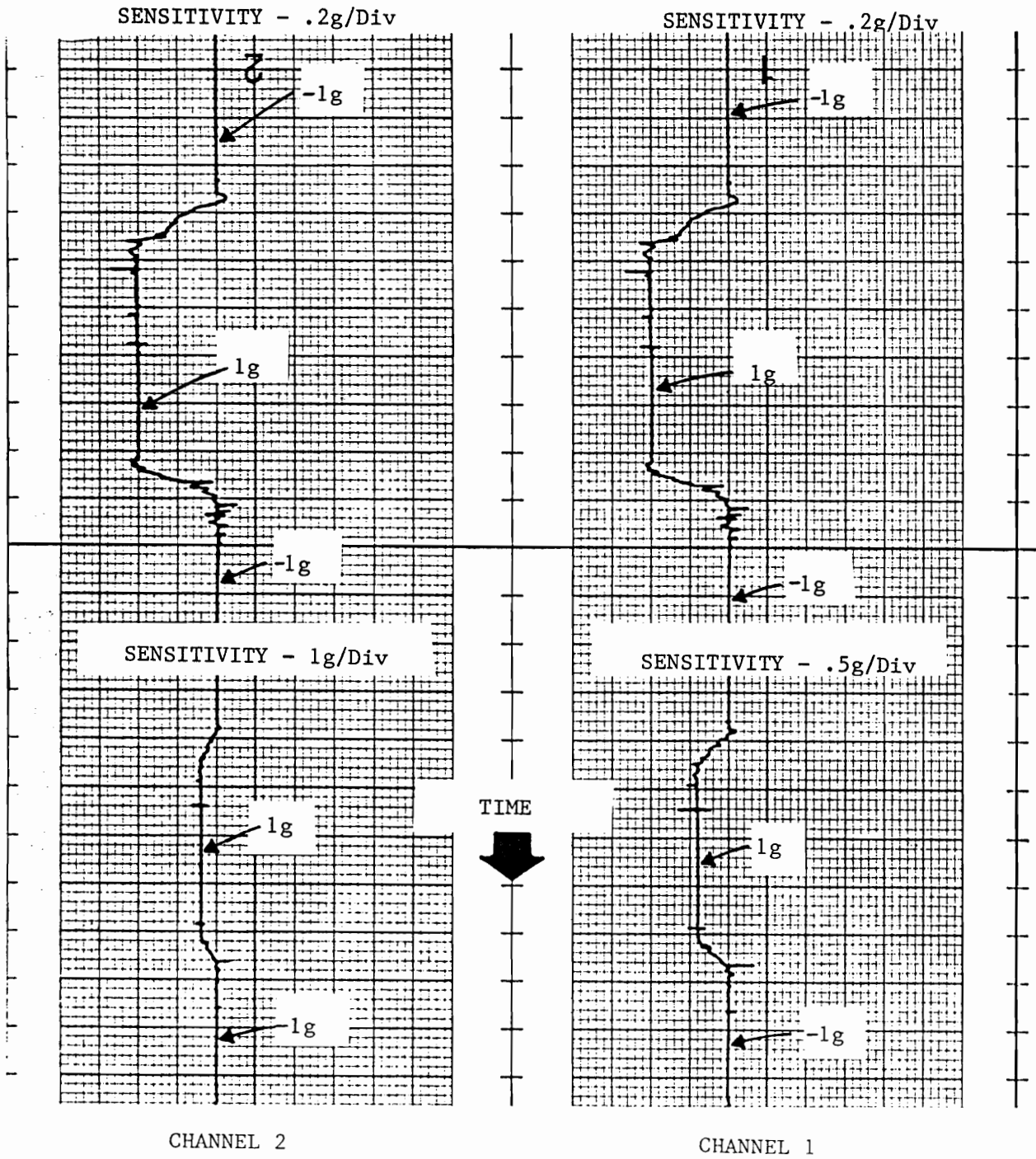
087-0205-00

calibration was performed. With the accelerometer setting on a level surface so that the transducer is experiencing an acceleration of 1 g, the strain gage bridge is balanced using the auto-balance feature of the model 2310 Vishay Amplifier. After the bridge was balanced, the transducer was turned over so that the transducer experiences an acceleration of 1 g in the opposite direction. Thus there was a total acceleration change of 2 g's from the balanced position. Figure (8) presents the calibration record obtained just minutes prior to the impact test.

4.2 HIGH SPEED FILM: The test was photographed by Jeff Bloom, of Adian Engineering Corp., using a Redlake Locam high speed camera (500 frames/sec) with Kodak 7251 film. The camera was used to obtain a close-up view of the impact zone to determine the impact and exit speeds, nose performance, and base failure pattern. The high speed film was subsequently analyzed by Jeff Bloom using a Vanguard Instrument Corporation model C11D motion analyzer.

5.0 TEST PROCEDURES: The pendulum was lifted 13'-6" to obtain an impact speed of 20 mph. A pointer is attached to the pendulum supporting structure to align with a mark on the pendulum to determine the correct lifting height. The vertical location of the pointer was verified with two different types of surveying equipment which were found to be accurate within plus or minus 1.5". The pendulum was released by mechanical latch which was operated with a rope.

FIGURE (8)
HAPCO TEST NO. 3237
CALIBRATION DATA



6.0 DATA ANALYSIS: Data were gathered and analyzed from two independent sources: high speed film and an accelerometer.

6.1 ACCELEROMETER: Following the measurement system calibration, the accelerometer was mounted to the rear face of the pendulum at the center of gravity of the pendulum in that plane. Data was gathered during the impact test and the record of acceleration is presented in Figure (9). The data was then digitized using a 386 personal computer, digitizer, and the software program "AutoCAD 11.0". The digitized data is presented in Figure (10). The area under the acceleration curve which represents the change in the pendulum velocity due to the impact was calculated using "AutoCAD". A change in the pendulum velocity of 14.75 ft/sec was determined.

6.2 HIGH SPEED FILM: The distance calibration, camera speed, impact speed, final speed, and the pendulum change in velocity data was provided to Hapco by Jeff Bloom of Adian Engineering Corporation. The results of the high speed film is presented as follows:

High Speed Camera Test Results
Test No. 3237

Pendulum Weight = 1800 lb.
Pendulum Nose = Current FHWA Honeycomb Design
Target Impact Speed = 20 mph
Target Camera Speed = 500 frames/sec

Distance Calibration:

Pendulum Length = 44" = 1.260 counts, 1 ft = .3436 counts
Pole Base Diameter = 7" = .21 counts, 1 ft = .36 counts
Impact Foundation = 24" = .676 counts, 1 ft = .338 counts
Average = .347 counts/ft

Actual Camera Speed = 516 frames/sec

Actual Impact Speed Calculation:

Number of Frames = 10
Time per Frame = .001938 sec
Number of Counts = .206
Speed = .206 counts/ (.347 c/ft*10 frames*.001938 sec/frame)
= 30.63 ft/sec

Actual Final Speed Calculation (First Location):

Number of Frames = 10
Time per Frame = .001938 sec
Number of Counts = .112
Speed = .112 counts/ (.347 c/ft*10 frames*.001938 sec/frame)
= 16.65 ft/sec

Change in Velocity = 30.63 - 16.65
= 13.98 ft/sec

7.0 TEST RESULTS

7.1 TEST RESULTS (20 mph): From the previous section, a change in velocity of the pendulum mass was determined from two independent sources. The accelerometer and high speed film data systems measured a velocity change of 14.75 ft/sec and 13.98 ft/sec respectively.

Figure (11) presents a post-test photograph of the pendulum's front nose. The front eight honeycomb cartridges were found to have experienced a significant amount of crushing. Figure (12) presents a post-test photograph showing the remains of the base flange on the test platform. There was found to be less than 3" of the base flange remains projecting above the surface of the test platform. Figures (13) & (14) present post-test photographs of the pole base flange and handhole area.

7.2 DATA EXTRAPOLATION (60 mph): The velocity change data presented above and pole geometry has been processed in a

FIGURE (9)
HAPCO TEST NO. 3237
ACCELEROMETER DATA

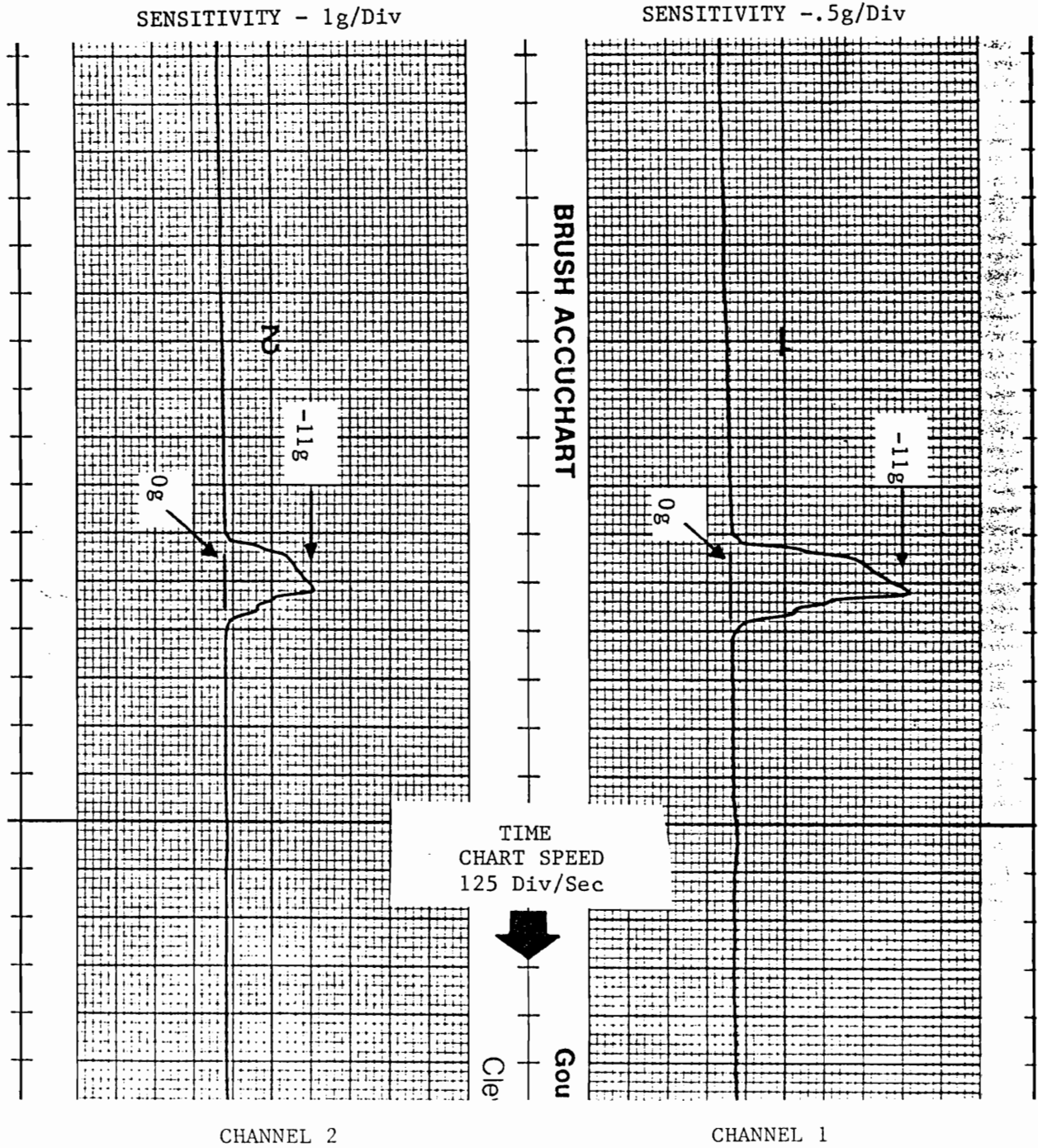


Figure (10)
Accelerometer Digitized Data

HAPCO TEST NO. 3237
ACCELERATION VS TIME

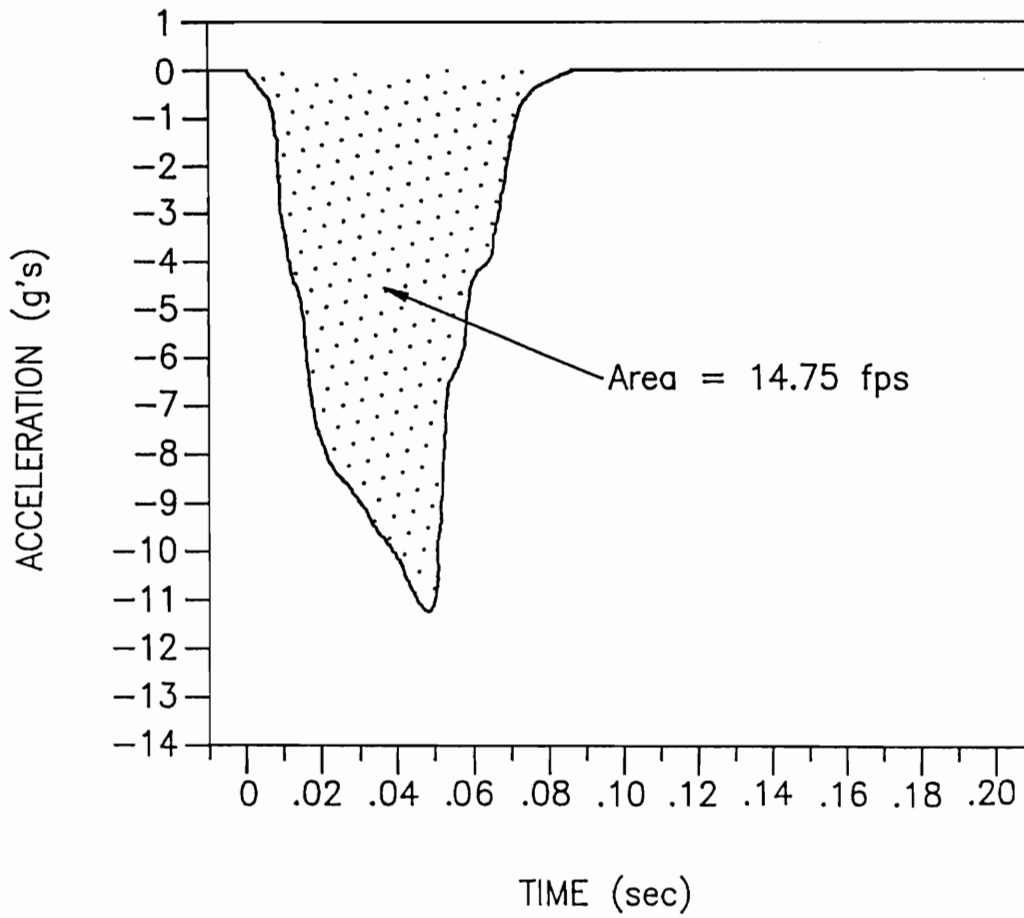


Figure (11)
Post-test Photograph, HOITF Pendulum
Test No. 3237

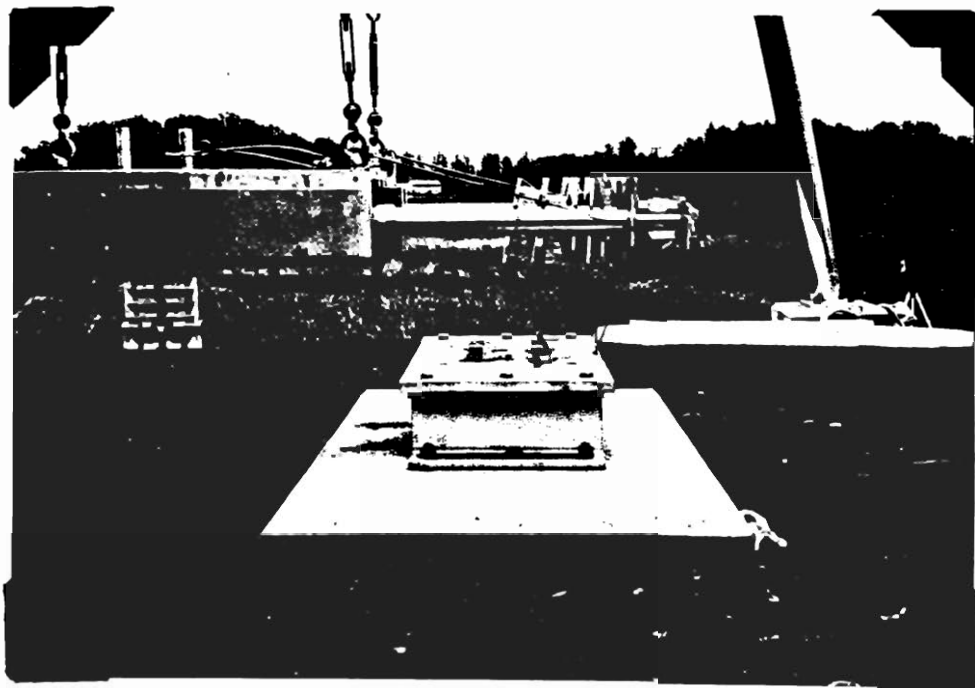


Figure (12)
Post-test Photograph, Remaining Stub
Test No. 3237

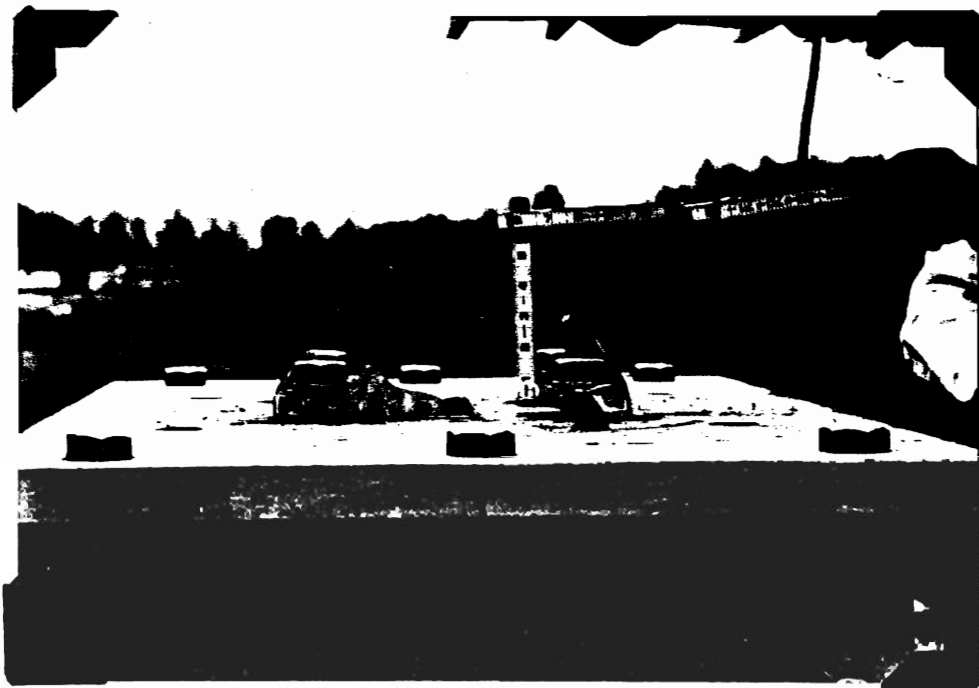


Figure (13)
Post-test Photograph, Pole Base Flange
Test No. 3237



Figure (14)
Post-test Photograph, Pole Handhole Area
Test No. 3237



analytical method for extrapolating the results of 20 mph impact test data to the 60 mph case. The extrapolation method was developed in reference (2). The pole assembly weight, center of gravity, and radius of gyration were determined from the front end of a basic program, FOILSIM.BAS, which was provided by the Federal Highway Administration. The input and output to FOILSIM.BAS is presented below.

DATE = 05-15-1992 TIME = 12:44:50
 WEIGHT IN POUNDS AND DISTANCE IN INCHES

WEIGHT AND HEIGHT OF BREAKAWAY DEVICE..... 0,0
 WEIGHT AND HEIGHT OF POLE FLANGE..... 5,3
 HEIGHT OF SHAFT IN INCHES..... 393
 SHAFT MATERIAL A=ALUMINUM S=STEEL..... A
 POLE RADIUS AT TOP..... 2.25
 POLE RADIUS AT BASE..... 3.5
 SHAFT THICKNESS..... .188
 MASTARM WEIGHT AND HEIGHT ABOVE TOP OF POLE..... 12,10
 LUMINAIRE WEIGHT AND HEIGHT ABOVE TOP OF POLE..... 50,24
 IS THIS DATA CORRECT (Y/N)y
 POLE WEIGHT,ROG,CG FROM BASE 124.3^{**} 9.7' 177.4''

	CG	WEIGHT
1 BREAKAWAY DEVICE	0.0	0.0
2 FLANGE	1.5	5.0
3 SHAFT	184.8	119.3
4 MAST ARM	406.0	12.0
5 LUMINAIRE	420.0	50.0

SYSTEM WEIGHT = 186.3
 SYSTEM CENTER OF GRAVITY = 257.2
 SYSTEM RADIUS OF GYRATION = 147.5

The change in the pendulum mass for the 60 mph impact case is extrapolated as follows:

$$\Delta V_{60} = \Delta V_{20}/3 + B_v[60 \text{ mph} - (1/3)(20 \text{ mph})]$$

$$\Delta V_{60} = \Delta V_{20}/3 + B_v(78.2 \text{ ft/sec})$$

ΔV_{60} = Extrapolated Change in Velocity of 60 mph Impact Velocity Case

ΔV_{20} = Change in Velocity in 20 mph Impact Velocity Test
= 13.98 ft/sec (From High Speed Film Data)

$B_V = 1.10 (M_p/M_v) [R^2/(R^2 + D_o^2)]$

D_o = Distance from cg to impact point

$Y_{cg} = 257.2$ in

$Y_{impact} = 17.0$ in

$D_o = Y_{cg} - Y_{impact}$

= 257.2 - 17.0

= 240.2 in

R = Radius of Gyration about Center of Gravity

= 147.5 in

M_p = Mass of Pole

= 186.3 lbm

M_v = Mass of Vehicle

= 1800 lbm

$B_V = 1.10 (186.3/1800) [147.5^2/(147.5^2 + 240.2^2)]$

= .0312

$\Delta V_{60} = \Delta V_{20}/3 + B_V(78.2 \text{ ft/sec})$

$\Delta V_{60} = (13.98 \text{ ft/sec})/3 + (.0312)(78.2 \text{ ft/sec})$

$\Delta V_{60} = \underline{7.09 \text{ ft/sec}}$

8.0 List of References

Reference Number

- 1 "Test Report of a Breakaway Luminaire Support Tested at the Federal Outdoor Impact Laboratory (FOIL)", Report Prepared by Analysis Group, Incorporated, November, 1986.
- 2 "Evaluation of an Analytical Approach for Establishing Velocity Change Values", Report Prepared by Jeff Bloom, July, 1987