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TEST RESULTS SUMMARY REPORT
FOR
DODX RAILCAR STABILITY TEST
IN SUPPORT OF
TEST REQUESTS SV-127, SV-197 AND SV-206

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Contract Number DOT-FR-64113

TEST RESULTS SUMMARY REPORT
FOR
DODX RAILCAR STABILITY TEST
IN SUPPORT OF
TEST REQUESTS SV-127, SV-197 AND SV-206

Prepared for:

U.S. DEPARTMENT OF TRANSPORTATION
Federal Railroad Administration
2100 Second Street, S.W.
Washington, D.C. 20590

December 30, 1976

Prepared by:

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370-0000
P76-247

December 30, 1976

Mr. John C. Mould
Office of Rail Safety Research, RRD-31
Federal Railroad Administration
2100 Second Street, S.W.
Washington, D.C. 20590

Re: DOT-FR-64113, Plan of Action for Task 412
DODX Rail Car Stability.

Dear Mr. Mould:

Enclosed is one copy of a Results Summary Report for the Test Operations conducted between October 8, 1974 and July 27, 1976. This report is titled "Test Results Summary for DODX Rail Car Stability Tests."

If you have any questions, please contact Mr. Ross directly.

Sincerely,

ENSCO, Inc.

Carl D. Jones
for R.D. Christian

R.D. Christian
Project Manager

WR/lfb

Encl.

cc: E. Embry
D. Gray
R. Sarvas

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1.0 INTRODUCTION

1.1 BACKGROUND

Early in 1971, the Military Traffic Management Command (MTMC) initiated efforts to determine the roll stability, wheel lift, and derailment tendency of 100-ton railcars mounted with high center-of-gravity containers. Behind this effort was the fact that railroads had been experiencing roll stability-related difficulties with this type of railcar for several years. The MTMC decided to evaluate the stability of this equipment and make modifications if required to insure acceptability for interchange service. To minimize the probability of derailment was of equal importance since the containers carried radioactive elements.

In April of 1971, stability tests were performed by the C&O/B&O Railroad on the 100-tone railcar fitted with the M130 and simulated DIG containers. Suspension modifications, which included softer springs and hydraulic stabilizers, reduced railcar response to an acceptable level. The success of these tests prompted MTMC to test other railcars of marginal stability. In September of 1972, the testing of five additional railcars was initiated. This testing, again performed by C&O/B&O Railroad, proved beneficial in determining which railcars required modification and to what extent.

By early 1974, MTMC decided that all of the railcars used for the transport of radioactive materials should be tested. This decision increased to twelve the number of railcars to be tested, including three new procurements. This report summarizes results of the tests performed on these twelve railcars.

1.2 OBJECTIVE

The purpose of these specific tests was to insure compliance of the DODX railcars for different car loadings with the Pittsburgh

Naval Reactors amended American Association of Railroads Specification D-65. This specification, entitled <u>Special Devices to Control Stability of Freight Cars</u>, requires that total carbody roll angle shall not exceed six degrees, wheel lift shall be less than 1/2 inch, and/or derailment tendency shall not be permitted. PNR amended AAR Specification D-65 is presented in Appendix A.

2.0 TEST DESCRIPTION

2.1 TEST TECHNIQUE

Testing was performed by towing the test vehicle over a section of track which had been specifically perturbed to excite the test vehicle in the roll mode. The vehicle was operated over the test section at a series of different speeds and its dynamic behavior in the roll mode, as well as other modes, was measured and observed. Testing was performed with various load configurations and, in those cases where performance did not meet the amended specification, modifications to the vehicle suspension were made. The vehicle was then retested for compliance with the modifications. The procedure was repeated until a suspension configuration was found which would provide performance compliance.

2.2 TEST ZONE

Two separate test zones were selected at the Transportation Test Center in Pueblo, Colorado. Figure 1 is a map of the test center and the test zones are delineated on the map. The first zone was located between Stations 1560 and 1580 on the Fast Track while the second zone was 1 mile south of the LIM switch on the PAD access track. Both zones are 390 feet long; however, test zone 1 consisted of bolted rail while zone 2 consisted of continuously welded rail. Twenty alternate rail joints on the bolted rail and the equivalent distance along

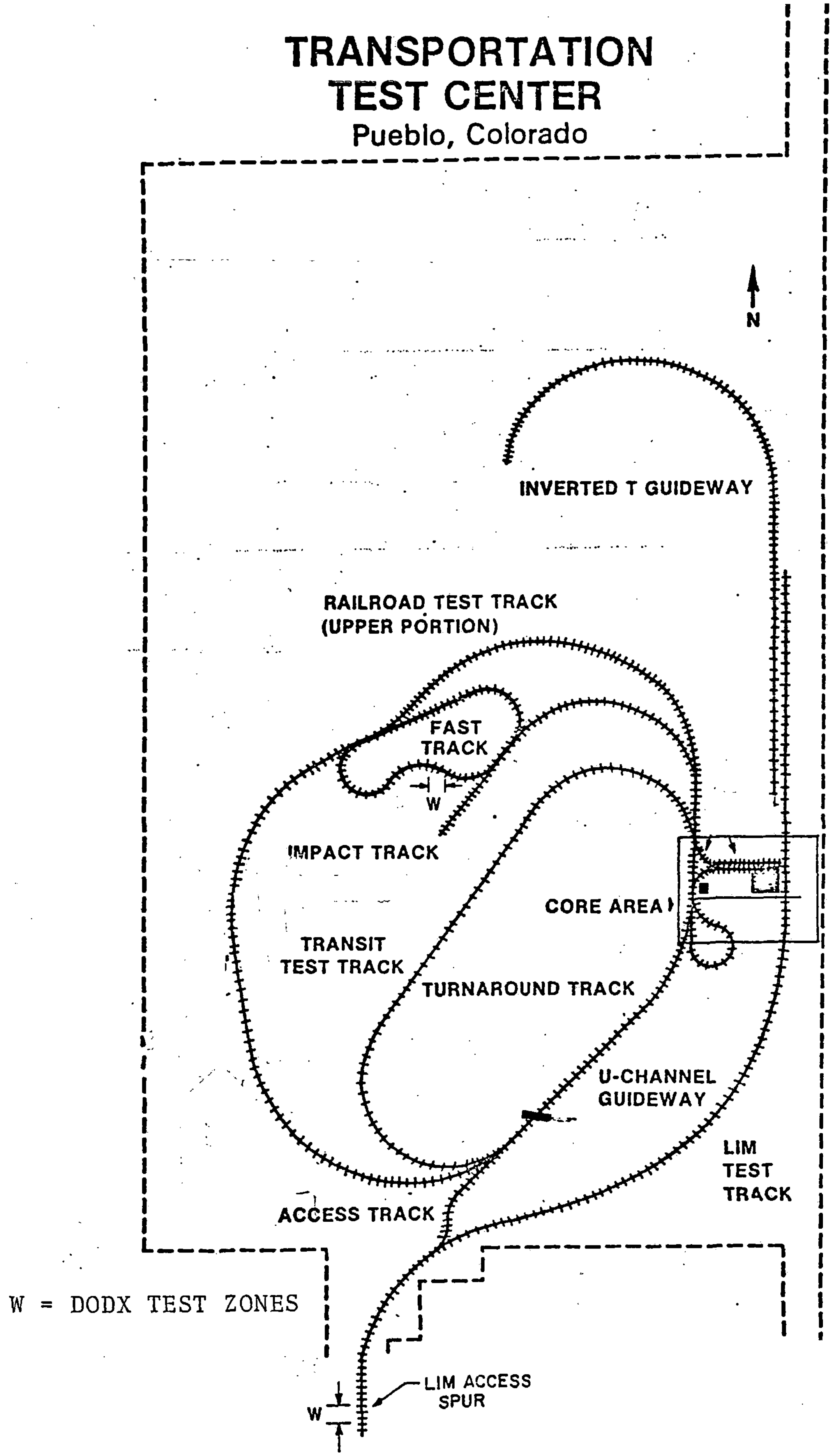


Figure 1. Map of TTC Showing Test Zones

the welded rail were shimmed to a maximum of 3/4 ±1/8 inch cross level. Figure 2 shows the shimming plan.

Figure 3 shows installation of shims while Figure 4 shows a photographic view of a test zone. The periodic variation in crosslevel produced by the shimming can be seen by careful inspection of Figure 4.

Initial testing was performed in the test zone located in the area labelled "FAST Track." However, because one of the test cars would not clear the third rail coverboard on the track leading to the "FAST Track" test zone, the second test zone was built on the PAD access track. As testing traffic at the Test Center increased, the second test zone became the preferred test zone.

2.3 TEST CONSIST

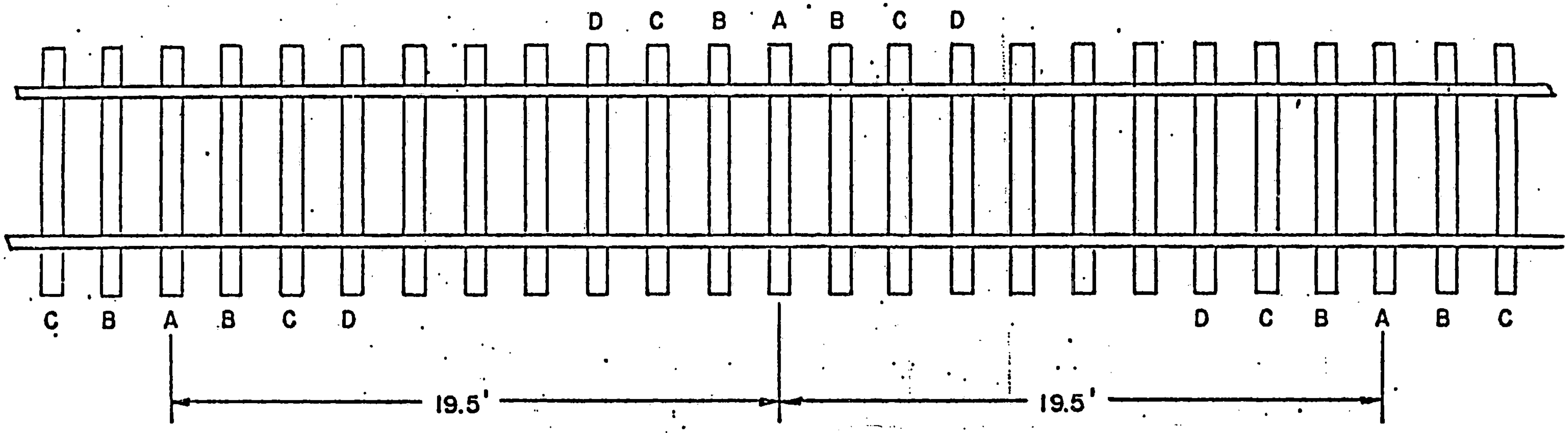
Testing was performed by placing the test vehicle in a small consist and towing it through the test zone. A typical test consist is shown in Figure 5. In this case, the consist is composed of a leading locomotive, two data collection/test support cars, the vehicle under test and a closure car. The data collection/support cars shown are the FRA track geometry cars, denoted T2 and T4. However, in later tests a special purpose data collection car, FRA's T-5, was also used.

2.4 INSTRUMENTATION

Five types of transducers were used to collect the required data. The first was a vertical reference gyroscope which measures the absolute angle of two axes referenced to a true earth vertical.

The gyroscope was oriented on the railcar body to measure the angle of the roll and pitch axes. The instrument had a range of ± 15 degrees. Three linear and three rotational accelerometers were mounted mutually perpendicular to a mounting base and attached to the railcar body. The accelerometers measured linear accelerations in the vertical, lateral and longitudinal directions and rotational accelerations in the roll, yaw and pitch axes. Potentiometer displacement transducers were used on each railcar to measure spring group travel and carbody to truck bolster travel. The number of this type transducer differed for each car depending upon the number of trucks and type of truck. The final two transducers measured train speed and location along the track. The train speed was measured by an optical tachometer connected to and driven by an axle of the data collection vehicle. The location sensor was a magnetic eddy current type which was attached to the leading truck of the test vehicle. The targets, placed opposite alternate shimmed points, were made of aluminum and were nailed to the ties.

The signals from the transducers were carried in multiconductor cable into the data collection vehicle. Initially T-2 and the support car T-4, were utilized as the data collection vehicles. Later T-5 was used, however, the data collection systems were identical. The signals from the transducers once in the data collection vehicle were conditioned and filtered by 4-pole programmable Bessel filters with a corner frequency typically of 100 Hz. Signals from the gyroscope, accelerometer, speedometer and location detector, were conditioned through units specifically designed for them. The displacement transducer signals were conditioned through amplifiers which are part of the standard data acquisition system. Once the data was filtered, it was digitized and recorded on digital magnetic tape at a sample rate of 300 samples per second.



SHIMS

A= 3/4"

B= 5/8"

C= 1/2"

D= 1/4"

Figure 2. Shimming Plan

Figure 3. Installation of Plywood Shims to Attain Crosslevel of 3/4 of an Inch

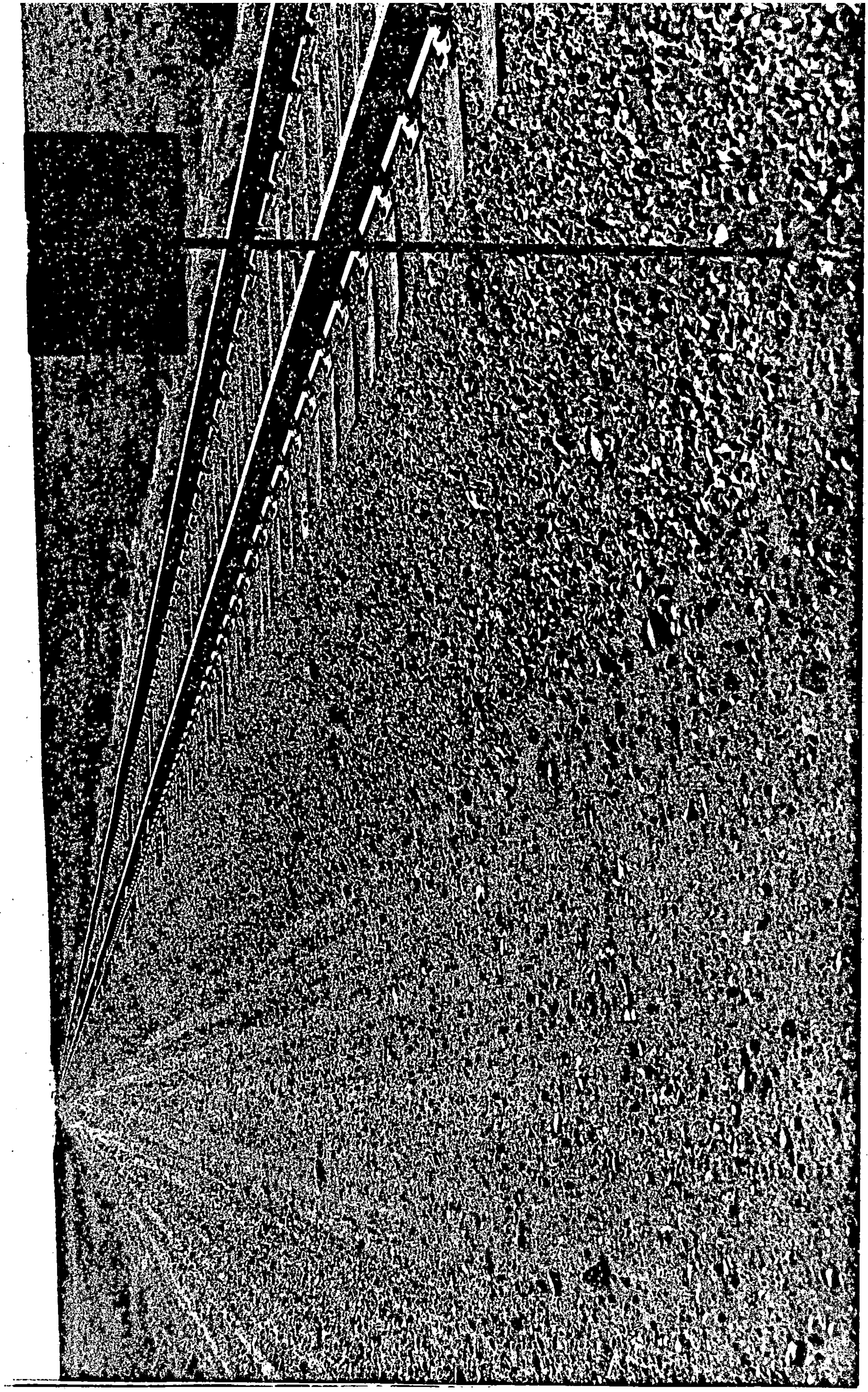


Figure 4. Pictorial View of Test Zone

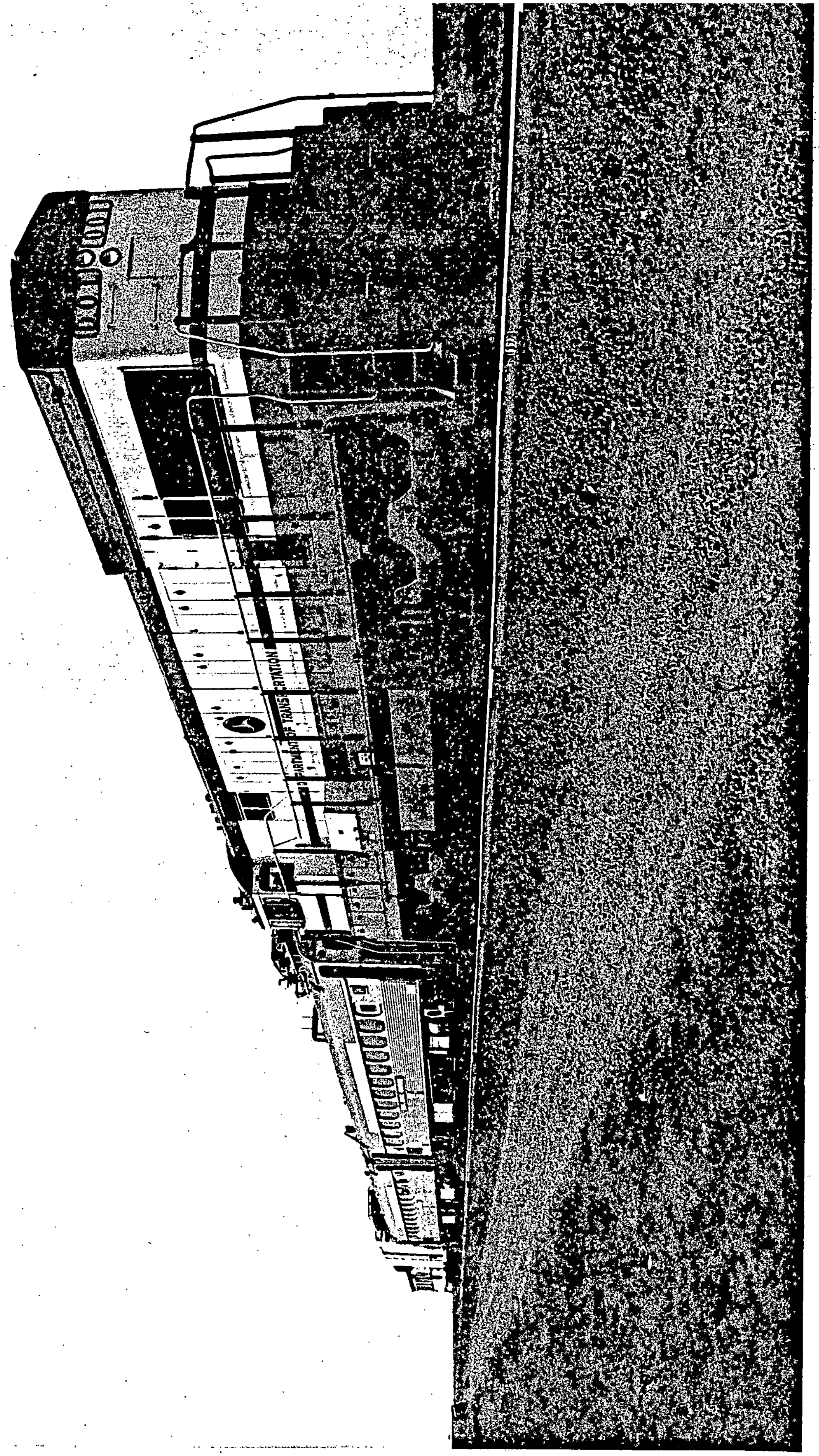


Figure 5. Test Consist with T2/T4 as Data Collection Vehicles

In addition to the transducers, two 16mm movie cameras and one video camera monitored wheel lift conditions. The video camera and one movie camera were paired and located on a common bracket hung from the steps of the data collection vehicle. The field of view included the right side of the leading truck. The remaining movie camera was installed on a bracket hung from the steps of the buffer car. Its field of view included the right side of the trailing truck. A ruler marked in 1 inch increments was placed on each side frame under observation for determination of wheel lift magnitude. The video signals were recorded for every test run while the movie cameras were used only during those test runs where lift was anticipated.

2.5 PROCEDURE

The test vehicle was towed through the test zone at a series of fixed speeds while its dynamic behavior was observed and recorded in the data collection cars. Table 1 is a general listing of the constant speeds at which the vehicle was tested. In some cases, some intermediate speeds were omitted. Individual tests begin at the lowest speed and each subsequent test was conducted at the next higher speed until the vehicle was found to be in compliance or the test was terminated. Testing was terminated if wheel lift exceeded 1/2 inch and/or carbody roll angle exceeded 6°. In the event a sequence was terminated, the additional runs were made near the resonant speed to better define vehicle behavior near resonance.

2.6 TEST VEHICLES

The 12 railcars were tested in a total of fifty different loading/suspension configurations. The 12 railcars varied from an old 50-ton boxcar with two standard 2-axle trucks to a new 300-ton flatcar with four 3-axle trucks. Table 2 lists the railcars tested.

Table 1. Test Speed Sequence

TEST RUN	SPEED INC. (m.p.h.)	TEST SPEED (m.p.h.)
01	5	5
02	5	10
03	2	12
04	2	14
05	2	16
06	2	18
07	2	20
08	2	22
09	2	24
10	2	26
11	2	28
12	2	30
13	2	32
14	2	34
15	2	36

Table 2. Description of Cars Tested

DODX No.	Type	Load Rating
26152	Boxcar	50 tons
39803	Depressed Center flatcar	150 tons
38851	Deep well car	90 tons
39551/39502	Flatcar	80 tons
21027	Flatcar	50 tons
39837	Depressed center flatcar	150 tons
38864	Flatcar with container	150 tons
39899	Flatcar	300 tons
38664/38444	Flatcar	100 tons
900	Caboose	N/A
39913	Flatcar	300 tons
29011	Boxcar	~~70~~ 50 tons

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2.7 LOAD SIMULATION

Simulated loading was implemented with timbers and weights made of concrete and steel. Two of the railcars, Nos. 39551 and 38864, had special containers attached. The containers where applicable and the simulated load were used to model actual in-service loading conditions of the railcars. Figure 6 illustrates a typical load used during the testing program. Wire rope cabling and blocking were used to minimize load shifting during test runs and logistic moves.

2.8 SUSPENSION MODIFICATIONS

The suspension components that were modified or changed during the test were the truck springs, hydraulic stabilizer, and side bearings. In some cases compliance to the amended specification was achieved by reducing the effective truck spring constant. This was achieved by either removing springs or replacing with softer springs such as D-4's in place of D-3's and D-5's in place of D-4's. This modification was not of major consequence, since a basic load-carrying capacity had to be retained to conform to other AAR requirements.

The second suspension component modification was the addition of a hydraulic stabilizer. One stabilizer was placed in an outboard location of each of the spring groups, replacing one of the springs. This unit provides viscous damping through a major portion of the compression stroke of the spring group. This stabilizer came with different ratings for different load-carrying capacity trucks. The modification provided some reduction in the carbody roll angle.

The third suspension component change was the addition of resilient side bearings to the standard truck bolster side-bearing pocket. The modification provided essentially constant contact between the truck bolster and the carbody. This modification did reduce the magnitude of carbody roll angle and wheel lift in most cases.

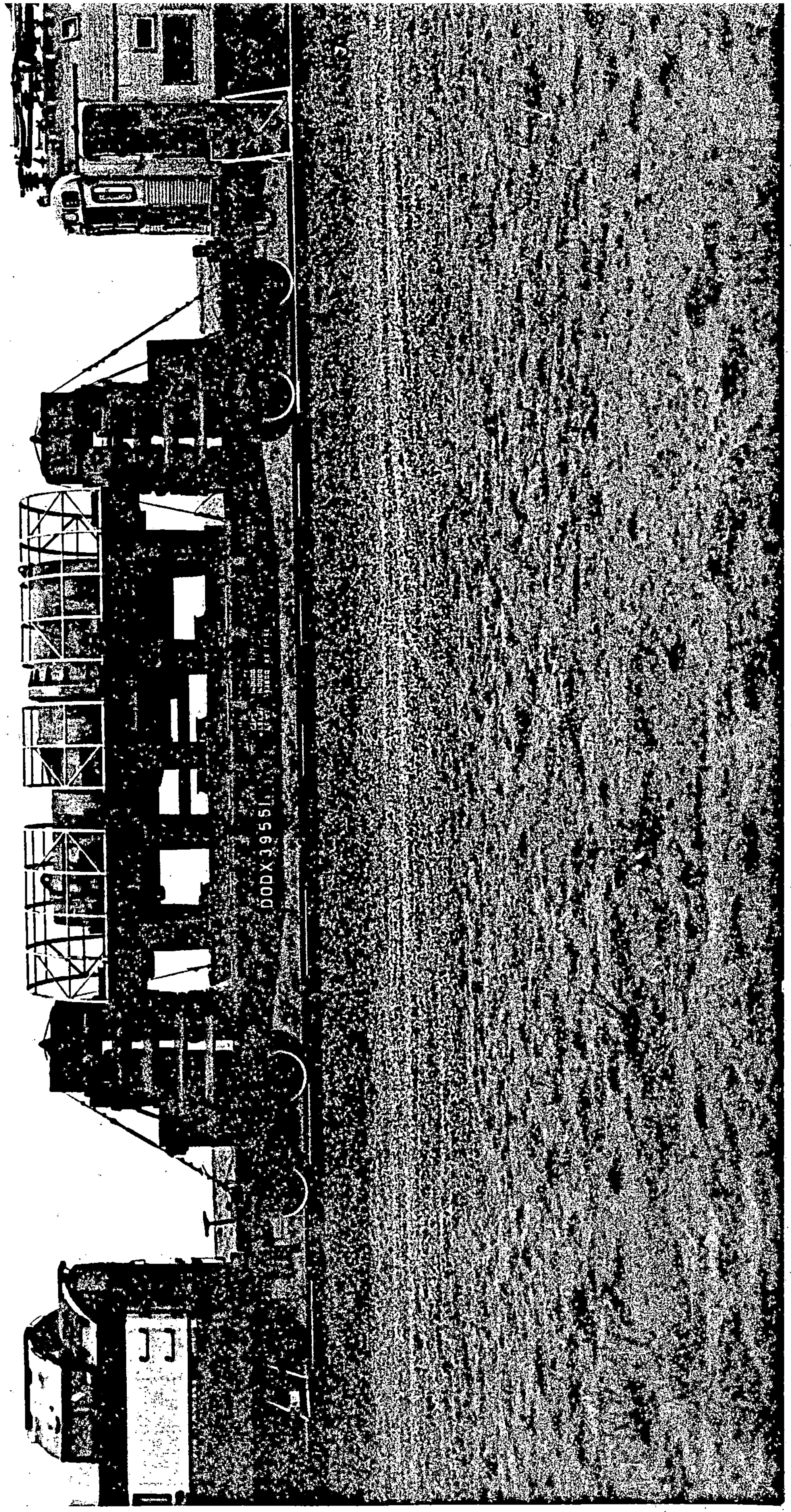


Figure 6. Typical Simulated Load

Table 3

DODX RAILCAR STABILITY PROGRAM TESTING SUMMARY

REVISED NOVEMBER 17, 1976

DATE	DODX NO.	SPRING CONFIGURATION	LOAD CONFIGURATION	RESONANT SPEED (MPH)	MAXIMUM ROLL ANGLE (DEGREES P-P)	WHEEL LIFT (INCHES)
10-18-74	26152	Four D-4 Outer and HS-6B Stabilizer.	23,520# @ 22" ATC	28	3.8	1/4
10-18-74	26152	Four D-4 Outer, HS-6B Stabilizer, Resilient Side Bearings.	23,520# @ 22" ATC	34	2.6	0
10-21-74	26152	Four D-4 Outer, HS-6B Stabilizer, Resilient Side Bearings.	Empty	32.5	3.2	0
10-22-74	26152	Four D-4 Outer and HS-6B Stabilizer.	Empty	27	5.4	1/4
10-25-74	26152	Five D-3 Outer, Three D-3 Inner.	Empty	26+	6.4	0
11-09-74	39803	Six D-4 Outer, Six D-4 Inner, HS-6 Stabilizer.	Empty	26	1.2	0
11-15-74	38851	Six D-5 Outer, Six D-5 Inner, Two Special Outer, Two Special Inner, Six Secondary Inner at heavy end and HS-6 Stabilizer.	Empty	35+	2.2	0
11-22-74	39803	Six D-4 Outer, Six D-4 Inner, HS-6 Stabilizer.	212,337# @ 79.8" ATC	26	1.8	0
11-25-74	39803	Seven D-3 Outer, Seven D-3 Inner.	212,337# @ 79.8" ATC	26	3.8	3/4
12-07-74	38851	Six D-5 Outer, Six D-5 Inner, Two Special Outer, Two Special Inner, Six Secondary Inner at heavy end and HS-6 Stabilizer.	141,250# @ 60" ATC	22	3.4	0

Table 3

DODX RAILCAR STABILITY PROGRAM TESTING SUMMARY

REVISED NOVEMBER 17, 1976

12-10-74	38851	Six D-5 Outer, Six D-5 Inner, Two Special Outer, Two Special Inner, Six Secondary Inner at heavy end and HS-6 Stabilizer.	141,250# @ 65" ATC	21	3.4	0
12-11-74	38851	Six D-5 Outer, Six D-5 Inner, Two Special Outer, Two Special Inner, Six Secondary Inners at heavy and light end and HS-6 Stabilizer.	141,250# @ 65" ATC	20	4.0	0
12-13-74	38851	Six D-5 Outer, Six D-5 Inner, Two Special Outer, Two Special Inner, Six Secondary Inner at heavy and light end and HS-6 Stabilizer.	Empty	35+	3.4	0
12-18-74	39551	Six D-4 Outer, Four D-3 Inner, HS-6 Stabilizer.	Empty with Container	23	6.0	1.0
12-20-74	39502	Six D-4 Outer, Four D-3 Inner	Empty	35+	2.4	0
01-06-75	39551	Six D-4 Outer, Four D-3 Inner, New HS-6 Stabilizer.	Empty with Container	22+	6.8	1-7/8
01-08-75	39551	Five D-4 Outer, Five D-4 Inner, New HS-6 Stabilizer.	Empty with Container	22+	5.8	1-1/4
01-13-75	21027	Four D-4 Outer, Four D-4 Inner, HS-6B Stabilizer.	Empty	35+	3.6	0
01-15-75	21027	Four D-4 Outer, Four D-4 Inner, HS-6B Stabilizer.	11,550# @ 65" ATC	27+	5.2	1.0
01-24-75	21027	Four D-4 Outer, Two D-4 Inner, HS-6B Stabilizer.	11,550# @ 65" ATC	27	4.5	1/4
01-24-75	21027	Four D-4 Outer, Two D-4 Inner, HS-6B Stabilizer, Resilient Side Bearings.	11,550# @ 65" ATC	30+	1.9	0

Ta le 3

DODX RAILCAR STABILITY PROGRAM TESTING SUMMARY

REVISED NOVEMBER 14, 1976

06-04-75	39899	Four D-3 Outer, Four D-3 Inner, HS-7 Stabilizer.	502,786# @ 64.5" ATC	16	2.3	0
06-09-75	38664	Three D-3 Outer, Three D-3 Inner, Cardwell Snubber.	30,680# @ 49" ATC	26	4.2	1/8
06-17-75	38444	Three D-3 Outer, Three D-3 Inner, HS-6B Stabilizer.	164,593# @ 47.4" ATC	18	4.7	0
06-18-75	900	Standard spring and Side Bearings.	Empty	16	1.1	0
06-19-75	900	Standard springs with Resilient Side Bearings.	Empty	16	1.1	0
06-19-75	900	Standard springs with Resilient Side Bearings, modified 'narrow' Coupler Key.	Empty	16	1.2	0
06-23-75	38444	Three D-3 Outer, Three D-3 Inner, HS-6B Stabilizer.	82,868# @ 61.8" ATC	19	5.3	1/4
06-25-75	38444	Three D-3 Outer, Three D-3 Inner, HS-6B Stabilizer.	30,960# @ 48.6" ATC	26	4.0	0
06-27-75	39502	Five D-4 Outer, Four D-3 Inner, HS-6 Stabilizer, Resilient Side Bearings.	82,868# @ 61.8" ATC	22	4.3	1/8
07-01-75	39551	Five D-4 Outer, Four D-3 Inner, HS-6 Stabilizer.	Empty with Container	26	3.8	1.5
07-08-75	21027	Four D-4 Outer, Two D-4 Inner, HS-6B Stabilizer, Resilient Side Bearings.	72,245# @ 48.4" ATC	18	2.2	0
07-09-75	39551	Five D-4 Outer, Four D-3 Inner, HS-6 Stabilizer.	124,225# @ 56.6" ATC	24.5	3.4	1/2

NOTE: '+' notation used in resonant speed data indicated that no data was taken above that speed and, therefore, an exact resonant speed for the particular configuration cannot be determined.

Table 3

DODX RAILCAR STABILITY PROGRAM TESTING SUMMARY

REVISED NOVEMBER 17, 1976

02-03-75	39551	Five D-4 Outer, Five D-4 Inner, New HS-6 Stabilizer.	134,140# @ 68" ATC with Container	20+	4.8	1.0
02-07-75	21027	Four D-4 Outer, Two D-4 Inner, HS-6B Stabilizer.	72,245# @ 48.4" ATC	19	3,4	0
02-14-75	21027	Four D-4 Outer, Two D-4 Inner, HS-6B Stabilizer.	Empty	35+	3,6	0
02-15-75	39551	Five D-4 Outer, Five D-4 Inner, New HS-6 Stabilizer.	123,245# @ 53.7" ATC with Container	20+	4,8	7/8
02-24-75	39551	Five D-4 Outer, Four D-3 Inner, New HS-6 Stabilizer, Resilient Side Bearings.	123,245# @ 53.7" ATC with Container	25	3.4	0
02-26-75	39551	Five D-4 Outer, Four D-3 Inner, New HS-6 Stabilizer, Resilient Side Bearings.	134,140# @ 68" ATC with Container	23	3,5	1/4
02-26-75	39551	Five D-4 Outer, Four D-3 Inner, New HS-6 Stabilizer, Resilient Side Bearings.	Empty with Container	27	3.5	3/4
05-05-75	39837	Six D-4 Outer, Six D-4 Inner, HS-6 Stabilizer.	Empty	35+	1.4	0
05-12-75	39837	Six D-4 Outer, Six D-4 Inner, HS-6 Stabilizer.	216,635# @ 78" ATC	19	2,3	0
05-14-75	39837	Six D-4 Outer, Six D-4 Inner, HS-6 Stabilizer.	281,260# @ 78" ATC	18	2,6	1/4
05-22-75	38864	Four D-4 Outer, Four D-4 Inner, HS-6 Stabilizer.	30,180# @ 78" ATC	23	3.4	0
05-31-75	39899	Four D-3 Outer, Four D-3 Inner, HS-7 Stabilizer.	209,220# @ 54" ATC	21	4,5	0

Table 3

DODX RAILCAR STABILITY PROGRAM TESTING SUMMARY

REVISED NOVEMBER 17, 1976

05-07-76	39913	Four D-3 Outers and Inners, HS-7 Stabilizer	528,995# @ 65" ATC	17	2.2	0
05-14-76	39913	Four D-3 Outers and Inners, HS-7 Stabilizer	201,895# @ 57" ATC	23	2.9	0
05-24-76	39913	Four D-3 Outers and Inners, HS-7 Stabilizer	Empty	28	1.4	0
07-13-76	29011	~~Four~~ Six D-5 Outers and Five D-5 Inners, HS-7 Stabilizer	101,000# @ 49.5" ATC	22	3.2	0
07-27-76	29011	~~Four~~ Six D-5 Outers and Five D-5 Inners, HS-7 Stabilizer	Empty	28	4.7	0

Revised 3/31/77

3.0 DATA REDUCTION AND PRESENTATION

Real-time data reduction was performed by monitoring six selected transducer outputs on the Brush recorder in the data collection vehicle. The maximum values of carbody roll angle versus speed were hand plotted after each test run so that the decision to continue testing could be made. Also, the video monitor was observed during the test run so that occurrence of wheel lift and its magnitude could be noted. At the completion of the day's runs all recorded data was reproduced on the six channel Brush chart. The maximum peak-to-peak values measured by the gyroscope, accelerometers and displacement transducers were determined for each test run, and this data was tabulated. This information was subsequently plotted versus the speed of the test run. The resulting plots and tables were presented in the specific test results report for each railcar. Typical carbody roll angle plots are found in Appendix B of this report.

Wheel lift was monitored in real-time as noted; however, the simultaneous video recordings were played back several times immediately after each run to obtain a better estimate of maximum lift. Likewise, the movie films were developed and reviewed to more precisely establish the amplitude of the observed wheel lift. While the video system provided real-time information, the movie films provided the best estimate for determining wheel lift amplitude because of the resolution provided during stop-action examination. The final, reported value of wheel lift for each configuration was determined from examination of the films.

4.0 RESULTS

4.1 GENERAL

Twelve vehicles in a total of 50 configurations were tested for compliance with the PNR amended AAR Specification D-65. Table 3 delineates the individual test efforts as to date, test vehicle

vehicle number, suspension and load configuration, resonant speed, maximum roll angle and wheel lift.

A substantial number of the test configurations met or exceeded the specification without modification to the spring group or stabilizers, or installing resilient sidebearings. In those cases where a standard configuration failed to meet the specifications, specific modifications were implemented and the vehicle retested. This procedure was repeated until acceptable results were obtained.

The following sections summarize the test results for each of the vehicles.

4.2 DODX 26152 (50-Ton Boxcar)

A total of five tests were conducted on this car which, with standard load and suspension, easily met the amended specification. In addition to the standard configuration tests, tests to evaluate the effects of elastic sidebearings and stiffer springs were also conducted. The elastic sidebearings subsequentially reduced the maximum roll angle on both loaded and empty configurations. The stiffer springs on an empty configuration produced a roll angle which was outside the 6° maximum but did not produce wheel lift.

Test #	Objective	Max Roll Angle	Wheel Lift	Comments
* 1	Compliance testing with 23% of rated load and standard suspension	3.8°	1/4	Met specification
2	Evaluate effect of resilient sidebearings	2.6°	0	Decreased roll angle
3	Determine characteristics of empty vehicle with standard suspension	5.4°	1/4	Near roll angle limit
* 4	Evaluate effect of resilient sidebearings on empty vehicle	3.2°	0	Decreased roll angle reasonable level
5	Evaluate effect of stiffer spring rate on empty vehicle	6.4°	0	Roll angle outside specification

* Beginning of new test load configuration

4.3 DODX 39803 (150-Ton Depressed Center Flatcar)

Three tests, two with standard load and suspension and one with modified suspension, were conducted. The two standard tests produced results which were in compliance. The stiffer, modified suspension, which was installed to produce worst case behavior, caused excessive wheel lift.

Test #	Objective	Roll Angle	Wheel Lift	Comments
*1	Compliance test of standard, empty car	1.2°	0	Compliant
*2	Compliance test of standard car loaded to 71% of rated	1.8°	0	Compliant
3	Much stiffer suspension	3.8°	3/4"	Excessive wheel lift

*Beginning of new test load configuration

4.4 DODX 38851 (90-Ton Deep-Well Car)

Three tests with standard suspension and loads, and two tests with modified suspension, were conducted. All produced results which met the amended specification.

Test #	Objective	Roll Angle	Wheel Lift	Comment
*1	Compliance testing with standard suspension, empty car	2.2°	0	O.K.
*2	Compliance testing with standard suspension, rated load	3.4°	0	O.K.
3	Same load, center of gravity raised 5"	3.4°	0	Raising c.g. 5" produced no change.
4	Spring rate at light end increased	4.0°	0	Roll angle increased 0.6°
*5	Empty car with stiffer springs at light end of car	3.4°	0	Roll angle increased 1.2°

*Beginning of new test load configuration

4.5 DODX 39551/39502 (80-Ton Flatcar With Container)

This vehicle required the largest number of tests, twelve, of the test series. Compliant results were ultimately achieved for all configurations with the exception of the car-with-empty-container. The initial test was conducted with no load and the container in place. It produced a 6° roll angle and 1 inch wheel lift which is outside specification. The test was repeated with a new hydraulic stabilizer, and the results were worse, with 6.8° roll angle and 1 7/8 inches wheel lift.

A third test was conducted with slightly decreased spring rate. Although this reduced the roll angle to 5.8° and wheel lift to 1 1/4 inches, the wheel lift was still unacceptable. Resilient sidebearing, and slightly softer suspension were then installed and tested. The results were a very close to meeting specification with a roll angle of 3.6° and wheel lift of 3/4 inches. A final test with resilient side-bearings and with the previously decreased spring rates, achieved by removing one outer spring in each group, again produced a result which was out of compliance. No further efforts were made to improve performance for this load configuration.

The car-with-container was then loaded to 84% of rated load and the standard suspension modified to reduce the spring rate slightly. The results were a roll angle of 4.8° and an out of compliance wheel lift of 1 inch. This load configuration was then retested with slightly softer suspension. The results were acceptable with a roll angle of 3.5° and 1/4 inch wheel lift.

The next load configuration tested was with the container at 77% of rated load and with slightly softened suspension. The results were marginal, and resilient sidebearings along with standard inner springs were then installed and tested. This resulted in no wheel lift and a roll angle of 3.4°. As a supplemental test, the test was repeated without resilient sidbearings. The results were just out of compliance because of 0.5 inches of wheel lift.

A load of 51% of rated, no container, resilient sidebearing and slightly softened standard spring rate were tested. The results were within satisfactory limits.

Test #	Objective	Roll Angle	Wheel Lift	Comments
*1	Compliance testing for empty-with-container configuration	6°	1"	Out of compliance
2	Replaced hydraulic stabilizer	6.8°	1 7/8"	Worse
3	Decreased spring rate	5.8°	1 1/4"	Some improvement
4	Resilient sidebearings and slightly softer than standard spring rate	3.6°	3/4"	Just out of compliance
5	Slightly softer than standard spring rate	3.8°	1 1/2"	Out of Compliance
*6	Compliance testing of no-container, empty car	2.4°	0	O.K.
*7	Car/container loaded to 84% for standard compliance test	4.8°	1"	Out of compliance
8	Slightly softened standard suspension	3.5°	1/4"	O.K.
*9	Car/container loaded to 77% and softened standard suspension	4.8°	7/8"	Marginal
10	Resilient sidebearing with standard inner springs	3.4°	0	Much improved
11	Supplemental test with resilient sidebearings removed	3.4°	1/2"	Marginal
*12	Testing with container 52% load; resilient sidebearings	4.3°	1/8"	O.K.

*Beginning of new test load configuration

4.6 <u>DODX 21027 (50-Ton Flatcar)</u>

The initial test on this car was with standard suspension and no load. The test results were well within the specification. When the spring rate was decreased slightly and the vehicle re-tested, no change in performance was seen.

The car was then loaded to 12% of capacity (11,550#) and the result was wheel lift of 1" and a near maximum permissible roll angle. The effective spring rate was then decreased slightly by removing two D-4 inner springs in each spring group and the configuration provided test results which met the specification. The same configuration was then tested with the addition of resilient sidebearings which produced a dramatic decrease in roll angle from 4.5° to 1.9° and also eliminated the previously measured 1/4" of wheel lift.

The suspension was then reconfigured to the softened spring rate and the car was loaded to 72% of rated load (72,245#). This proved to be a stable combination which provided acceptable results.

Test #	Objective	Roll Angle	Wheel Lift	Comments
*1	Compliance testing for empty vehicle with standard suspension	3.6°	0	OK
2	Slightly decreased spring rate	3.6°	0	Roll angle decreased significantly
*3	As above except loaded to 11% of rated load	5.2°	1	Out of compliance
4	Slightly decreased spring rate	4.5°	1/4	Passible;decreased spring rate helped
5	Decreased spring rate and resilient sidebearings	1.9°	0	Much improved performance
*6	Loaded to 72% of rated with softened suspension	3.4°	0	Satisfactory

* Beginning of new test load configuration

4.7 DODX 39837 (150-Ton, Depressed Center Flatcar)

Three configurations were tested, one empty and two with loads. All three tests produced results which were within acceptable maximums although slight wheel lift occurred with the larger load of 281,260 pounds. No suspension modifications were investigated.

Test #	Objective	Roll Angle	Wheel Lift	Comments
*1	Compliance testing of empty vehicle	1.4°	0	Met specification
*2	Compliance vehicle at approximately 72% of maximum load	2.3°	0	"
*3	Compliance testing at approximately 94% of max. load	2.6°	1/4"	"

*Beginning of new test load configuration

4.8 DODX 38864 (150-Ton With Container)

A single loaded test was conducted. The maximum roll angle of 3.4° was well below the specified maximum of 6° and no wheel lift was observed.

Test #	Objective	Roll Angle	Wheel Lift	Comment
1	Compliance testing at 10% max load	3.4°	0	Met specification

4.9 DODX 39899 (300-Ton Flatcar)

This vehicle was tested with standard suspension in two load configurations of 35% and 84% of rated load. Both tests produced results which were well within specification and no modifications to the car were made.

Test #	Objective	Roll Angle	Wheel Lift	Comment
*1	Compliance testing with 35% load	4.5°	0	Acceptable
*2	Compliance testing with 84% load	2.3°	0	"

*Beginning of new test load configuration

4.10 DODX 38664/38444 (100-Ton Flatcar)

In addition to compliance testing the vehicle with 15% of rated load and standard suspension, testing was conducted with modified suspension at 41% and 82% loading. All four configurations met the specification.

Test #	Objective	Roll Angle	Wheel Lift	Comments
*1	Testing for compliance with standard suspension (friction snubber) and 15% of rated load	4.2°	1/8"	Met specification
2	Comparison of hydraulic stabilizer with friction snubber performance	4.0°	0	Hydraulic unit results compared favorably with friction snubber
*3	Hydraulic stabilizer; 82% rated load	4.7°	0	Met specification
*4	Same as (3) except 41% load	5.3°	1/4"	Approaching specification limit of roll and lift

*Beginning of new test load configuration

4.11 DODX 900 (Caboose)

Three tests, all with the vehicle empty, were conducted. The first test was conducted with standard suspension, test two with resilient sidebearing and test three with resilient sidebearings and loose coupler keys. The standard suspension produced among the lowest roll angles, 1.1°, of any vehicle in this test series. The resilient sidebearing and loose coupler keys produced no significant changes in roll angle. No wheel lift was detected in any of the tests.

Test #	Objective	Roll Angle	Wheel Lift	Comments
1	Test with standard load and suspension	1.1°	0	Very low roll angle
2	Evaluate effect of resilient sidebearings	1.1°	0	
3	Evaluate combined effects of resilient sidebearings and loose coupler keys	1.2°	0	

4.12 DODX 39913 (300-Ton Flatcar)

This vehicle exhibited modest roll angles and no wheel lift in three load configurations, empty, 34% and 88% of full load rating of 300 tons. Its performance easily met the specification. No suspension or other vehicle modifications were investigated.

Test #	Objective	Roll Angle	Wheel Lift	Comment
*1	88% load	2.2°	0	Met specification
*2	34% load	2.9°	0	"
*3	Empty	1.4°	0	"

*Beginning of new test load configuration

4.13 DODX 29011 (50 TON BOXCAR)

Only two tests were conducted, one with an empty car and the second with a 101,000# load, both with unmodified suspensions. Both tests produced maximum roll angles which were within specification and no wheel lift was observed. Modified suspensions were not investigated.

Test #	Objective	Roll Angle	Wheel Lift	Comment
*1	Compliance test 100% loaded vehicle	3.2°	0	Met specification
*2	Compliance test loaded vehicle	4.7°	0	Met specification

*Beginning of new test load configuration

4.13 DODX 29011 (~~70~~ 50-Ton Boxcar)

Only two tests were conducted, one with an empty car and the second with a ~~71%~~ (101,000#) load, both with unmodified suspensions. Both tests produced maximum roll angles which were within specification and no wheel lift was observed. Modified suspensions were not investigated.

Test #	Objective	Roll Angle	Wheel Lift	Comment
*1	Compliance test ~~71%~~ 100% loaded vehicle	3.2°	0	Met specification
*2	Compliance test unloaded vehicle	4.7°	0	Met specification

*Beginning of new test load configuration

Revised 3/31/77

APPENDIX A

SPECIAL DEVICES TO CONTROL STABILITY OF FREIGHT CARS

APPENDIX A

SPECIAL DEVICES TO CONTROL STABILITY OF FREIGHT CARS
D-65-Amended

I. Scope. These specifications cover testing and performance requirements for trucks or other special devices to control car stability.

II. Test Conditions. The tests shall be conducted using rail cars specified. This test will be run over a track section as specified below.

A. Description of the test cars.

1. Car shall be loaded to specified loads to obtain the desired center of gravity.

2. Where conventional side bearings are used the side bearing clearance shall be 3/16" minimum to 1/4" maximum.

3. Outside wheel rims to be painted white.

B. Test track conditions.

1. The track is to be laid to 4' 8 1/2" gage with 39' rails of 100 lb. section or heavier with joints uniformly staggered at approximately 19' 6", on a good tie and ballast support. Outside face of high rail head to be painted white.

2. The tangent track for the distance in which the test trains will be operated approaching the shimmed joints shall have the joint condition and crosslevel maintained to avoid excessive car roll.

3. The rail shall be shimmed opposite 20 consecutive joints to within 1/16" of 3/4" low joint condition. A re-check of the cross-level shall be made as often as required to maintain the test conditions uniformly.

III. Instrumentation. The test car shall be fitted with the following instrumentation to check various conditions developed in the test car during the runs over the test track:

A. A vertical reference gyro to placed on the longitudinal center line of the car, preferably on the center sill, near the body bolster of the car to measure angular displacement of the car body.

Specification for Vertical Reference Gyro:

1. Roll angle minimum $\pm$ 15 deg.
2. Erection rate 2 deg. to 8 deg. per minute.
3. Accuracy 0.15 deg. of true vertical.
4. Pickoff resolution 1/8 deg. or better.
5. Potentiometer linearity 1% or better.

B. Accelerometer to measure angular accelerations about the roll, yaw and pitch axes and linear accelerations about the vertical, lateral and longitudinal axes are to be mounted on the car body. Specifications for these accelerometers are:

1. Roll accelerometer range ± 5 radians/sec^2.
2. Yaw and Pitch accelerometer range ± 1 radian/sec^2.
3. Vertical, lateral and longitudinal accelerometer range ± 1 g.
4. Accuracy $\pm 1\%$ of full scale.

C. Cable Potentiometers to measure spring group and carbody to bolster deflection. Specifications are:

1. Linearity of 1% or better.
2. Range of ± 5 inches.

D. Motion picture camera (or equivalent) shall be installed to view the lead wheel of the lead truck and the rear wheel of the rear truck and shall be capable of showing any wheel lift or wheel climb in relation to the rail.

IV. Running Tests.

A. Test train consist. The test train shall consist of the following locomotives and cars in the order presented:

1. Locomotive.
2. Instrumentation Car.
3. Observation Car (optional).
4. Test car or cars including base (control car).
5. Trailing car which should be a loaded car of at least 77 ton capacity.
6. Caboose or other car to complete train consist if desired.

B. The test train shall be run over the prepared section of track at speeds beginning at approximately 5 mph and 10 mph and then running in increments at about 2 mph through the critical speed up to a limit of about 35 mph. The speeds shall be accurately measured by instrumentation in the instrument car. It may be desireable to repeat runs at any speed, particularly within the critical speed range to establish precisely the action of the car in the critical range.

V. Specifications.

A. The test car when operated under the conditions of "IV. Running Tests" shall not show excessive roll, wheel lifting or derailment tendency. The limits and definitions of these parameters are as follows:

1. The total roll angle as determined by the gyro shall not exceed 6 deg.

2. Wheel lifting shall be defined as "slight" up to 1/2"; "small" from 1/2" to 1"; "medium" from 1" to 2"; "large" above 2". Wheel lifts if developed shall be restricted to "slight".

3. The derailment tendency is determined by the action whereby the flange rides on the head of the rail for any distance during the test. This shall not be permitted and will be cause for rejection of any device.

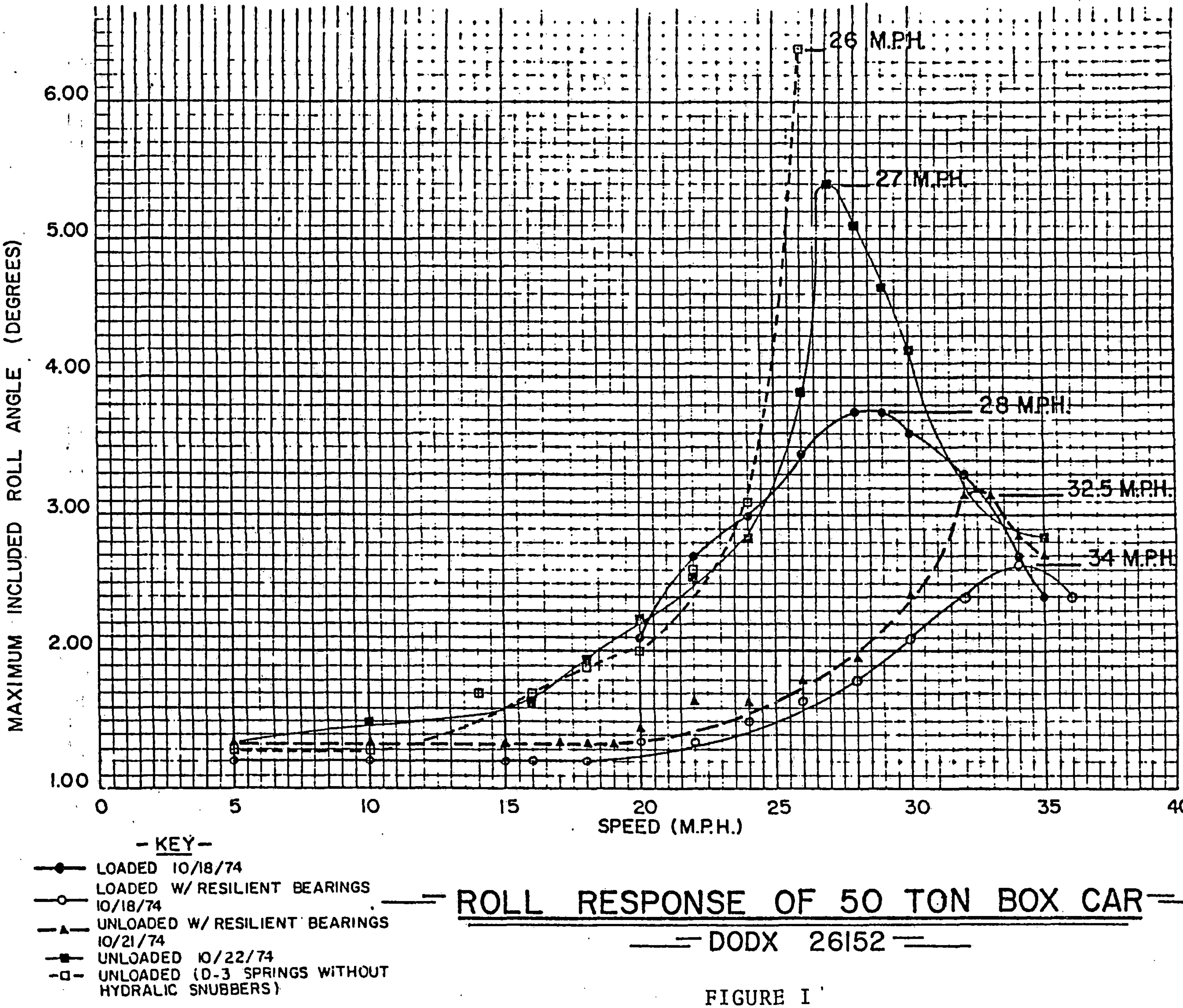
B. The data developed from instrumentation will be used to determine the roll angle, wheel lift and derailment tendencies of the car.

APPENDIX B

CARBODY ROLL ANGLE RESPONSE PLOTS

CARBODY ROLL ANGLE RESPONSE PLOTS

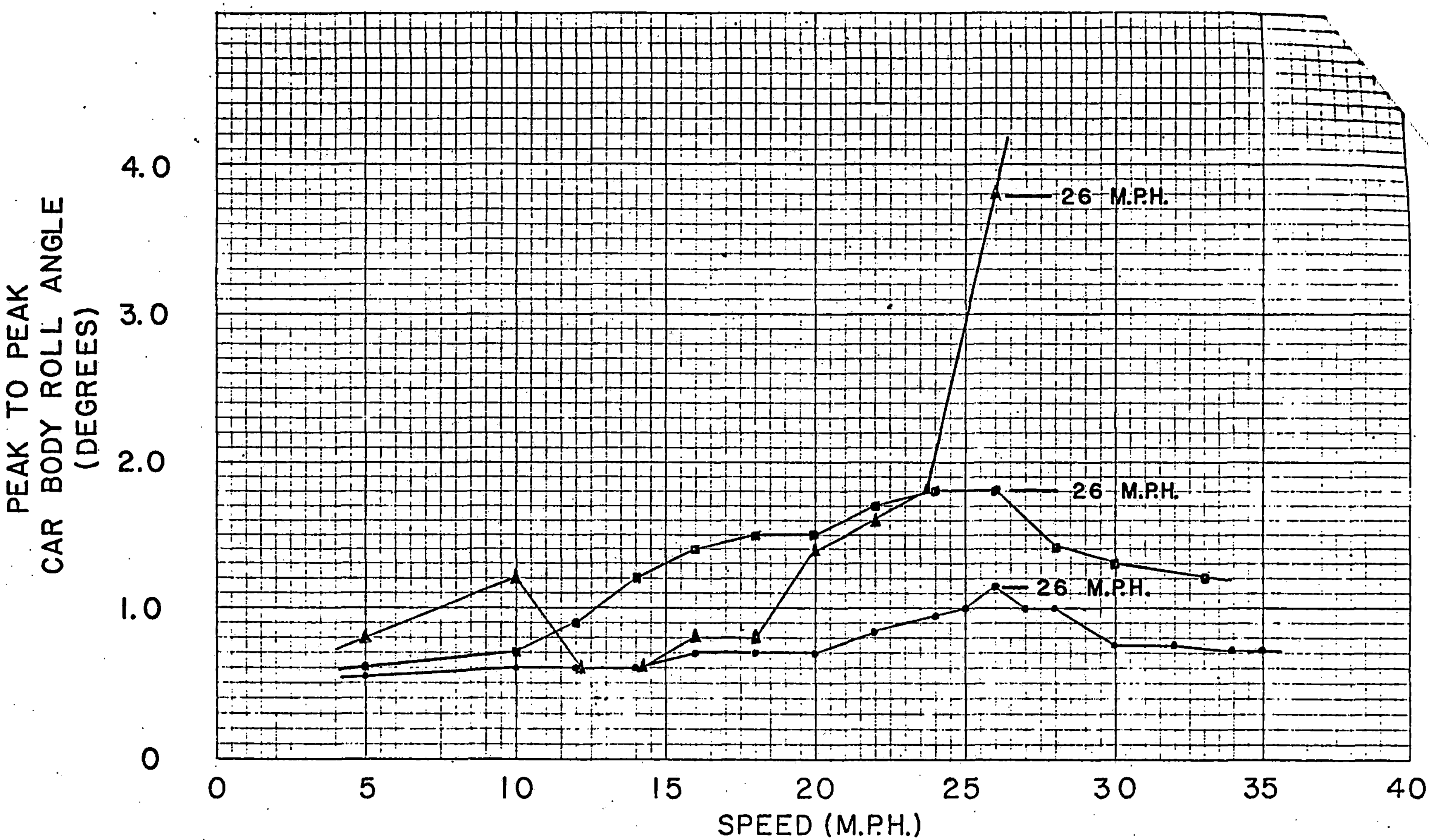
These carbody roll angle response curves are plots of the maximum peak to peak carbody roll angle observed on a test run versus the speed of that test run. These curves, for each configuration tested, are plotted on the same graph for that particular railcar. The configuration information, if not presented adequately in the key of the graph, can be found in Table 2 of this report.



ROLL RESPONSE OF 50 TON BOX CAR

DODX 26152

FIGURE I



KEY

UNLOADED 11/9/74

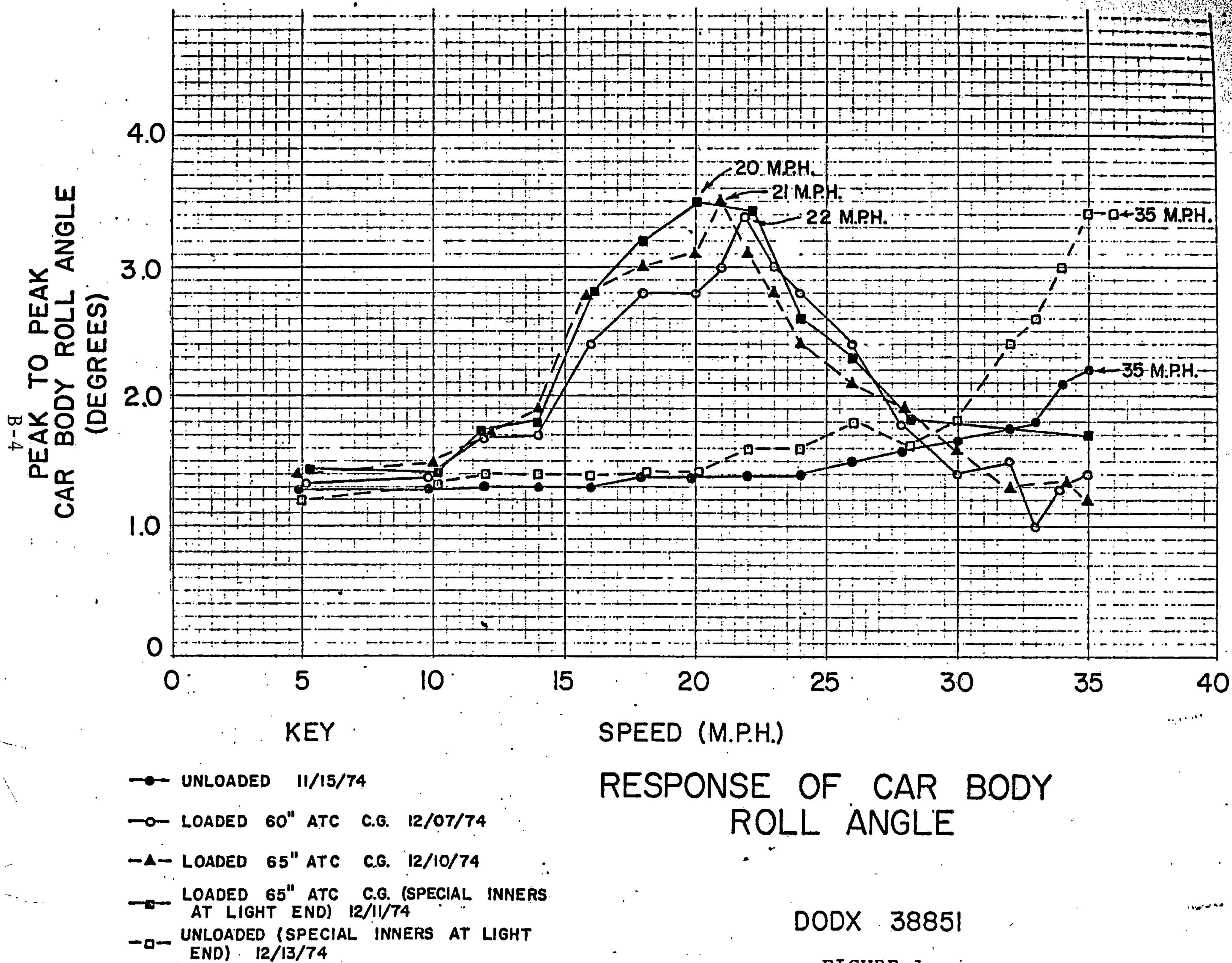
LOADED 11/22/74

LOADED (D-3 SPRINGS WITHOUT HYDRAULIC SNUBBERS) 11/25/74

RESPONSE OF CAR BODY ROLL ANGLE

DODX 39803

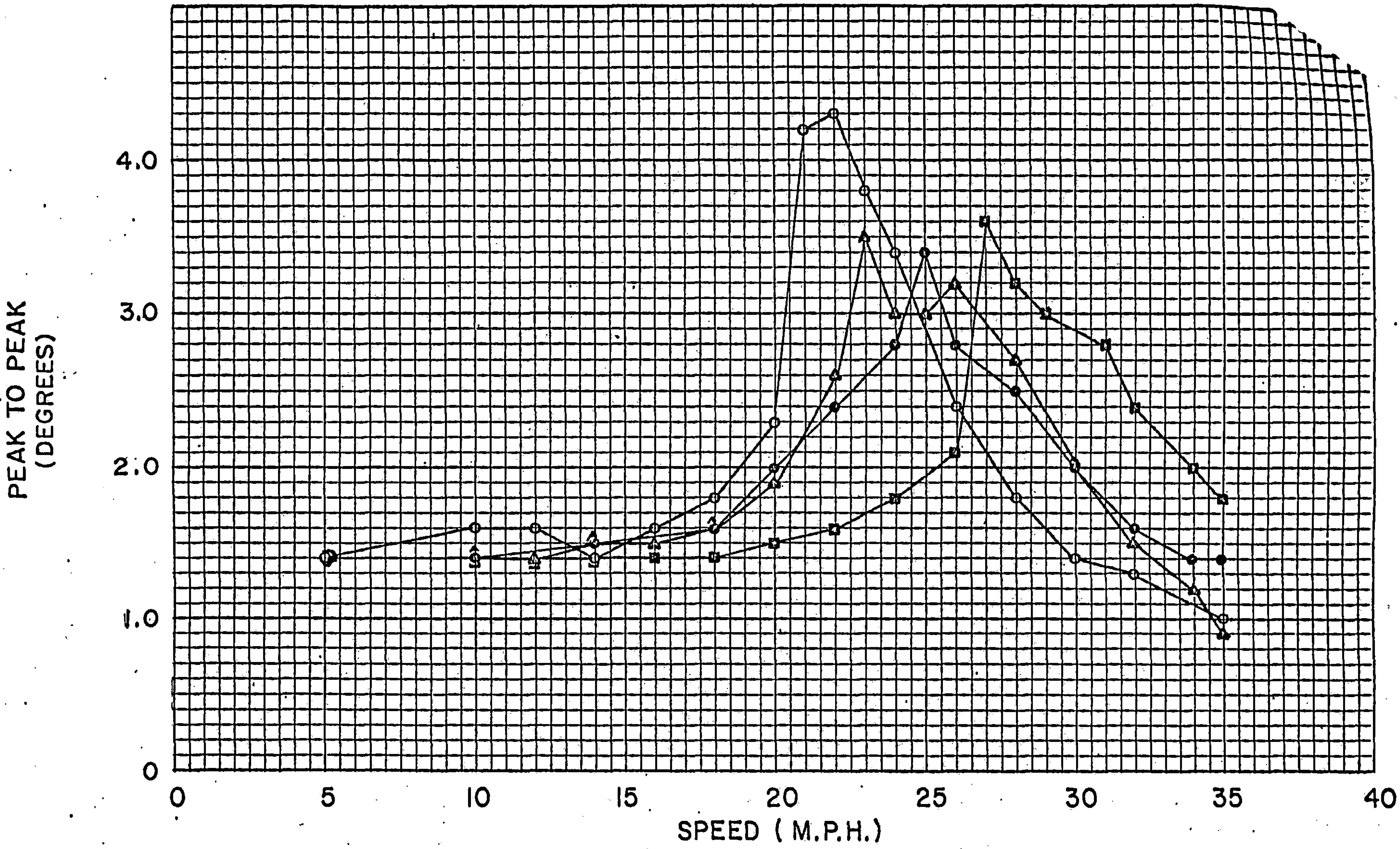
Fig. 1



RESPONSE OF CAR BODY ROLL ANGLE

DODX 38851

FIGURE 1



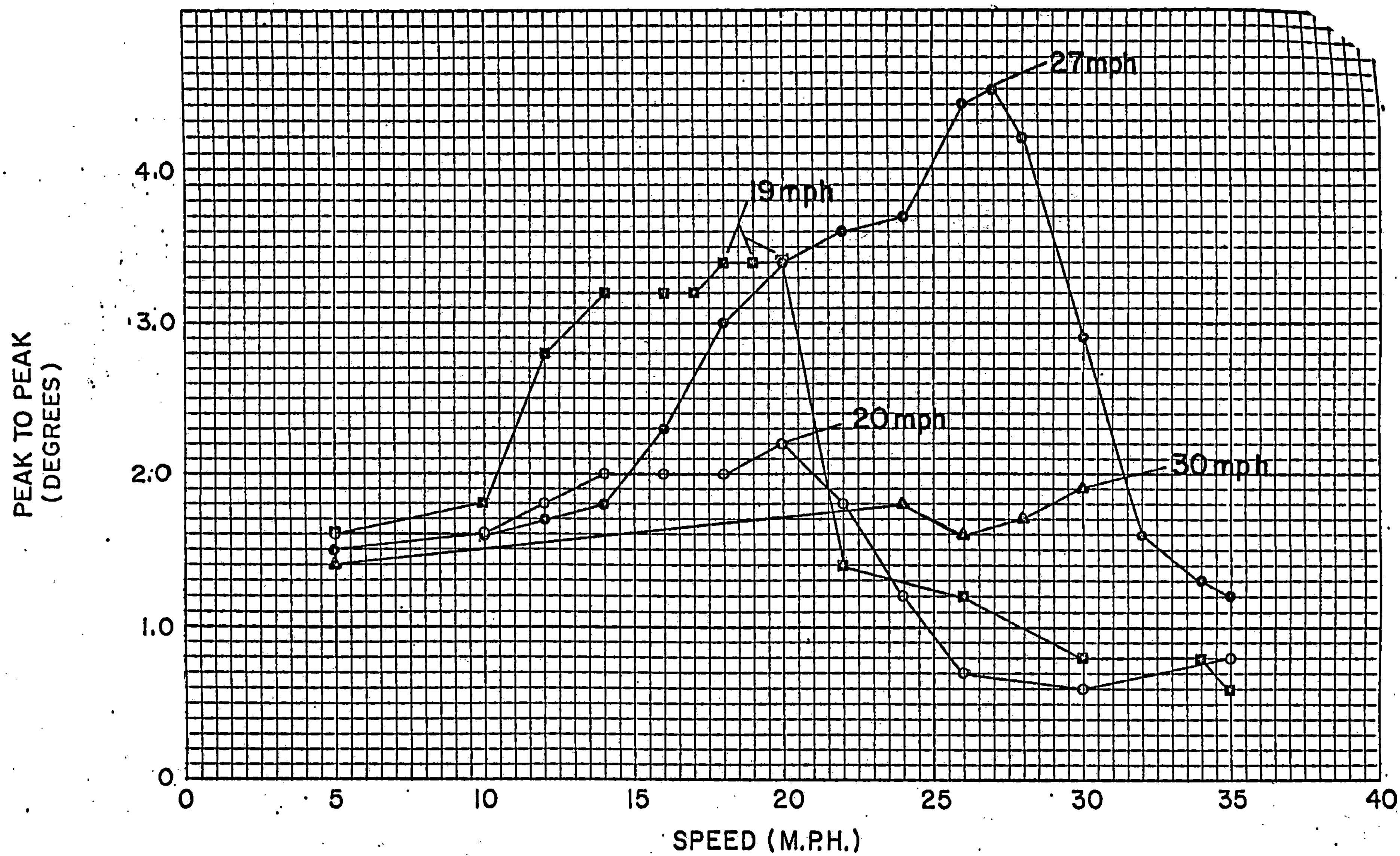
KEY

- ● CONFIG. No. 7 2-24-75
- ▲ CONFIG. No. 8 2-26-75
- ■ CONFIG. No. 9 2-26-75
- ○ CONFIG. No. 10 6-27-75

RESPONSE OF CAR BODY
ROLL ANGLE

DODX 39551/39502

FIGURE 1



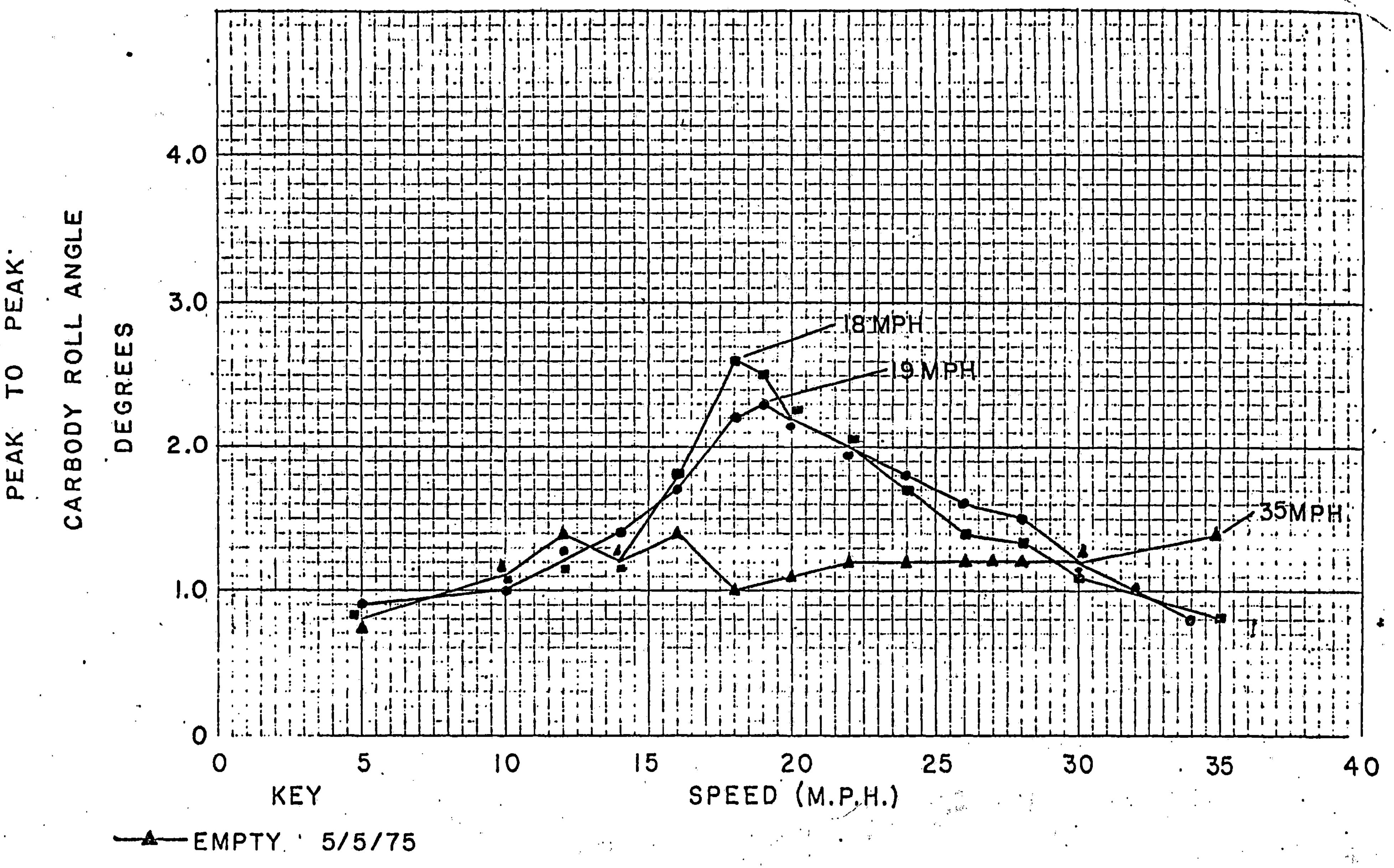
KEY

- ● CONFIG. No. 3 1-24-75
- ▲ CONFIG. No. 4 1-24-75
- ■ CONFIG. No. 5 2-07-75
- ○ CONFIG. No. 7 7-08-75

RESPONSE OF CAR BODY
ROLL ANGLE

DODX 21027

FIGURE 1

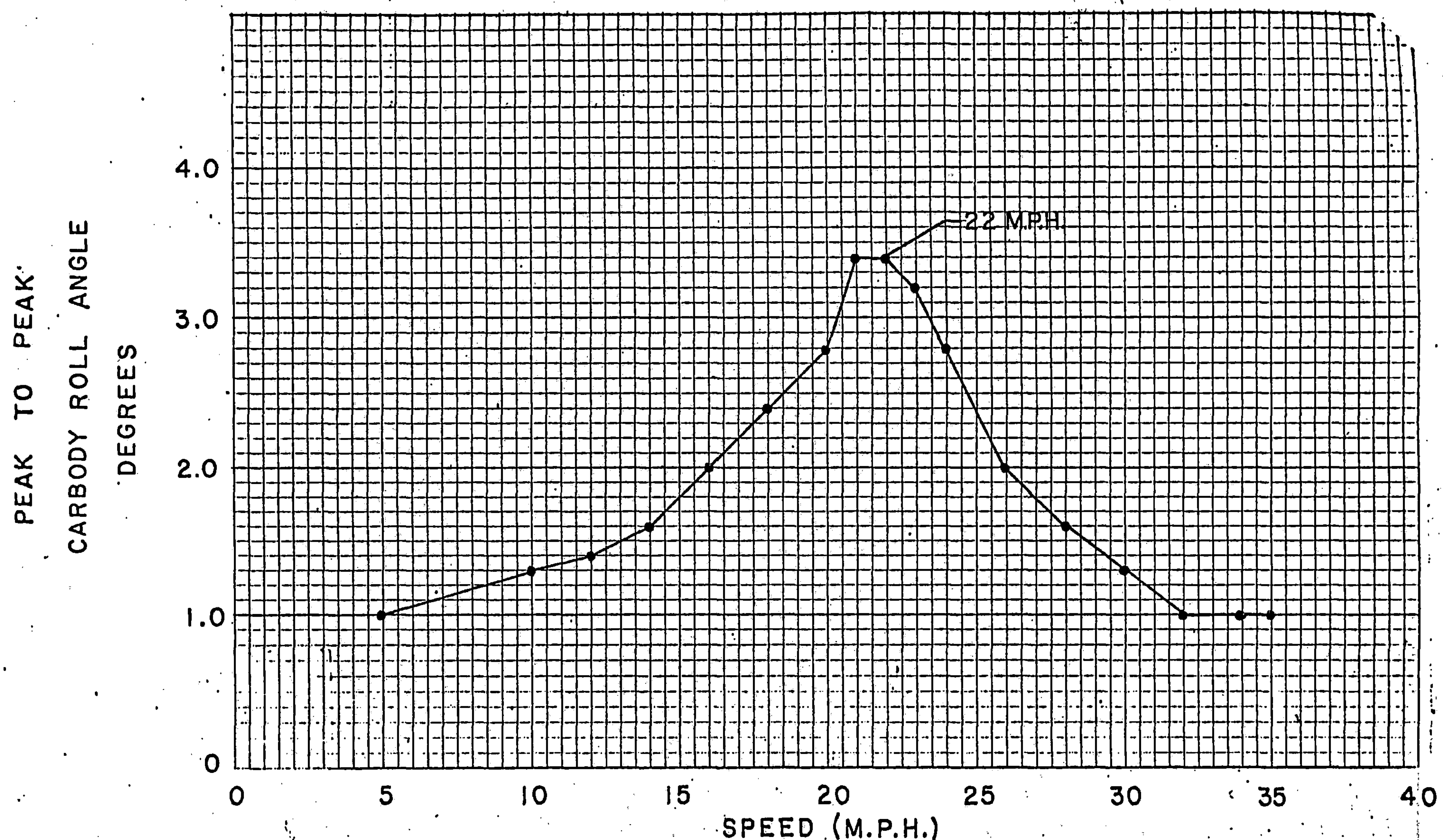


RESPONSE OF CAR BODY

ROLL ANGLE

DODX 39837

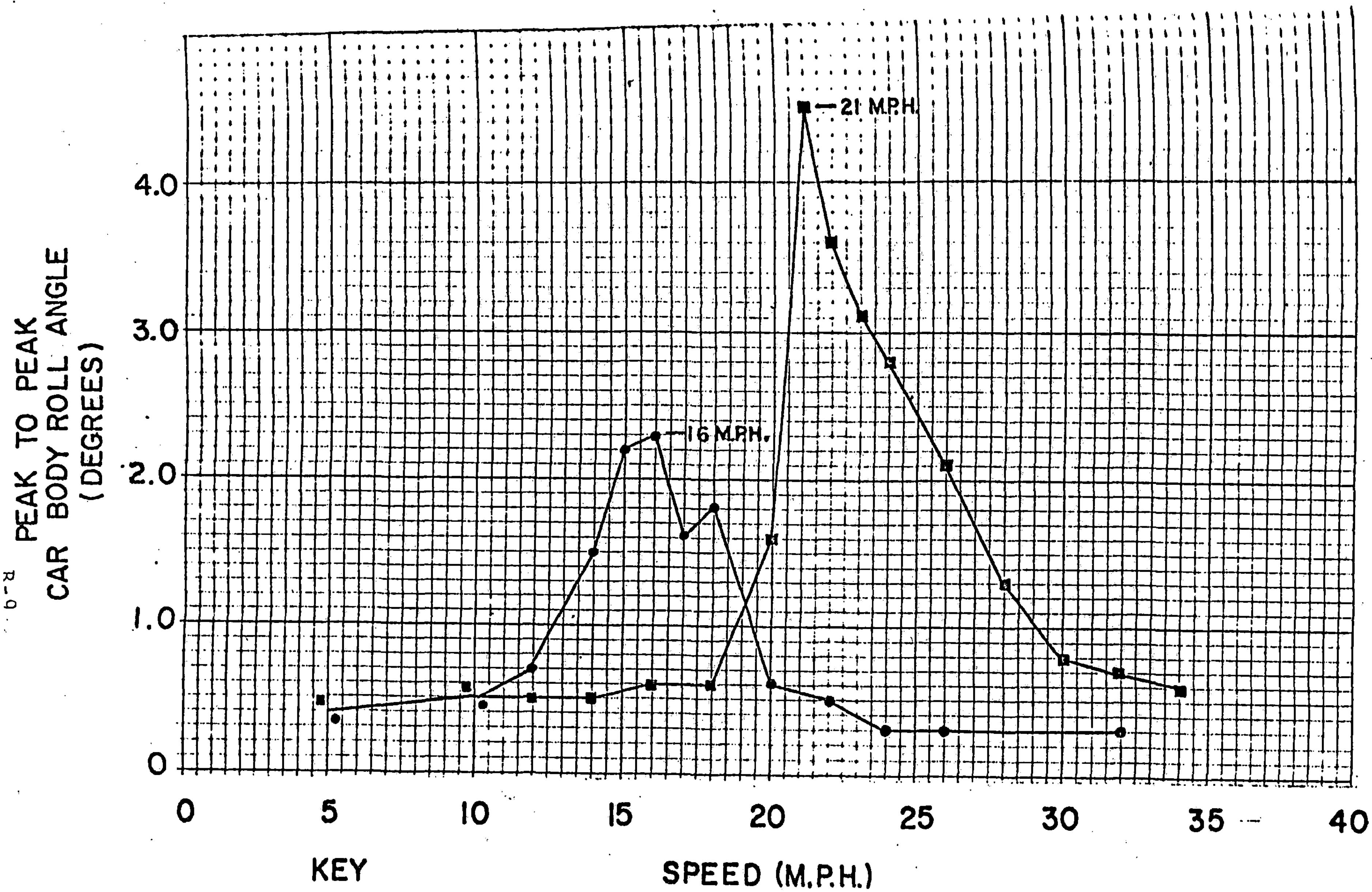
FIGURE 1



RESPONSE OF CAR BODY
CARBODY ROLL ANGLE

DODX 38864

FIGURE 1



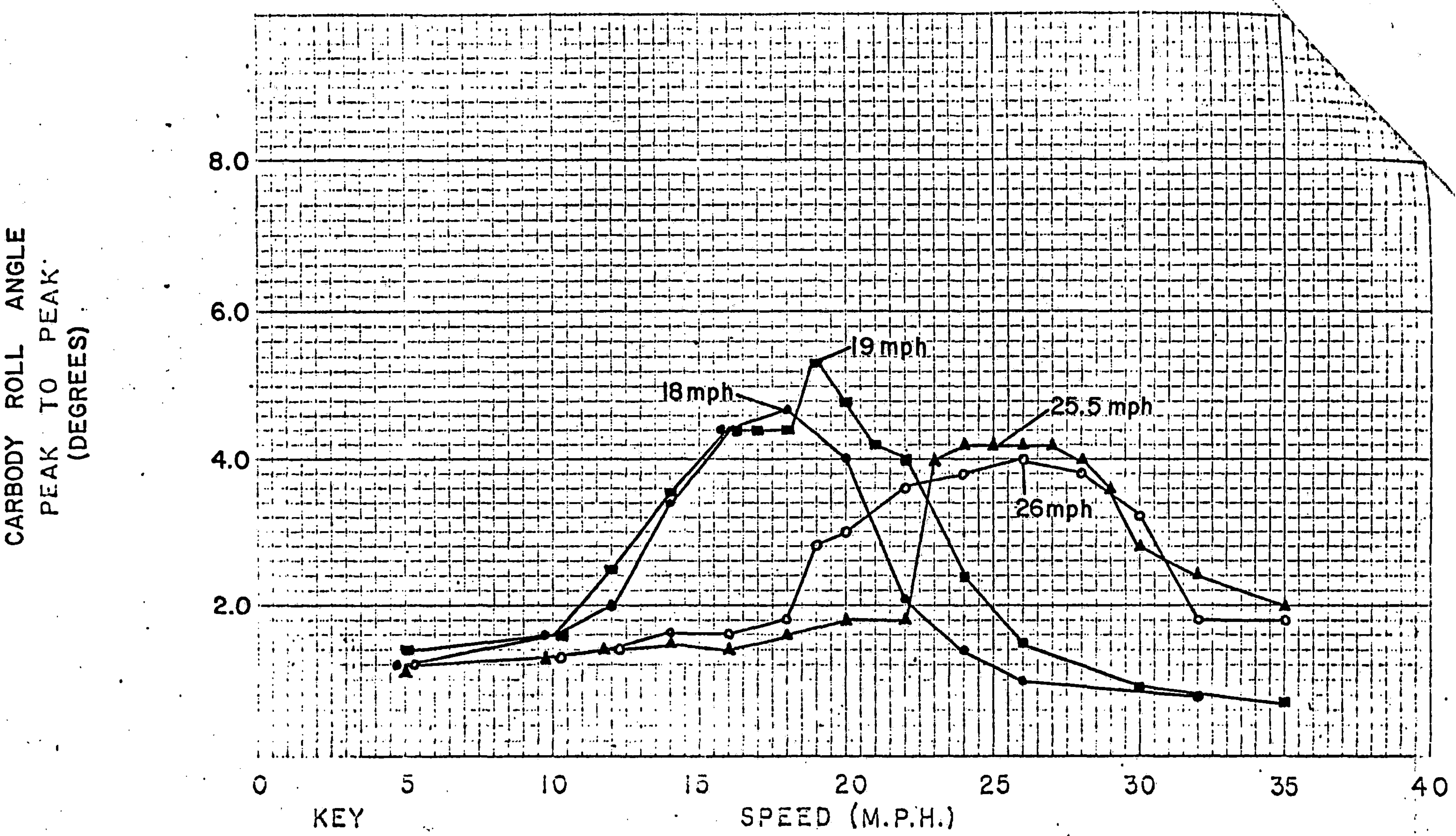
KEY

LOADED 5/31/75
209,220 LB.
LOADED 6/04/75
503,560 LB.

RESPONSE OF CAR BODY ROLL ANGLE

DODX 39899

FIGURE 1



KEY

—△— LOADED 30,680 lbs 6/09/75

—○— LOADED 164,593 lbs 6/17/75

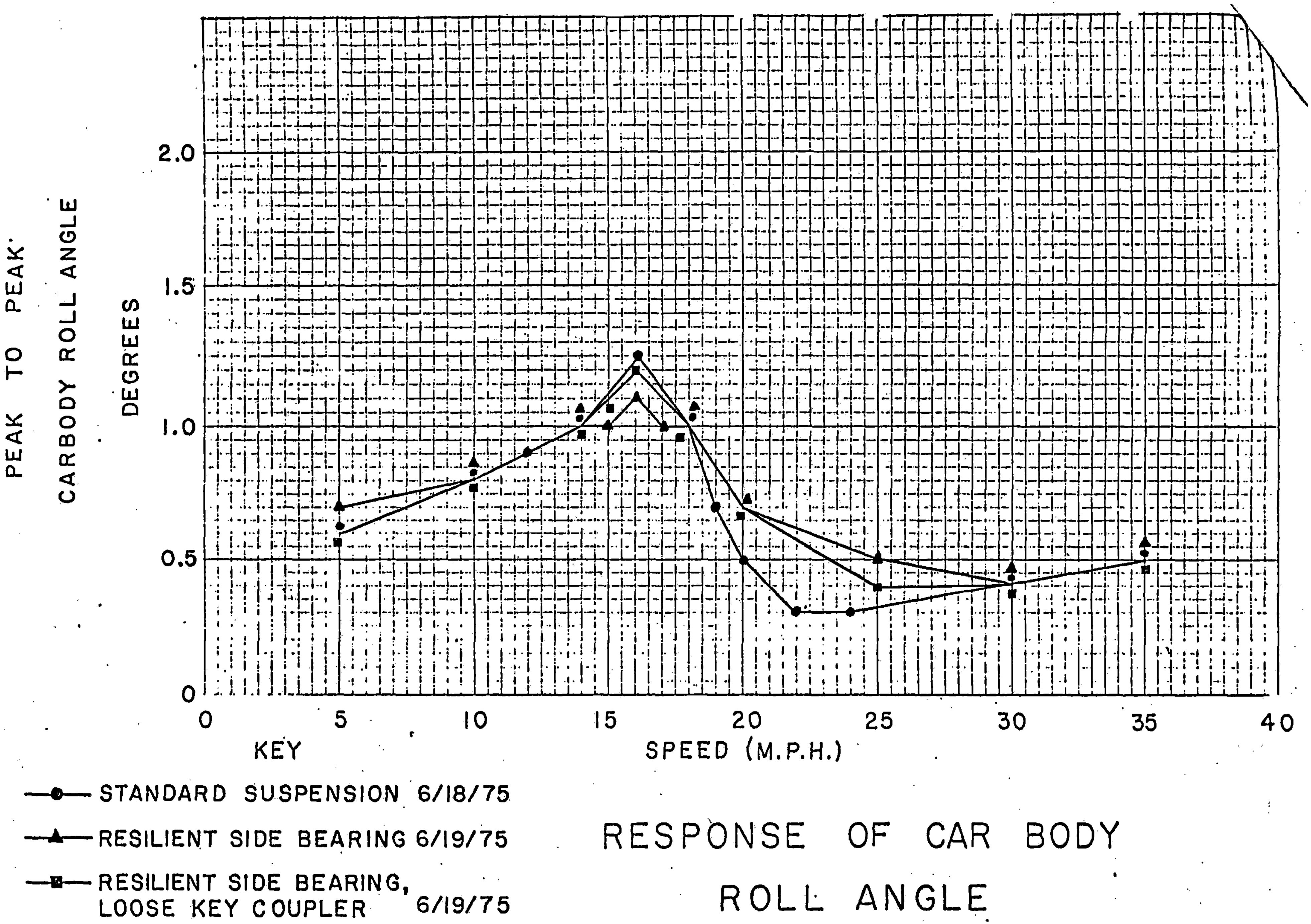
—■— LOADED 82,868 lbs 6/23/75

—●— LOADED 30,960 lbs 6/25/75

RESPONSE OF CAR BODY
ROLL ANGLE

DODX 38664/38444

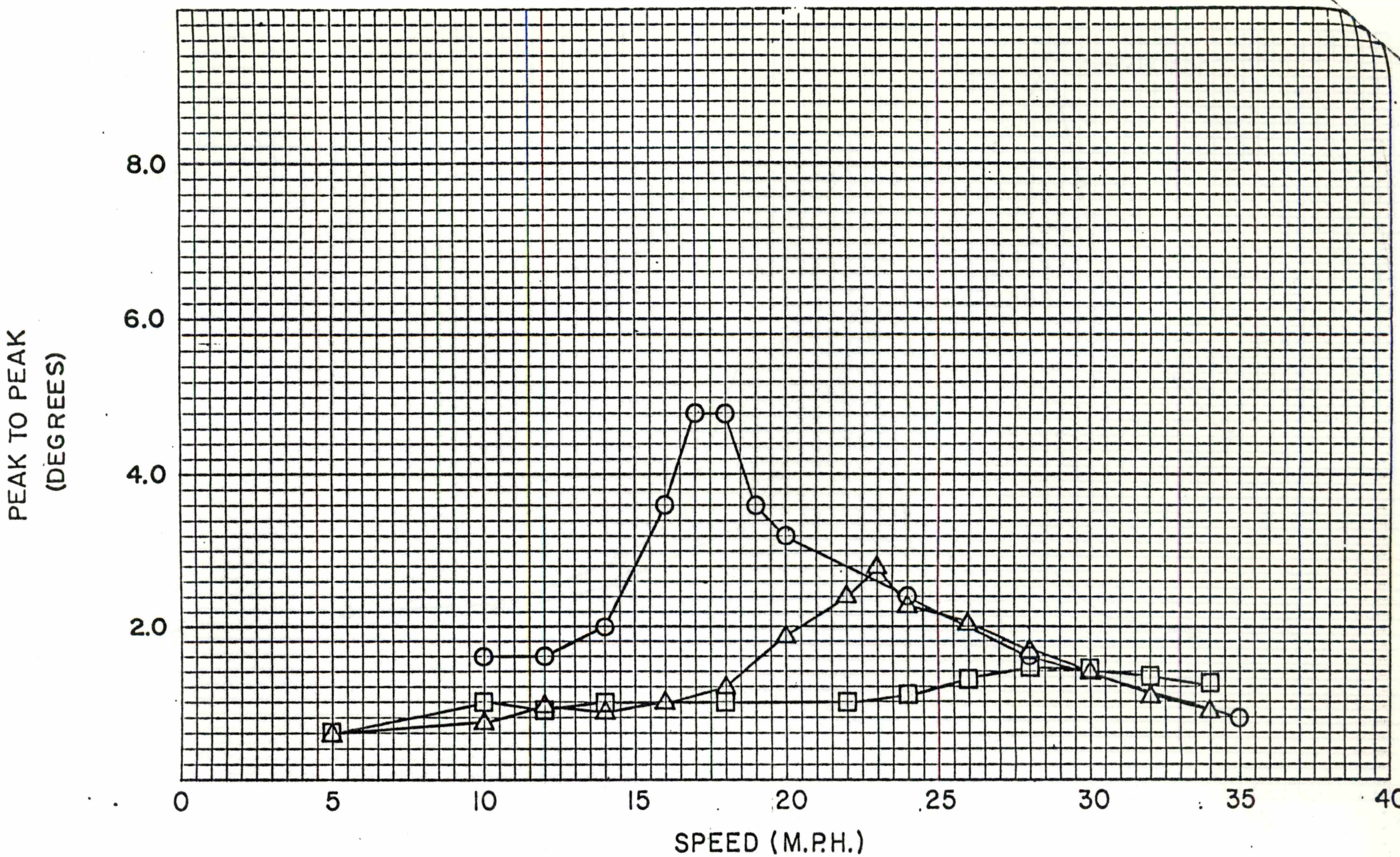
Figure 1



RESPONSE OF CAR BODY ROLL ANGLE

DODX 900

FIGURE 1



KEY

○ CONFIG. No. 1 5-07-76

△ CONFIG. No. 2 5-14-76

□ CONFIG. No. 3 5-24-76

RESPONSE OF CAR BODY

ROLL ANGLE

DODX 39913

FIGURE 1

Test Results Summary Report for DODX Railcar Stability Test in Support of Test Requests SV-127, SV-197 and SV-206, 1976
ENSCO, Inc.