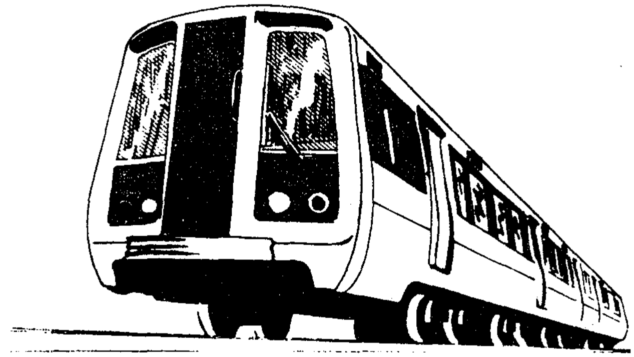
TECHNICAL NOTE

U.S. Department of Transportation
Urban Mass Transportation Administration



TRANSPORTATION TEST CENTER

UMTA/TTC/TN-82/05

March 3, 1982

MARTA "C" CAR: STANDARD PROFILE ENERGY CONSUMPTION

SUMMARY

The Metropolitan Atlanta Rapid Transit Authority (MARTA) "C" Car underwent energy consumption testing as part of a broader array of characteristic tests. The test objectives, procedures and profile data from the energy consumption test are presented here, representing "standard" run performance.

INTRODUCTION

The energy consumed by a transit car in normal revenue service depends upon the type of propulsion system, the nature of the track and the operational (route) requirements. These primary influences can be sub-divided as follows:

Propulsion system -

- Resistor controlled series motors
- Chopper controlled series motors
- Chopper controlled shunt motors
- Regeneration braking

Track characteristics -

- Grades
- Curves
- Track type

Operational requirements -

- Maximum speed
- Braking rates
- Station dwell time
- Headway between trains

In order to provide electrical performance data, a transit car must be tested under the conditions for which it was designed to operate. Also, to compare one car with another, tests must be conducted under the same operating and track conditions for each car. The Standard Profile Energy Tests evolved from the need to establish standardized conditions and requirements for transit car testing at the Transportation Test Center (TTC).

TEST OBJECTIVES

The Energy Consumption Test had two primary objectives:

1. To lay out a standard profile.

2. To determine the energy consumed by the Metropolitan Atlanta Rapid Transit Authority (MARTA) "C" Car while running on a standard profile at AW2 weight (100,000 lbs).

The MARTA "C" Car was tested on selected portions of the Transit Test Track (TTT) to take advantage of all track variables (grades, curvatures, and elevation) that are available at TTC. Table 1 is a list of test zones that incorporate these variables.

This test was limited to accelerating to preselected speeds at maximum acceleration, coasting for 10 seconds, then braking to a stop at a full service rate. This eliminated all car variables in the test, and made it possible to compare one vehicle with another for energy consumed to accelerate to a selected speed, coast, then stop on a particular track section. The data obtained for the MARTA "C" Car is plotted in Figures 1 through 11 and presented in tabular form in Table 2.

TEST PROCEDURE

A d.c. kilowatt hour meter was installed on the vehicle to measure the energy consumed during each run. The vehicle was then positioned at the start of each test zone (see Table 1). The kW hr meter was started at the same time the Master Controller was moved to "Maximum Acceleration Level." This maximum acceleration was held until the vehicle reached the desired speed (20, 30, 40, 50, or 60 mi/h); then the Master Controller was moved to the "Coast" position and held there for a period of 10 seconds. At the end of the 10 seconds, the Master Controller was moved to the "Full Service Brake" position. This position was held until the vehicle came to a complete stop. At the time the vehicle came to a stop, the kW hr meter was stopped. This sequence was repeated for each speed at each test zone.

Throughout the tests the track power source was maintained as "non-receptive." Thus the electrical energy derived in braking was delivered to the auxilliaries and the on-board dynamic brake resistor bank.

DISCUSSION

The kilowatt hour meter used an accumulating type counting device that counted only when the line voltage and line current signals from the Electronic Control Equipment Monitor Panel were both positive.

The MARTA "C" Car propulsion system is designed such that during dynamic braking, the auxiliaries are powered by the propulsion system acting in the generating mode. The data presented in Table 2 and Figures 1 through 10 include the energy used by the auxiliaries during acceleration and coasting, but not during braking. The energy consumed by the auxiliaries during braking was measured and is presented in Figure 11 as the average for each speed through all test zones.

During the tests all car auxiliaries were running as in normal revenue service. That is, the air compressor and the HVAC System were being controlled by their respective control systems, and all blower fans were running.

Data acquisition and analysis for this report were done by Robert F. Carter, Engineer, Test Support Section, Boeing Services International, Incorporated, Transportation Test Center, Pueblo, Colorado.

Metric Conversions

1 lb = 0.454 kg
1 mi = 1.609 km

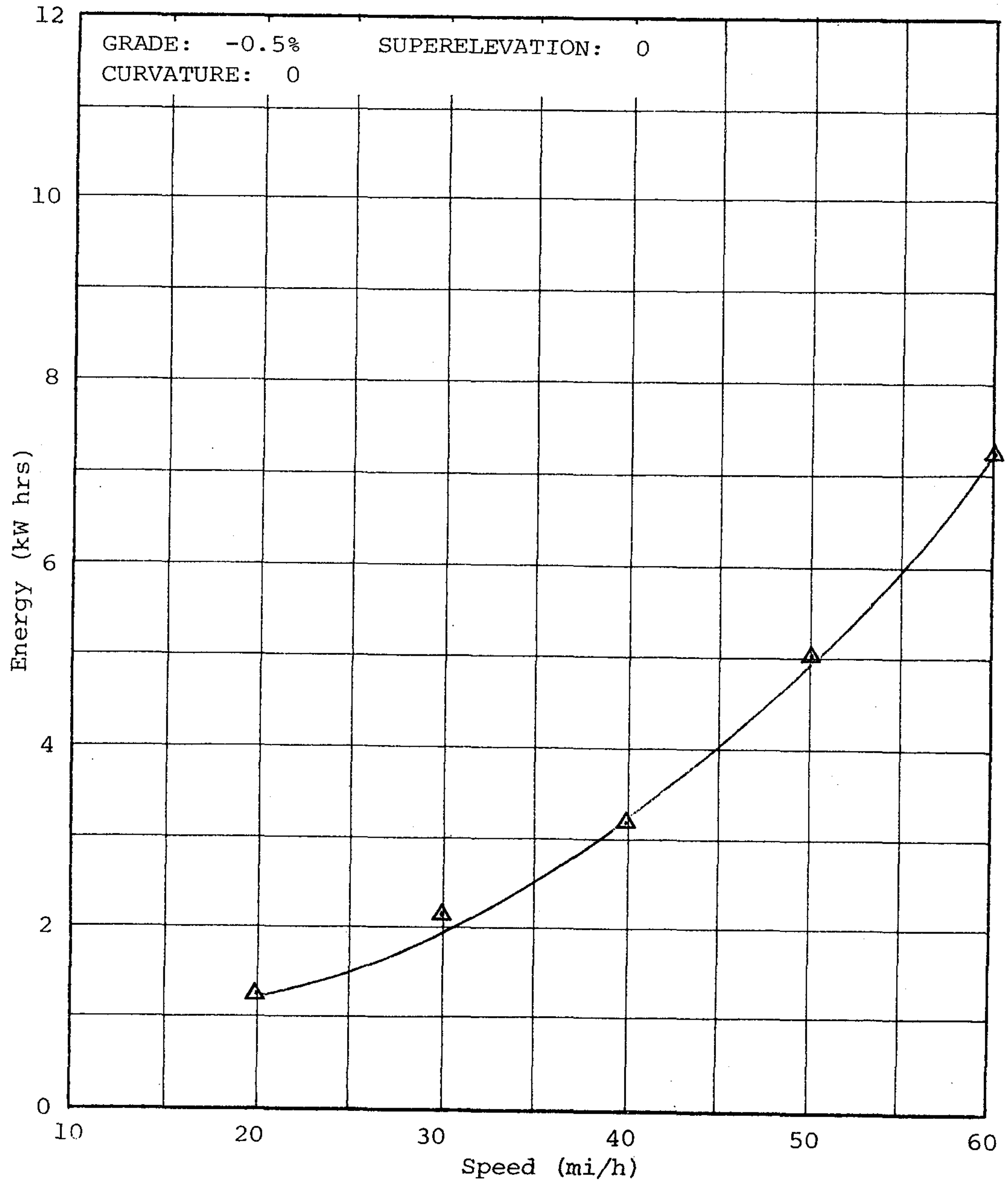


FIGURE 1. ENERGY CONSUMPTION PROFILE, TEST ZONE 1.

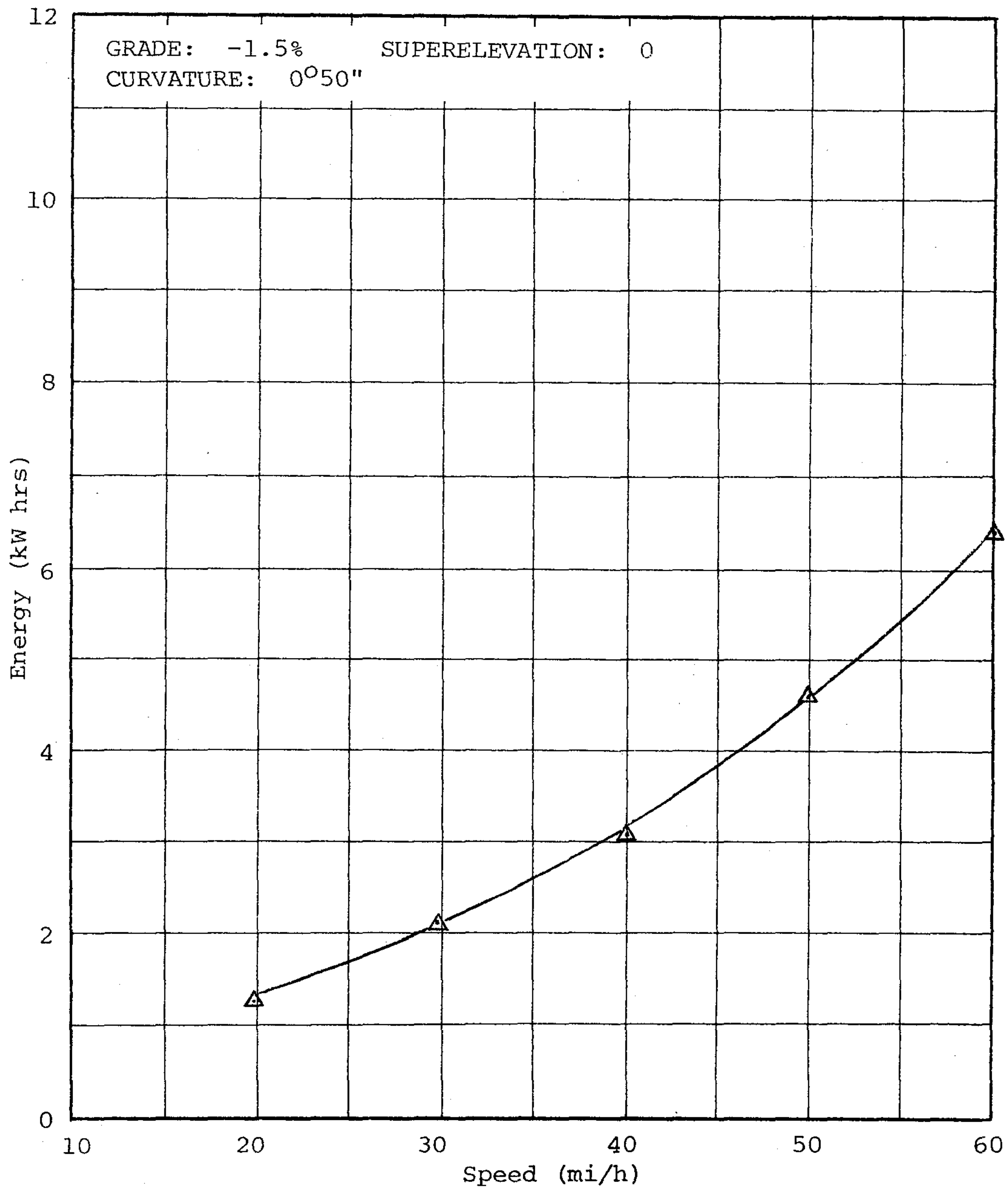


FIGURE 2. ENERGY CONSUMPTION PROFILE, TEST ZONE 2.

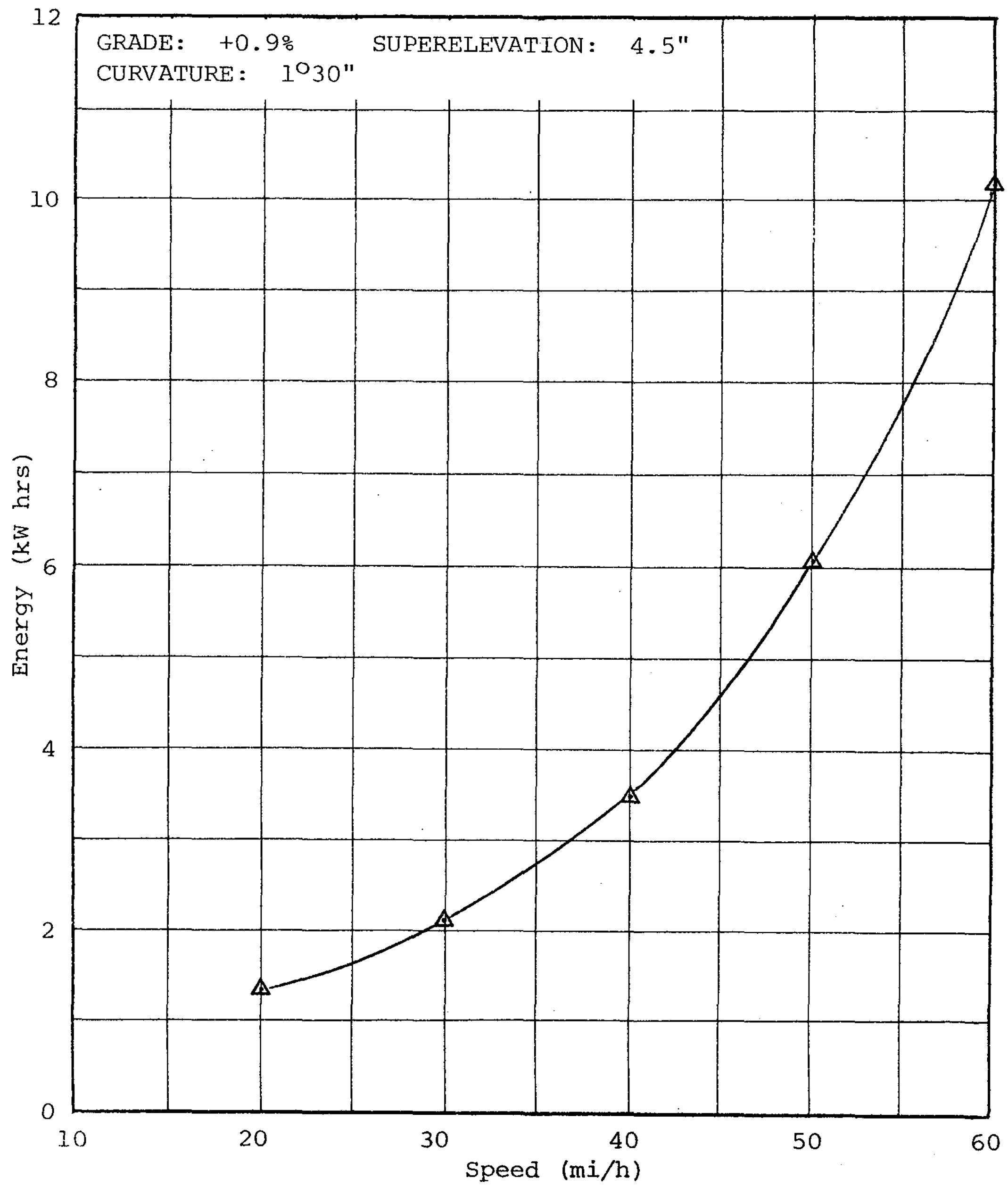


FIGURE 3. ENERGY CONSUMPTION PROFILE, TEST ZONE 3.

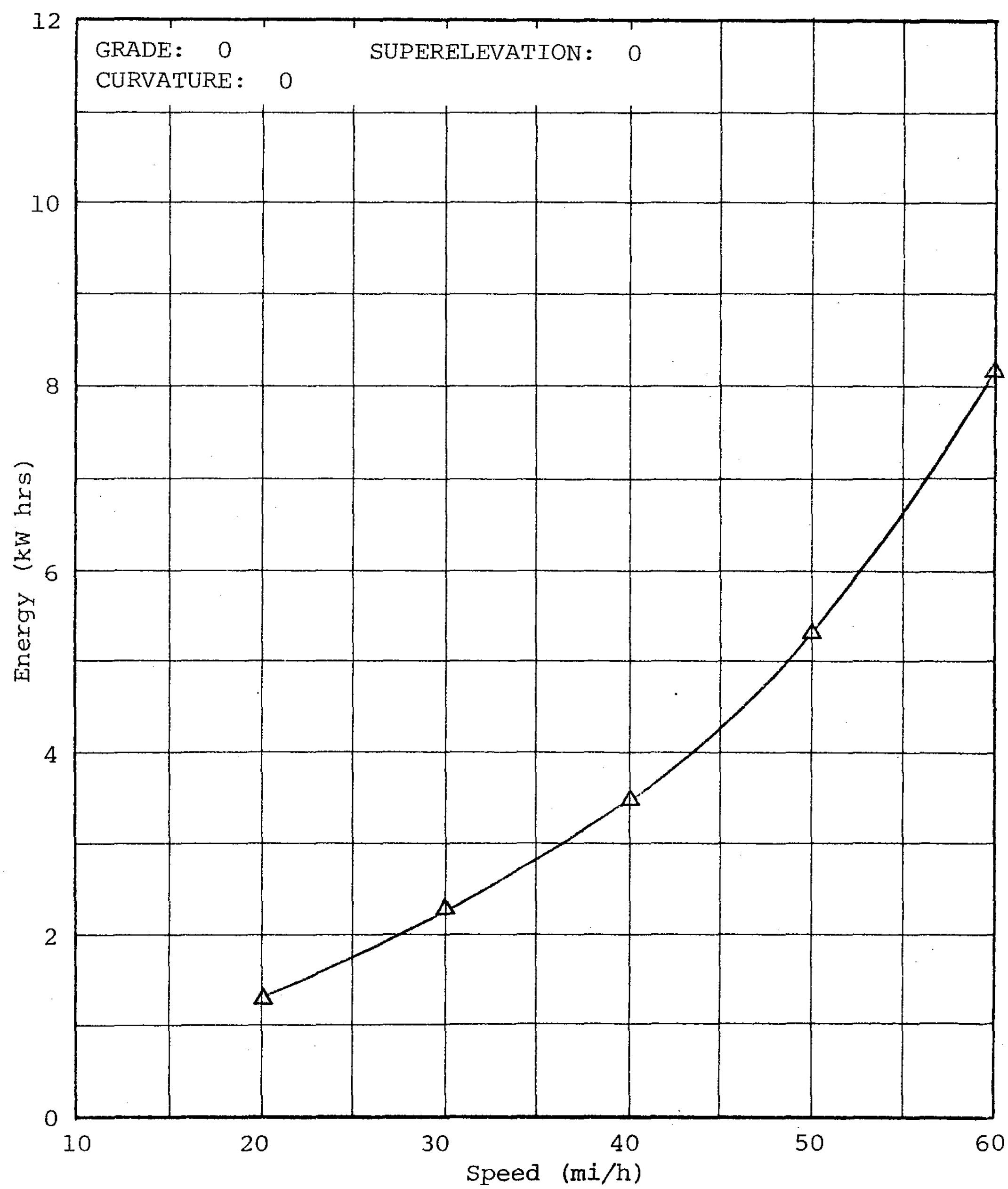


FIGURE 4. ENERGY CONSUMPTION PROFILE, TEST ZONE 4.

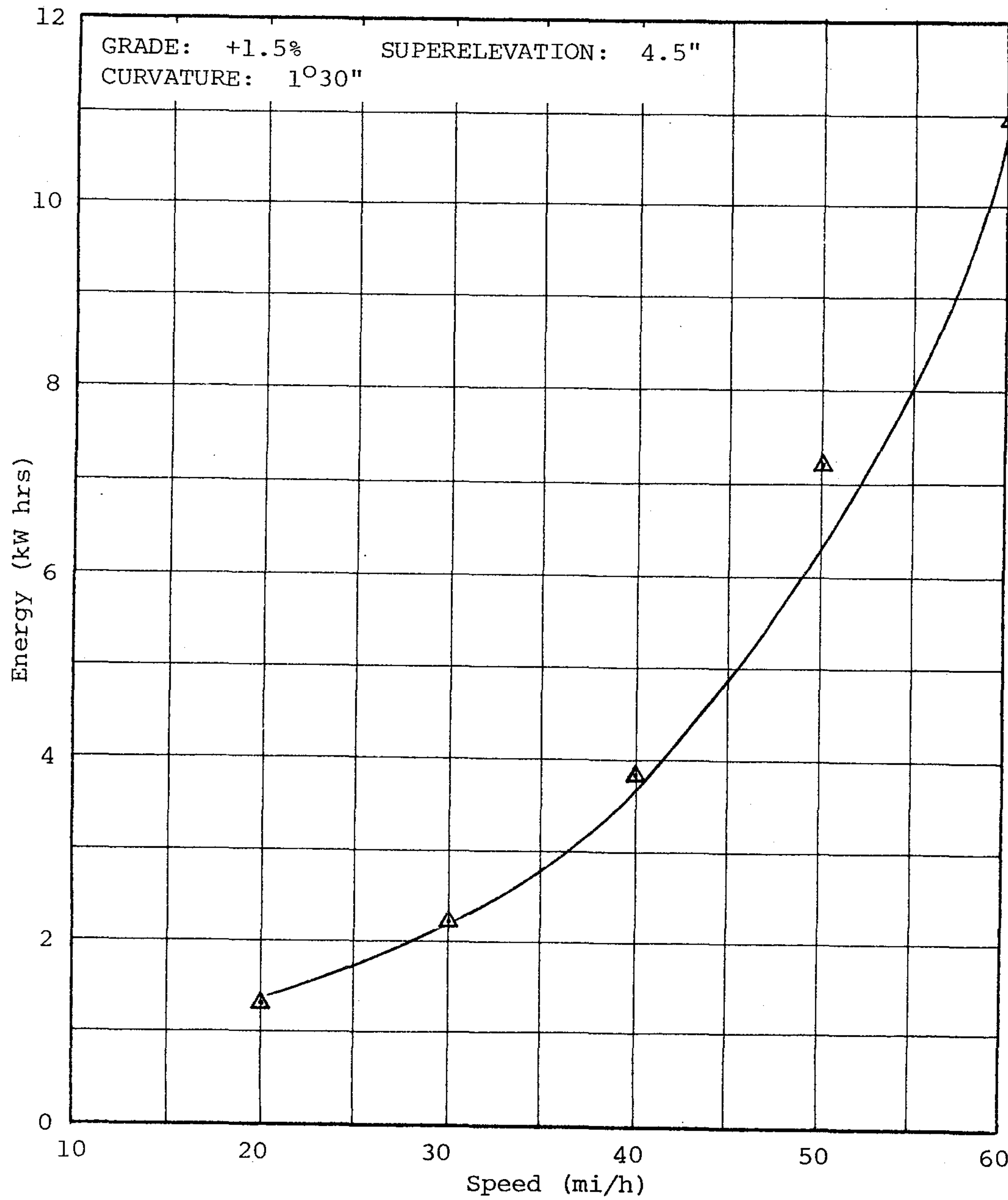


FIGURE 5. ENERGY CONSUMPTION PROFILE, TEST ZONE 5.

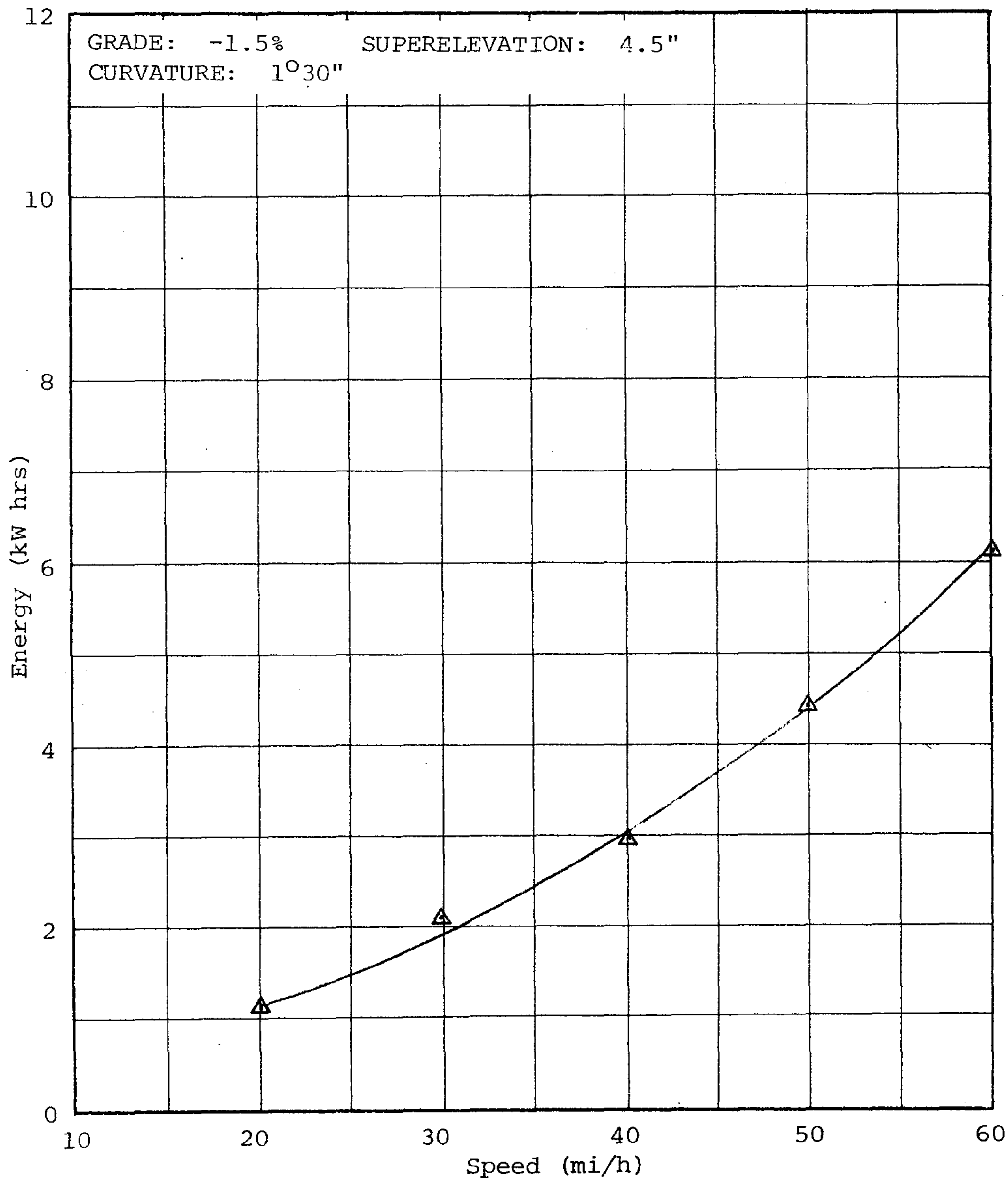


FIGURE 6. ENERGY CONSUMPTION PROFILE, TEST ZONE 6.

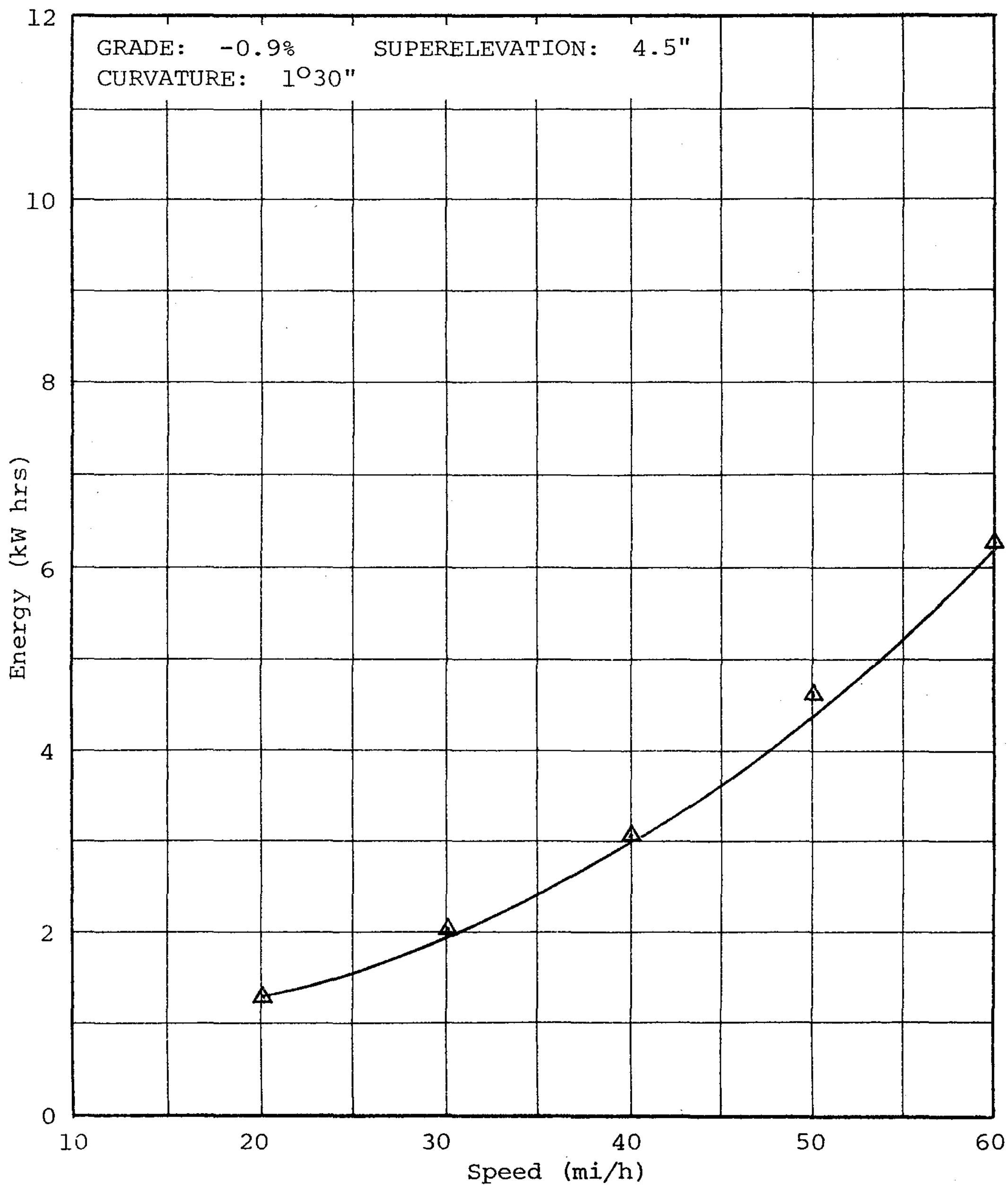


FIGURE 7. ENERGY CONSUMPTION PROFILE, TEST ZONE 7.

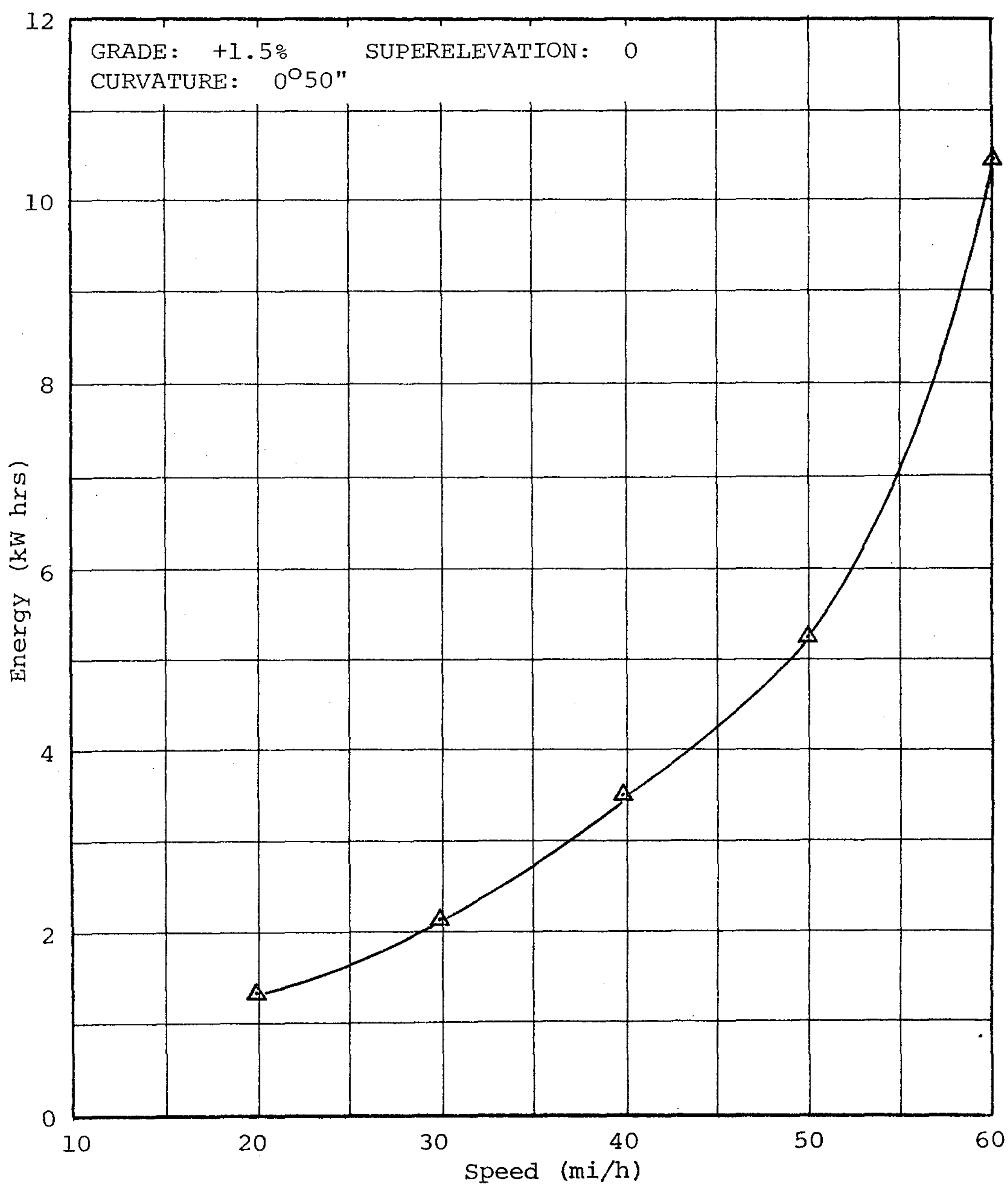


FIGURE 8. ENERGY CONSUMPTION PROFILE, TEST ZONE 8.

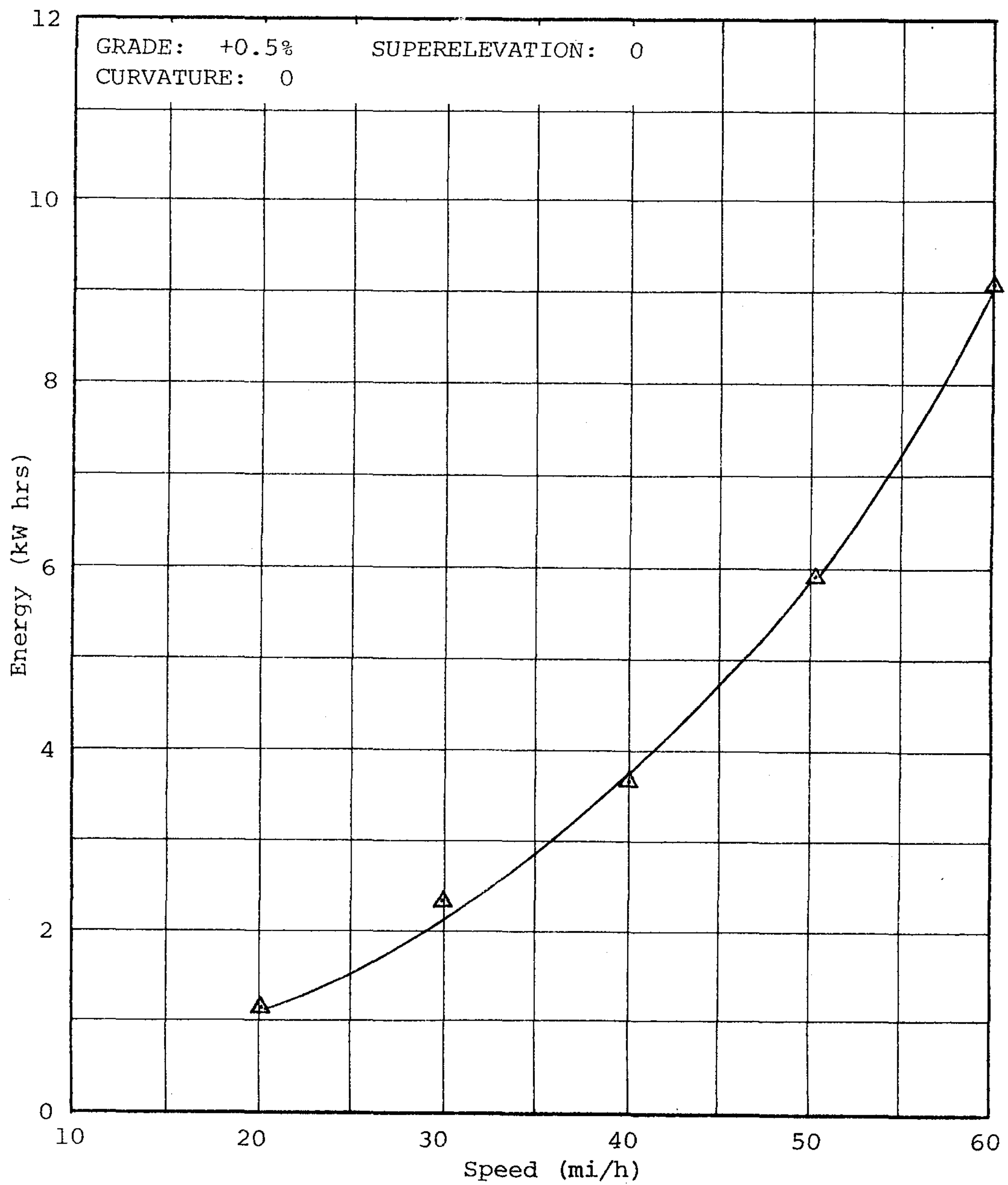


FIGURE 9. ENERGY CONSUMPTION PROFILE, TEST ZONE 9.

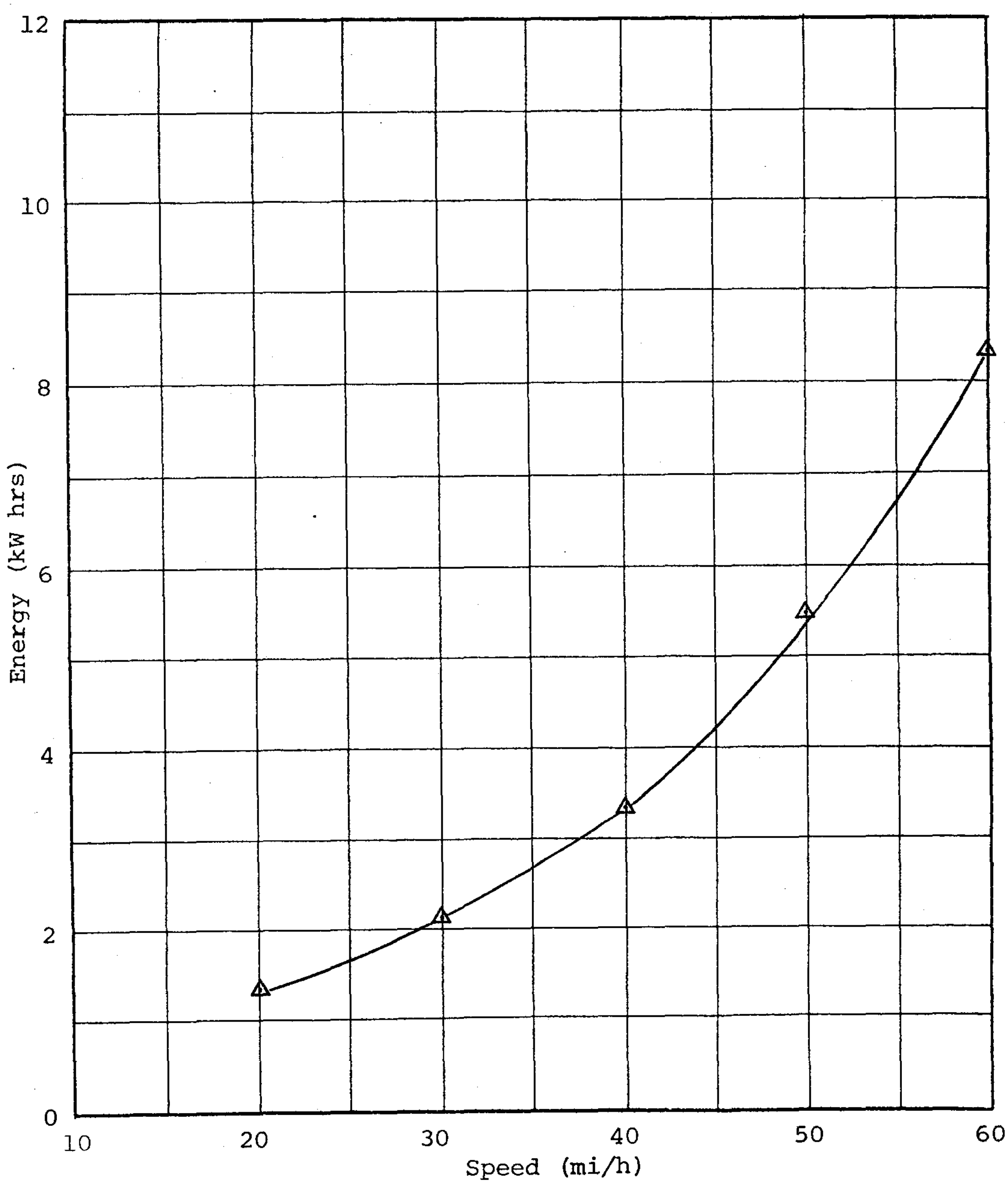


FIGURE 10. ENERGY CONSUMPTION PROFILE, AVERAGE FOR ALL TEST ZONES.

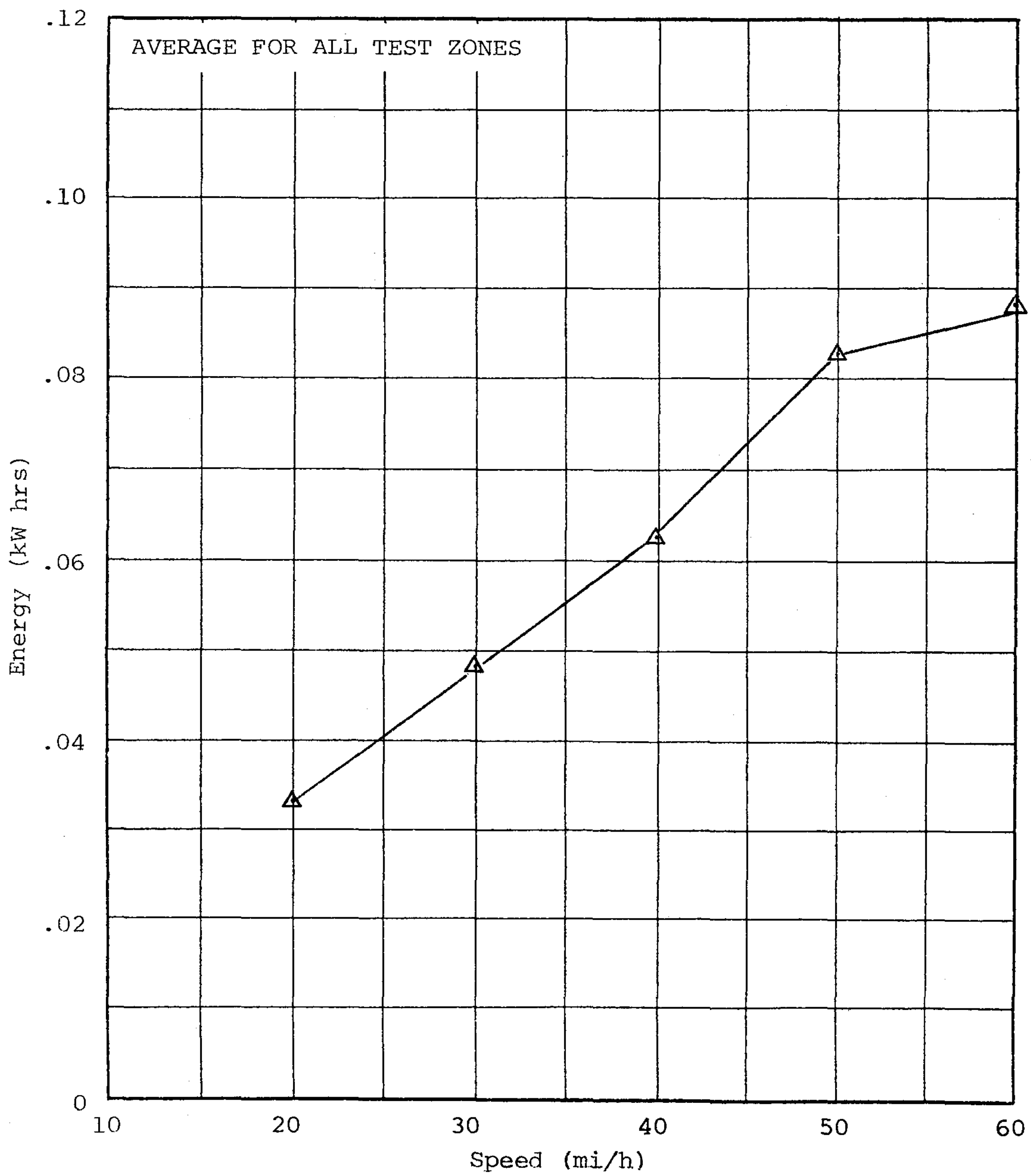


FIGURE 11. ENERGY CONSUMED BY AUXILIARIES DURING BRAKING.

TABLE 1. TEST PROFILE DESCRIPTIONS.

TEST ZONE	START STATION	TRAVEL DIRECTION	PERCENT GRADE	TRACK CURVATURE	SUPER ELEVATION
1	5.0	cw	-0.5	-0-	-0-
2	8.0	cw	-1.5	0° 50'	-0-
3	25.0	cw	+0.9	1° 30'	4.5 inches
4	30.0	cw	-0-	-0-	-0-
5	41.0	cw	+1.5	1° 30'	4.5 inches
6	44.5	ccw	-1.5	1° 30'	4.5 inches
7	29.0	ccw	-0.9	1° 30'	4.5 inches
8	14.0	ccw	+1.5	0° 50'	-0-
9	9.0	ccw	+0.5	-0-	-0-

TEST CONDITION NOTES:

Third Rail Voltage - Nominal (750 V d.c.)
Third Rail Power - Substation #2 (manual)*
Third Rail Configuration - Cross tie and all quadrant switches closed.

* voltage regulated at the substation

TABLE 2. MARTA "C" CAR STANDARD PROFILE ENERGY CONSUMPTION.

TEST	ENERGY (KILOWATT HOURS)				
ZONE	20 mi/h	30 mi/h	40 mi/h	50 mi/h	60 mi/h
1	1.27	2.13	3.20	5.03	7.26
2	1.27	2.10	3.13	4.60	6.40
3	1.37	2.17	3.47	6.03	10.20
4	1.30	2.23	3.43	5.37	8.20
5	1.33	2.20	2.80	7.20	10.97
6	1.13	2.07	2.97	4.40	6.07
7	1.30	2.00	3.10	4.60	6.33
8	1.30	2.10	3.50	6.20	10.53
9	1.33	2.23	3.67	5.93	9.13

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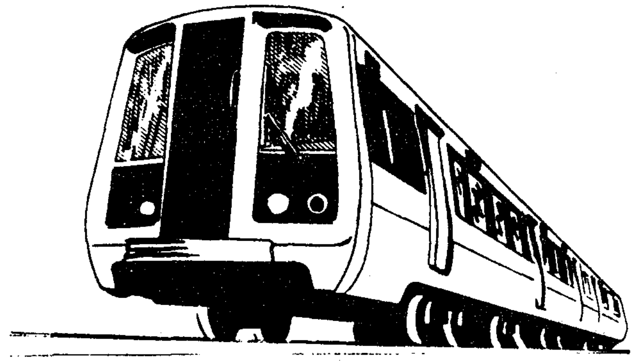


TRANSPORTATION TEST CENTER

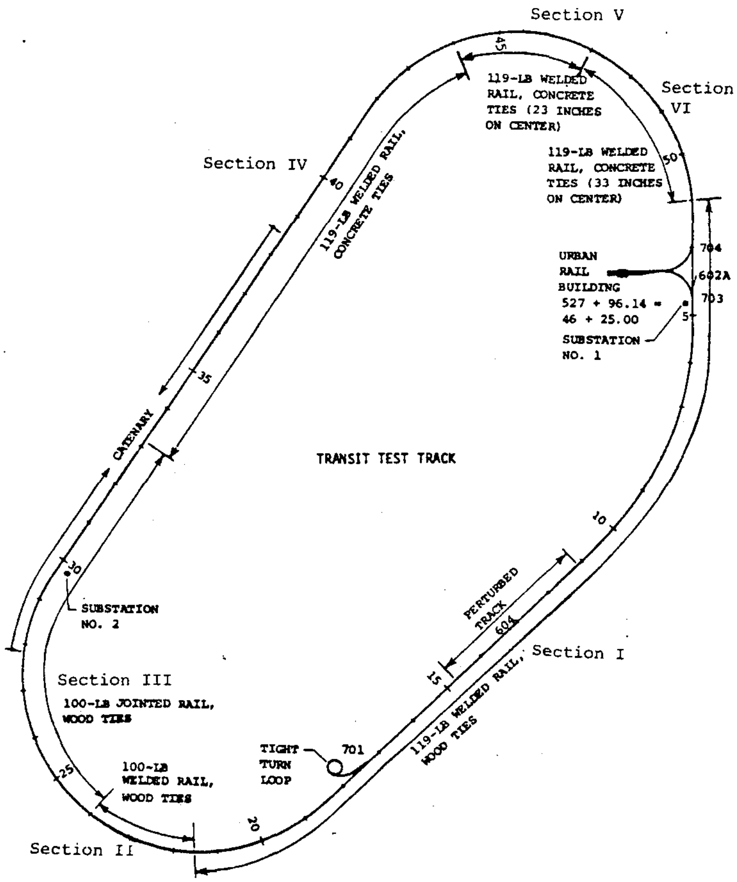
Test and evaluation activities of the Urban Mass Transportation Administration (UMTA) are coordinated through The Office of Technical Assistance in Washington, D.C., and are conducted by The UMTA Program Office at the Transportation Test Center (TTC) in Pueblo, Colorado.

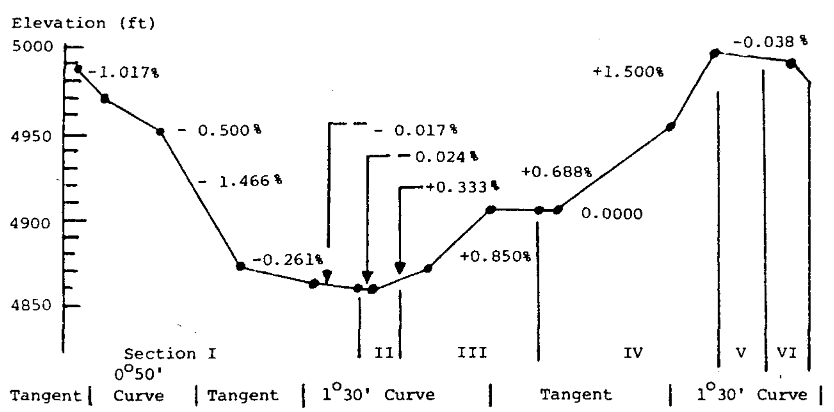
The urban rail transit test facilities at the TTC provide for test and evaluation of urban rail vehicles, subsystems, track, and structural components in an environment that is both safe and free from the scheduling constraints imposed by revenue service operations.

The Transit Test Track (TTT) is a 9.1 mile oval (see next page) designated for sustained 80 mi/h vehicle operation with the exception of the perturbed track section, which is subject to a speed limit based on ride quality test requirements and safety considerations. Power is provided either by a conventional third rail or a section of overhead catenary cable; the third rail was constructed to New York City Transit Authority specifications.

The rectifier station voltage can be varied infinitely from 400 to 1,200 V.d.c. with a current limit of 11,000 A. The stations each feed from one bus to all of the TTT and are designed to operate in several alternate modes, including computer control. Voltage can be controlled at a constant level at the substation, or at the position of the vehicle and held within the above constraints to a constant value at the vehicle regardless of demand or voltage drop through the rails. In alternate modes of operation the test vehicle can be subjected to a voltage profile or a voltage step such as might occur in revenue service at the transition between one substation and another.

The Test Center's technical support capabilities include test management, engineering instrumentation, calibration and electronic repair, photo-optical instrumentation, and data processing. In addition, TTC has the capability to assist users in developing test plans and requirements, and preparing reports.





NOTES:

Track Curvature:

Sta. to Sta.		Degree of Curve
55.3	10.3	0° 50"
18.9	29.4	1° 30"
41.8	50.8	1° 30"

Elevation:

Minimum - 4863 ft at Station 22.0.
Maximum - 5003 ft at Station 46.0.

Curve Superelevation:

1° 30' curves are superelevated a maximum of 4.5". The maximum superelevation on the 0° 50' curve is 2".

Tight Turn Loop

150 ft radius.
119 lb AREA Head Hardened running rail.
85 lb ASCE restraining rail installed as per Massachusetts Bay Transit Authority specifications.