User's Guide to EAGLES Version 1.1: An Electric- and Gasoline-Vehicle Fuel-Efficiency Software Package

**Center for Transportation Research
Argonne National Laboratory**

Operated by The University of Chicago,
under Contract W-31-109-Eng-38, for the

United States Department of Energy

Argonne National Laboratory

Argonne National Laboratory, with facilities in the states of Illinois and Idaho, is owned by the United States Government, and operated by the University of Chicago under the provisions of a contract with the Department of Energy.

This technical memo is a product of Argonne's Energy Systems (ES) Division. For information on the division's scientific and engineering activities, contact:

Director, Energy Systems Division
Argonne National Laboratory
Argonne, Illinois 60439-4815
Telephone (708) 252-3724

Presented in this technical memo are preliminary results of ongoing work or work that is more limited in scope and depth than that described in formal reports issued by the ES Division.

Publishing support services were provided by Argonne's Information and Publishing Division.

Disclaimer

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

Reproduced directly from the best available copy.

Available to DOE and DOE contractors from the Office of Scientific and Technical Information, P.O. Box 62, Oak Ridge, TN 37831; prices available from (615) 576-8401.

Available to the public from the National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

ANL/ESD-27

User's Guide to EAGLES Version 1.1: An Electric- and Gasoline-Vehicle Fuel-Efficiency Software Package

by W.W. Marr

Center for Transportation Research, Energy Systems Division,
Argonne National Laboratory, 9700 South Cass Avenue, Argonne, Illinois 60439

January 1995

Work sponsored by United States Department of Energy,
Assistant Secretary for Energy Efficiency and Renewable Energy,
Office of Transportation Systems

MASTER

CONTENTS

AVAILABILITY OF COMPUTER SOFTWARE	ix
ACKNOWLEDGMENTS	x
ABSTRACT	1
1 OVERVIEW OF EAGLES VERSION 1.1	1
1.1 Introduction	1
1.2 Development of the EV Battery Model	2
1.3 Calculation of the Battery Power Requirement	4
1.4 Battery Sizing for EV Applications	5
1.5 Fuel Economy Model for Gasoline Vehicles	5
1.6 Calculation of Engine Speed	6
1.7 Climate Comfort Control	8
1.7.1 Gasoline Vehicles	8
1.7.2 Electric Vehicles	8
1.8 Organization of the Software Program	13
2 DESCRIPTION OF INPUT VARIABLES	15
2.1 Input Data for Vehicles	15
2.2 Input Data for Driving Profiles	15
2.3 Input Data for Batteries	18
3 SOFTWARE PROGRAM OPERATION AND OUTPUT INFORMATION	20
3.1 Step-by-Step Operation of EAGLES Version 1.1	20
3.2 Sample Problems	30
4 VERIFICATION OF RESULTS	32
4.1 Electric Vehicle Analysis	32
4.2 Gasoline Vehicle Analysis	32
5 REFERENCES	34
APPENDIX A: Calculation of Power Requirements and Parameter g_1	37
APPENDIX B: Default Vehicle Data Files	43
APPENDIX C: Default Driving Profile Data Files	81
APPENDIX D: Default Battery Data Files	115

FIGURES

1	Approximation of Engine Torque and Speed Relationship	8
2	Minivan Cooling Loads	10
3	Compact Car Cooling Loads	10
4	Steady-State Heating of Minivan	11
5	Transient Heating of Minivan	11
6	Compact Car Heating Loads	12
A.1	Schematic Diagram of Forces Acting on a Vehicle	40

TABLES

1	Coefficient of Performance for Cooling and Heating	13
2	Organization of EAGLES Version 1.1	14
3	Input Vehicle Data for EV Simulation	16
4	Input Vehicle Data for EV Specification: Battery Sizing	16
5	Input Vehicle Data for GV Simulation	17
6	Input for Driving Profile Data File	18
7	Input for Power Profile Data File	19
8	Input for Battery Data File	19
9	Sample Problems	31
10	Comparison of Calculated and Laboratory EV Simulation Results	32
11	Comparison of EPA Unadjusted Mileage and EAGLES Results for Eight 1991 Model Year Cars	33
B.a.1	Default Electric Vehicle Data File for the Eaton Dual-Shaft Electric Propulsion Van (DSEP)	45

TABLES (Cont.)

B.a.2	Default Electric Vehicle Data File for the Improved Dual-Shaft Electric Propulsion Van (IDSEP)	46
B.a.3	Default Electric Vehicle Data File for the Griffon Electric Van (GRIFFON)	47
B.a.4	Default Electric Vehicle Data File for the Second-Generation Single-Shaft Electric Propulsion System (ETX-II)	48
B.a.5	Default Electric Vehicle Data File for G-Van (G-VAN)	49
B.a.6	Default Electric Vehicle Data File for TEVan (TEVAN)	50
B.a.7	Default Electric Vehicle Data File for the Improved Electric Test Vehicle (IETV-1)	51
B.a.8	Default Electric Vehicle Data File for GM Impact (IMPACT)	52
B.a.9	Default Electric Vehicle Data File for Ford Ecostar (ECOSTAR)	53
B.b.1	Default Data File for an EV Two-Seater Car for Battery Sizing (TWOSEATS)	54
B.b.2	Default Data File for an EV Compact Car for Battery Sizing (COMPACT)	55
B.b.3	Default Data File for an EV Minivan for Battery Sizing (MINIVAN)	56
B.b.4	Default Data File for an EV Full-Size Van for Battery Sizing (VAN)	57
B.c.1	Default Gasoline Vehicle Data File for 1991 VW Jetta (VWJETTA)	58
B.c.2	Default Gasoline Vehicle Data File for 1991 Chevrolet Beretta (BERETTA)	59
B.c.3	Default Gasoline Vehicle Data File for 1991 Chevrolet Camaro (CAMARO)	60
B.c.4	Default Gasoline Vehicle Data File for 1991 Honda Accord (ACCORD)	61
B.c.5	Default Gasoline Vehicle Data File for 1991 Ford Cougar (COUGAR)	62
B.c.6	Default Gasoline Vehicle Data File for 1991 Ford Escort (ESCORT)	63
B.c.7	Default Gasoline Vehicle Data File for 1991 Ford Taurus (TAURUS)	64

TABLES (Cont.)

B.c.8	Default Gasoline Vehicle Data File for 1991 Ford Thunderbird (THUNDER)	65
B.d.1	Default Gasoline Vehicle Data File for 1993 Manual BMW 325i (BMWWM)	66
B.d.2	Default Gasoline Vehicle Data File for 1993 Automatic BMW 325i (BMWWA)	67
B.d.3	Default Gasoline Vehicle Data File for 1993 Manual Cutlass Supreme (LUMINAM)	68
B.d.4	Default Gasoline Vehicle Data File for 1993 Automatic Lumina (LUMINAA)	69
B.d.5	Default Gasoline Vehicle Data File for 1993 Manual Toyota Camry DX (CAMRYM)	70
B.d.6	Default Gasoline Vehicle Data File for 1993 Automatic Camry LE (CAMRYA)	71
B.d.7	Default Gasoline Vehicle Data File for 1993 Manual Honda Accord (ACCORDM)	72
B.d.8	Default Gasoline Vehicle Data File for 1993 Automatic Honda Accord (ACCORDA)	73
B.d.9	Default Gasoline Vehicle Data File for 1993 Manual Ford Topaz (TAURUSM)	74
B.d.10	Default Gasoline Vehicle Data File for 1993 Automatic Ford Taurus (TAURUSA)	75
B.d.11	Default Gasoline Vehicle Data File for 1993 Manual Lexus (LEXUSM)	76
B.d.12	Default Gasoline Vehicle Data File for 1993 Automatic Lexus (LEXUSA)	77
B.d.13	Default Gasoline Vehicle Data File for 1993 Manual Ford Escort (ESCORTM)	78
B.d.14	Default Gasoline Vehicle Data File for 1993 Automatic Ford Escort (ESCORTA)	79

TABLES (Cont.)

C.1	Driving Profile for SAE J227aC (J227AC)	83
C.2	Driving Profile for SAE J227aD (J227AD)	84
C.3	Simplified Federal Urban Driving Schedule (SFUDS)	85
C.4	Federal Urban Driving Schedule (FUDS)	87
C.5	Federal Highway Driving Profile (HIGHWAY)	92
C.6	New York City Driving Cycle (NYCC)	95
C.7	LA-92 Driving Cycle (LA-92)	98
C.8	CARB Test Cycle (CARB)	103
C.9	ECE-15 Driving Profile (ECE-15)	105
C.10	Sydney Driving Profile (SYDNEY)	106
C.11	Japan-10 Driving Profile (JAPAN-10)	107
C.12	Constant 40 km/h Driving Profile (40KMPH)	108
C.13	Constant 72 km/h Driving Profile (72KMPH)	109
C.14	Constant 88 km/h Driving Profile (88KMPH)	110
C.15	Power Profile at Battery Terminals for IETV-1/J227aD	111
C.16	Power Profile at Battery Terminals for SFUDS/IDSEP	112
D.1	Default Data File for Sodium/Sulfur Batteries, 1988 Technology (NA-S.88)	117
D.2	Default Data File for Sodium/Sulfur Batteries, 1989 Technology (NA-S.89)	118
D.3	Default Data File for Sodium/Sulfur Batteries, 1990 Technology (NA-S.90)	119
D.4	Default Data File for Nickel/Iron Batteries (NIF-200)	120
D.5	Default Data File for Nickel/Iron Batteries (NIF-220)	121

TABLES (Cont.)

D.6	Default Data File for Tubular Lead/Acid Batteries (3ET205)	122
D.7	Default Data File for Zinc/Bromine Batteries (ZN-BR)	123
D.8	Default Data File for Nickel/Cadmium Batteries (NI-CD)	124
D.9	Default Data File for Nickel/Metal-Hydride Batteries (NI-MH)	125

AVAILABILITY OF COMPUTER SOFTWARE

This computer software has been developed under the sponsorship of the United States Department of Energy (DOE). Any further distribution by any holder of the software package or other data therein outside of DOE offices or other DOE contractors, unless otherwise specifically provided for, is prohibited without the approval of the Energy Science and Technology Software Center. Requests from outside the Department of Energy for DOE-developed computer software shall be directed to Energy Science and Technology Software Center, P.O. Box 1020, Oak Ridge, TN 37831-1020; telephone: (615) 576-2606.

ACKNOWLEDGMENTS

I want to thank Dr. Feng An of the University of California at Riverside and Professor Marc Ross of the University of Michigan for their advice and assistance in using their fuel economy model for gasoline-engine vehicles; Dr. Danilo J. Santini of the Center for Transportation Research at Argonne National Laboratory for his continued support and guidance in developing the software package; and Dr. Philip Patterson, project officer, U.S. Department of Energy, for support of the "Transportation Projection and Assessment" research project under which the software package has been developed. I would also like to thank Ellen Hathaway of Argonne National Laboratory, who edited the text, and the Document Processing Center at Argonne, which provided word-processing support.

**USER'S GUIDE TO EAGLES VERSION 1.1:
AN ELECTRIC- AND GASOLINE-VEHICLE
FUEL-EFFICIENCY SOFTWARE PACKAGE**

by

W.W. Marr

ABSTRACT

EAGLES is an interactive microcomputer software package for the analysis of fuel efficiency in electric-vehicle (EV) applications or the estimation of fuel economy for a gasoline vehicle. The principal objective of the EV analysis is to enable the prediction of EV performance on the basis of laboratory test data for batteries. The EV model included in the software package provides a second-by-second simulation of battery voltage and current for any specified vehicle velocity/time or power/time profile. The capability of the battery is modeled by an algorithm that relates the battery voltage to the withdrawn (or charged) current, taking into account the effect of battery depth-of-discharge. Alternatively, the software package can be used to determine the size of the battery needed to satisfy given vehicle mission requirements. For gasoline vehicles, a generic fuel-economy model based on data from EPA Test Car List 1991 is included in the software package. For both types of vehicles, effects of heating/cooling loads on vehicle performance, including range penalty for EVs, can be studied. Also available is an option to estimate the time needed by a specified vehicle to reach a certain speed with the application of a constant power and an option to compute the fraction of time and/or distance in a driving cycle at speeds exceeding a specified value. Certain parameters can be changed interactively prior to a run.

1 OVERVIEW OF EAGLES VERSION 1.1

1.1 INTRODUCTION

In electric-vehicle (EV) applications, the relationship between the performance of a battery and its operational history is extremely complex. The energy and power capabilities of the battery are generally influenced by the nature and number of discharges that the battery has experienced, which, in turn, are determined by the velocity/time profiles and the driving pattern of the vehicle. Evidence of the complexity of the relationship can sometimes be found in the poor correlation among the results of laboratory testing of EV battery modules, the results of dynamometer or track

testing of EV performance, and the actual in-use ranges and accelerations that have been observed in precommercial demonstrations.

Numerous attempts have been made to analytically describe battery performance so that EV performance can be projected. Such attempts include the fractional utilization model in ELVEC (Slusser, Chapman, and Chazanoff 1982) and the design algorithms in MARVEL (Marr and Walsh 1984, 1992). In most cases, oversimplified or generalized representations of battery performance were used. The state of battery modeling has not yet advanced to the point where it is possible to uniquely determine the performance of a battery at any point in its life by analytically solving a set of equations. However, the simulation process employed in EAGLES, which is described in this report, has the objective of enabling accurate predictions of EV performance by relating battery performance and empirical characteristics of the battery.

For gasoline vehicles (GVs), the study of fuel economy in driving cycles has been based in the past on engine maps (Santiago 1983) or regression methodology (Evans, Herman, and Lam 1976). Both of these approaches are rather time-consuming. In EAGLES version 1.1, a simple model (An and Ross 1993) is used that is based on test data from the Environmental Protection Agency (EPA) for several 1991 vehicles. The generic model provides an analytic approximation to the fuel economy of a gasoline vehicle with any driving cycle.

EAGLES version 1.1 is built upon the framework of DIANE 1.1 (Marr, Walsh, and Symons 1987, 1991, 1992). It is written in FORTRAN language for use on IBM-compatible microcomputers. The current version of EAGLES deals only with EVs using "fresh" batteries. (An algorithm for simulating the aging and recuperation effects of batteries was included in an earlier version of DIANE [Marr, Walsh, and Symons 1987]). In EAGLES, deterioration of battery performance capability due to aging can be simulated with user-input parameters accounting for an increase of effective internal resistance and/or a decrease of cell no-load voltage.

1.2 DEVELOPMENT OF THE EV BATTERY MODEL

The most fundamental assumption in the EAGLES version 1.1 formulation is that the voltage of a battery cell under load can be represented, at any point in its discharge, by the simple electrical equation

$$V = V_0 - IR \quad (1)$$

where

V = the voltage of a cell being discharged (V);

V_0 = the effective no-load voltage, or NLV (V);

I = the discharge current (A); and

R = the effective internal resistance of the cell (Ω).

At any given time during the discharge cycle, the relationship between battery voltage and current is more complicated than is indicated in the simple formulation given in Equation 1. The internal resistance of a battery cell can rarely be represented by a simple ohmic resistance; among other effects, the effective resistance often varies with discharge rate. However, inspection of the discharge current/voltage curves for a number of batteries shows that, over the range of discharge rates and periods of discharge at these rates that are likely to be used in EVs, the formulation given in Equation 1 is a reasonable approximation, provided that the parameters V_0 and R are properly defined.

The effective NLV is the y-intercept of an extrapolated plot of voltage versus current for the cell over the rates and periods of discharge that are of interest for EV applications. Similarly, R in Equation 1 is the slope of the voltage/current plot just described.

In the present version of EAGLES, empirical values of V_0 and R , obtained from laboratory test data, are input in table form as functions of the depth-of-discharge (DOD); thus,

$$V_0 = f_1 (DOD) \quad \text{and} \quad (2)$$

$$R = f_2 (DOD) \quad . \quad (3)$$

For the case of regenerative braking, V_0 and R become V_{0r} and R_r , and therefore the following functional relationships are used:

$$V_{0r} = f_3 (DOD) \quad \text{and} \quad (4)$$

$$R_r = f_4 (DOD) \quad . \quad (5)$$

The parameter DOD in Equations 2-5 is defined as

$$DOD = \frac{\int_0^T I \left[1 + g_1 \left(\frac{I}{I_3} - 1 \right) \right] dt}{C_3} \quad (6)$$

where

t = time (h),

T = discharge time to reach DOD (h),

- I = discharge current at time t (A),
- I_3 = the battery cell current corresponding to a three-hour rate (A),
- C_3 = battery cell capacity corresponding to I_3 (A·h), and
- g_1 = a user-input dimensionless parameter simulating the effect of discharge rate on capacity. The value of g_1 can be derived from battery test data (e.g., the Peukert curve; see Appendix A). For most types of batteries, g_1 can be assumed to be zero.

For a battery that is discharged at a three-hour rate or for a battery that has a capacity unaffected by its discharge rate (i.e., $g_1 = 0$), Equation 6 may be simplified to

$$DOD = \frac{\int_0^T Idt}{C_3} \quad (7)$$

An assumption made in the formulation is that the characteristics of an EV battery pack can be represented by a typical cell. The capacity of a cell (in ampere-hours) is determined from the discharge time that the cell can sustain at a given discharge current before the terminal voltage falls below a cutoff point, or that the cell can sustain before the discharge current reaches the maximum current limit of the controller.

1.3 CALCULATION OF THE BATTERY POWER REQUIREMENT

For a vehicle with specified characteristics, the power requirement at the wheels corresponding to the driving profile is calculated from the required force, which overcomes the air drag, the rolling resistance, and the grading effects while maintaining the vehicle at the specified speed. The equations used in the calculation are described in Appendix A. The battery current and voltage corresponding to the power/time profile are then calculated on a second-by-second basis. Battery power, P_B , at any time is the product of current, I , and voltage, V (i.e., $P_B = IV$). For a known battery power requirement P_B (see Equation A.9), and with the aid of Equation 1, we have the following quadratic equation that can be solved for I :

$$RI^2 - V_0I + P_B = 0 \quad (8)$$

The values of R and V_0 can be obtained from Equations 2 and 3 or Equations 4 and 5, depending on whether the battery is being discharged or charged.

After the instantaneous battery current is calculated, the battery voltage can be computed from Equation 1. The effective capacity discharged is then updated to include the time increment according to Equation 6. The calculation continues for the driving profile until the battery voltage falls below a cutoff point or the battery current reaches the controller limit set by the user. The range is obtained by multiplying the distance of the driving profile by the number of times the profile is repeated.

1.4 BATTERY SIZING FOR EV APPLICATIONS

In EV design, the capacity of the battery is determined by the power and energy demands of the vehicle, which in turn depend on the characteristics of the driving patterns. One of the options provided in EAGLES is the determination of battery size for a specified EV application. On the basis of the given vehicle characteristics (i.e., drag coefficient, rolling resistance, frontal area, and drivetrain efficiency), vehicle mission (i.e., design range, payload, top speed, and acceleration capability), and driving pattern, the peak power and the average energy requirements are estimated for the vehicle. Battery weight is then determined from the assumed attributes (i.e., specific power and energy) of the battery. An iterative procedure is necessary for this purpose because of the weight-dependency of the power and energy demands of the vehicle.

1.5 FUEL ECONOMY MODEL FOR GASOLINE VEHICLES

A simple analytical model (An and Ross 1993) relating fuel economy, vehicle parameters, and driving cycle characteristics is incorporated in the EAGLES version 1.1 software package for estimating fuel consumption in GVs. The model can be used to investigate the effects of changes in vehicle characteristics and driving patterns on fuel economy. The model was based on the following engine map approximation:

$$E_{fuel} = \frac{1}{D} (a_{idle} N_{idle} T_{idle} + a N_{pwr} T_{pwr}) + \frac{1}{\eta_E} E_{engine} \quad (9)$$

where

E_{fuel} = specific fuel energy consumed per unit distance (kJ/m),

D = total distance in a driving cycle (m),

a_{idle} = engine friction characteristic at idle (kJ/rev),
 $= f_{idle} a$,

f_{idle} = idle friction multiplier (dimensionless),

a = engine friction characteristic (kJ/rev),
 $= f_{cold} kV$,

f_{cold} = cold start friction multiplier (dimensionless),
= 1.0 for hot engine,

k = engine friction factor (kJ/rev/L),

V = engine displacement (L),

N_{idle} = engine idling speed (rps),

T_{idle} = engine idling time (s),

N_{pwr} = average engine speed while the engine is delivering power (rps),

T_{pwr} = time of engine delivering power (s),

η_E = engine thermal efficiency (fraction), and

E_{engine} = average energy delivered by the engine per unit distance of the driving cycle (kJ/m).

The energy delivered by the engine not only provides the necessary tractive force, but it also overcomes the losses in the drivetrain and powers the vehicle accessories:

$$E_{engine} = \frac{E_{tract}}{\eta_D} + \frac{P_{acc} T_c}{D} \quad (10)$$

where

E_{tract} = tractive energy at wheels per unit distance (kJ/m),

η_D = drivetrain efficiency (fraction),

P_{acc} = vehicle accessory power (kW), and

T_c = total cycle time (s).

1.6 CALCULATION OF ENGINE SPEED

To compute the average engine speed, N_{pwr} in Equation 9, a subroutine was created to convert the second-by-second vehicle speed to second-by-second engine speed for a given driving cycle, on the basis of user-specified gear ratios and gear shift schedule. The following is the general relationship between engine speed and vehicle speed:

$$N(t) = S \frac{R(L)}{R(L_g)} V_e(t) \quad (11)$$

where

$N(t)$ = engine speed at time t (rps),

S = engine speed/vehicle speed at top gear L_g (rps/mph),

$R(L)$ = gear ratio at L_{th} gear, $L = 1, \dots, L_g$, and

$V_e(t)$ = vehicle speed at time t (mph).

The general relationship between torque and power output of the engine is

$$Q(t) = \frac{5,252}{60} \frac{P(t)}{N(t)} \quad (12)$$

where

$Q(t)$ = engine torque at time t ($\text{lb}_f \cdot \text{ft}$) and

$P(t)$ = engine power output at time t (hp).

Engine torque at any engine speed must not exceed the wide-open-throttle torque of the engine. The wide-open-throttle torque, $Q_{WOT}(t)$, is estimated from the following approximation (see Figure 1) based on a typical spark-ignited (SI) engine performance map:

$$Q_{WOT}(t) = Q_m \left[1 - 0.25 \frac{N_m - N(t)}{N_m - N_{idle}} \right] \quad \text{if} \quad N(t) \leq N_m \quad (13)$$

$$Q_{WOT}(t) = Q_m \left[1 - \left(1 - \frac{Q_p}{Q_m} \right) \frac{(N(t) - N_m)}{(N_p - N_m)} \right] \quad \text{if} \quad N(t) > N_m \quad (14)$$

where

Q_m = maximum engine torque ($\text{lb}_f \cdot \text{ft}$),

N_m = engine speed at maximum torque (rps),

Q_p = engine torque at maximum power ($\text{lb}_f \cdot \text{ft}$), and

N_p = engine speed at maximum power (rps).

FIGURE 1 Approximation of Engine Torque and Speed Relationship

When the calculated $Q(t)$ is greater than $Q_{WOT}(t)$, the vehicle will be downshifted to the next lower gear. New values of engine speed, engine torque, and the wide-open-throttle torque will be recalculated from Equations 11-14. This process will be repeated until all operating conditions are satisfied.

1.7 CLIMATE COMFORT CONTROL

The vehicle climate control systems (including cooling and heating) can have a significant impact on vehicle fuel economy. In GVs, thermal energy is readily available for thermal comfort in the passenger compartment. The case for EVs is different. It is therefore necessary to consider GVs and EVs separately.

1.7.1 Gasoline Vehicles

The loss of fuel economy of a GV due to the operation of a cooling (or heating) system depends on the capacity of the system, type of fan drive, ambient air temperature, and vehicle speed. Power needed to operate the system is added to the accessory power demand, P_{acc} in Equation 10 before computation of the fuel economy of the vehicle is performed.

1.7.2 Electric Vehicles

Results from a study based on a thermal load model (Dieckmann and Mallory 1991a,b) are utilized to estimate the energy consumption and range penalty due to thermal comfort control

(cooling/heating) in an EV. In the Dieckmann and Mallory study, cooling and heating loads were each separated into a steady-state load and a transient load (i.e., for hot-soak cooldown or cold-soak heatup). Cooling and heating performances — capacity, coefficient of performance (COP), and electric power consumption, all as functions of ambient temperature — were calculated under the assumption that a combination of rather modest thermal design measures is employed. These design measures include rooftop insulation, wavelength-selective glass (e.g., PPG Sungate) for all windows, limitations on the ventilation makeup-air flow rate, and provision of an efficient low-voltage mode of interior blower operation to limit hot-soak temperatures when the vehicle is parked.

The design capacity of an air conditioning system was established by the worst case (i.e., Phoenix) cooling load. Instead of the commonly used liquid-fuel-fired heaters performing space heating and defrost functions, it was assumed that the air conditioning system was used as an electrically driven heat-pump system. Heating was provided by a combination of vehicle waste heat, the heat pump, and, when necessary, backup electric resistance heat. The baseline vehicle was assumed to have a maximum heat-pump capacity of meeting 150% of the steady-state cooling load at the Phoenix design ambient. Two vehicles, a four-door compact sedan and a minivan, were examined by Dieckmann and Mallory. Transient loads are shown in the report for several interior-air time constants, averaged over the time period required for the transient load to fall to within 20% of the steady-state load. They found that the interior air cooldown rate corresponding to a six-minute time constant approximates wind tunnel test data reasonably well.

Figures 2 and 3 show the transient and steady-state cooling loads as functions of ambient temperature for a minivan and a four-door compact sedan, respectively. The transient loads are computed by assuming a six-minute time constant and represent the averaged values over 20 min. Figure 4 shows the steady-state heating of the minivan, using vehicle waste heat, vapor cycle heat pump, and backup resistance heat to the extent necessary. Figure 5 shows the transient heating loads of the minivan, using vapor cycle heat pump and backup resistance heat to the extent necessary. Similar plots can be constructed for steady-state and transient heating loads, as shown in Figure 6, for the compact sedan.

In the estimation of energy consumption of climate comfort control in EVs, two categories of vehicles, passenger cars and vans, are considered in EAGLES version 1.1. For vehicles of different sizes in each category, the cooling and heating loads, as well as the heat pump capacity, are assumed to be proportional to their interior volumes.

Vehicle Waste Heat. Vehicle waste heat sources can be utilized as primary or supplemental heat sources. The battery pack, the main controller, and the motor/transmission are the major waste heat sources. The last two of these are reasonably compact, so heat dissipated in these components might be recovered and used for interior heating. From the estimated rate of power dissipation in the main controller and traction motor/transmission for selected EVs (Dieckmann and Mallory 1991b), it is estimated that for every kilowatt of power (including traction

FIGURE 2 Minivan Cooling Loads (adapted from Dieckmann and Mallory [1991b] with the permission of the copyright holder)

FIGURE 3 Compact Car Cooling Loads

FIGURE 4 Steady-State Heating of Minivan (source: Dieckmann and Mallory [1991b]; reproduced with the permission of the copyright holder)

FIGURE 5 Transient Heating (20-min average load) of Minivan (source: Dieckmann and Mallory [1991b]; reproduced with the permission of the copyright holder)

FIGURE 6 Compact Car Heating Loads

and regeneration) through the controller and motor/transmission, approximately 0.26 kW of waste heat is generated. In EAGLES, recovery of 50% of the waste heat during steady state operation is assumed. Both default values can be changed interactively by the user. No recovery of waste heat is assumed during transient warmup or cooldown.

Coefficient of Performance. A COP is defined as cooling (or heating) capacity divided by power consumption. In the estimation of electrical energy consumptions due to cooling and heating, EAGLES uses interpolated values based on the cooling/heating performance data shown in Table 1. For resistance heating, a COP of 1 is assumed.

In EAGLES 1.1, windshield de-icing, defogging, and defrosting loads are assumed to be taken up by an electrically heated windshield. The power required for this operation can be included in the accessory power demand, P_{acc} .

To calculate energy consumption due to climate comfort control, the user can specify the number of time constants (based on a six-minute time constant) required to reach steady state. For some driving cycles, it is possible that the transient period is longer than the duration of the driving cycle. Since recovery of waste heat for heating the vehicle interior is assumed to occur only during steady state, the computation of range penalty due to climate comfort control based on the duration and distance of one driving cycle might not be representative of actual driving conditions. EAGLES 1.1 allows the user to specify either a fixed duration or distance of driving for computing the range penalty. Once the value of one parameter (duration or distance) is given, the value of the other parameter is computed on the basis of the characteristics of the driving cycle.

TABLE 1 Coefficient of Performance for Cooling and Heating^a

Cooling		Heating	
Ambient Temperature (°F)	COP	Ambient Temperature (°F)	COP
90	2.8	14	2.3
110	2.2	47	2.8

^a With vapor cycle-variable speed compressor.

Source: Dieckmann and Mallory (1991b).

1.8 ORGANIZATION OF THE SOFTWARE PROGRAM

EAGLES 1.1 consists of one main program and several subprograms. The names and functions of these subprograms are listed in Table 2. Within each subprogram, there could be more than one subroutine.

TABLE 2 Organization of EAGLES Version 1.1

Name	Function	Subroutine Included
EAGLES11	Main program control; second-by-second EV simulation	RUNEV
INPUTA11	Read and write input data for vehicle, internal combustion engine, and driving profile	PINPUT,PPRINT
INPUTB11	Read and write battery input data; display screen	DINPUT,DPRINT,DISPLAY
SIL11	Set up output device; problem initialization; table look-up	SETPRINT,INIT,BETWEEN
INTER11	Interactive modification of preselected parameters	INTERACT
POWER11	Compute vehicle power profile	POWER
BSIZE11	Determine battery size for EV applications	BSIZE
ACCEL11	Determine power requirement for maximum vehicle acceleration, top speed, and hill climbing	SPEEDUP,APOWER,MPOWER,GPOWER, DERIVS,RKDUMB,RK4
ESPEED11	Compute engine torque and rpm	ESPEED
FUEL11	Compute fuel economy of a gasoline vehicle	FUEL
COUNT11	Count number of seconds vehicle exceeds a specified speed and output drive cycle statistics	COUNT
CLIME11	Compute climate comfort control energy consumption and range penalty for an EV	COOLHEAT
COMMON	Collection of common blocks	

2 DESCRIPTION OF INPUT VARIABLES

Input data are divided into three categories: vehicle (including engine data for GV's or battery specification for EV battery sizing), driving profile, and battery (for EV simulation). Respective default data files are included in Appendixes B through D. Input data to EAGLES 1.1 can be changed in either of two ways: (1) by modifying an existing (default) data file through the use of an on-line interactive text editor or (2) by changing the values of the preselected parameters interactively prior to a run.

2.1 INPUT DATA FOR VEHICLES

Table 3 lists the input data that are needed for an EV simulation run, Table 4 lists input data for battery sizing, and Table 5 lists input data for GV fuel economy estimation.

Nine default data files for EV simulations (shown in Appendix B) are available in the current version of the EAGLES software package. These data files include (1) the Eaton Dual-Shaft Electric Propulsion Van (DSEP); (2) the Improved Dual-Shaft Electric Propulsion Van (IDSEP); (3) the General Motors (GM) Griffon electric van; (4) the Ford Second-Generation Single-Shaft Electric Propulsion System (ETX-II); (5) the GM G-Van, (6) the Chrysler TEVan; (7) the Improved Electric Test Vehicle (IETV-1); (8) the GM two-passenger electric car, the Impact; and (9) the Ford Ecostar van. The name at the end of the title of an appendix table (in upper case) denotes the name of the data file.

For battery sizing, there are four default data files: (1) a two-seater passenger car, (2) a compact passenger car, (3) a minivan, (4) and a full-size van.

For GV's, eight default data files of 1991 model year vehicles with manual transmissions only and fourteen default data files of 1993 model year vehicles with either manual or automatic transmissions are included in the software package. The data are based on federal certification results for 1991 and 1993 model year vehicles (EPA 1991, 1993). These default data files are also shown in Appendix B.

User-input data files can also be used.

2.2 INPUT DATA FOR DRIVING PROFILES

Vehicle fuel efficiency varies significantly with trip characteristics (i.e., average speed, top speed, maximum acceleration rate, and idling time). Driving cycles in the form of repeatable speed-time sequences are designed to represent driving patterns in a particular environment. Velocity data in the driving cycle can be input in two ways: in segments (limit of 100 entries) or in seconds (limit of 2000 entries). Table 6 shows the input required for the driving profile data file.

TABLE 3 Input Vehicle Data for EV Simulation

Input Variable	Unit	Comment
Title	-	Limited to 75 characters
Curb weight, without batteries, CWNB	kg	Vehicle test weight is $TW = CWNB + BW + PLW$
Payload, PLW	kg	Usually half of the maximum
Accessory power demand, PACC	kW	Average power requirement for vehicle accessories
Drivetrain efficiency, EFFD	-	η_D in Equation A.9
Rolling resistance coefficient, K0	-	K_0 in Equation A.5
Rolling resistance coefficient, K1	s/m	K_1 in Equation A.5
Rolling resistance coefficient, K2	s^2/m^2	K_2 in Equation A.5
Frontal area, FAREA	m^2	A_F in Equation A.4
Drag coefficient, CD	-	C_D in Equation A.4
Grade, GRADE	%	$100 \times \tan \theta$; see Figure A.1
Battery weight, BW	kg	Including burden
Motor efficiency, EFFM	-	η_M in Equation A.9
Charger efficiency, EFFC	-	η_C in Equation A.10
Regenerative braking efficiency, EFFR	-	From wheels to battery terminals
Controller current limit, DCOI	A	Voltage limit is set at cell level

TABLE 4 Input Vehicle Data for EV Specification: Battery Sizing^a

Input Variable	Unit	Comment
Battery specific energy, SE	W·h/kg	At 3-hour rate
Battery specific power, SP	W/kg	At DODT
Battery efficiency, EFFB	-	
Vehicle maximum range, RKM	km	At DODT
Battery maximum DOD, DODT	-	
Vehicle acceleration to speed, ACCKM	km/h	
Vehicle acceleration time, ACCTS	s	From 0 to ACCKM
Vehicle top speed, TOPS	km/h	
Vehicle hill climbing speed, VG	km/h	Climbing GRADE at VG

^a In addition to Table 3 input data; battery weight is an initial guess.

TABLE 5 Input Vehicle Data for GV Simulation

Input Variable	Unit	Comment
Title		Limited to 75 characters
Curb weight, CWNB	kg	Vehicle test weight is $TW = CWNB + PLW$
Payload, PLW	kg	Usually 136 kg
Accessory power demand, PACC	kW	Average power requirement for vehicle accessories
Drivetrain efficiency, EFFD	-	η_D in Equation A.10
Rolling resistance coefficient, K0	-	K_0 in Equation A.5
Rolling resistance coefficient, K1	s/m	K_1 in Equation A.5
Rolling resistance coefficient, K2	s^2/m^2	K_2 in Equation A.5
Frontal area, FAREA	m^2	A_F in Equation A.4
Drag coefficient, CD	-	C_D in Equation A.4
Grade, GRADE	%	$100 \times \tan \theta$; see Figure A.1
Engine displacement, VDISP	L	V , see Equation 9
Engine/vehicle speed, RPMMPH	rpm/mph	At top gear
Number of cylinders, CYL	-	
Engine indicated efficiency, ETA	-	η_E in Equation 9
Engine friction factor, FK	kJ/rev/L	k , see Equation 9
Cold start friction multiplier, FCOLD	-	See Equation 9
Idle friction multiplier, FIDLE	-	See Equation 9
Engine idle speed, NIDLE	rpm	
Engine rpm at maximum torque, NT	rpm	N_m , see Figure 1
Engine maximum torque, TMAX	ft-lb	Q_m , see Figure 1
Engine rpm at maximum power, NP	rpm	N_p , see Figure 1
Engine torque at maximum power, TPMAX	ft-lb	Q_p , see Figure 1
Number of gears, LGEAR	-	
Shift schedule pairs: (mph, gear ratio) pairs	(mph, -)	

Fourteen default driving profiles, shown in Appendix C, are available in the software package. These profiles include (1) JPL-Standardized Version of SAE J227a Schedule C and (2) JPL-Standardized Version of SAE J227a Schedule D (Hewitt and Bryant 1982); (3) SFUDS, the Simplified Federal Urban Driving Schedule (DOE 1988); (4) FUDS, the Federal Urban Driving Schedule (Environment Reporter 1992); (5) Federal Highway Driving Cycle (Environment Reporter 1994); (6) NYCC, the New York City Driving Cycle (Environment Reporter 1993); (7) LA-92 (Austin et al. 1992); (8) CARB Test Cycle (Cicero-Fernandez and Long 1993); (9) ECE-15, (10) Sydney, and (11) Japan-10 (Milkins and Watson 1983); and (12-14) three constant speeds. SFUDS is a modification of FUDS, with the power requirement at the battery terminals limited to 79 W/kg.

TABLE 6 Input for Driving Profile Data File

Input Variable	Unit	Comment
Title	-	Limited to 75 characters
Cycle time, TC	s	
Input flag, IFLAG	-	= 0: second-by-second >0: segments
Second-by-second velocity, VEL0(N)	km/h	N=1 to TC; 2000 maximum entries (Format: 5E14.6)
or		
Number of pairs, NS	-	NS = segments + 1
(Time, velocity) pairs	(s,km/h)	Starting from time zero; 100 maximum entries (Format: 5E14.6)

For the case where power profile instead of velocity profile is specified, the second-by-second power requirement (based on battery weight) at the battery terminals should be entered as input. Table 7 shows the input for a power profile data file.

Two default power data files, J227AD.POW (for the IETV-1 with SAE J227aD driving profile) and SFUDS.POW (for the IDSEP vehicle with a battery weight of 695 kg under the SFUDS), are also included in the software package and are shown in Appendix C.

2.3 INPUT DATA FOR BATTERIES

Input variables required for a battery data file are listed in Table 8.

Nine default battery data files are included in the EAGLES software package (see Appendix D). Battery characteristics are based on test data from the Analysis and Diagnostic Laboratory at Argonne National Laboratory (DeLuca et al. 1989, 1992; Miller 1989; EPRI 1992a,b). The Na/S 1988 data file represents the 1988 CSPL Na/S cell technology (as demonstrated in the 24-cell, 8-V module), the Na/S 1989 data file represents the 1989 cell technology (as demonstrated in the 960-cell, 64-V one-third battery), and the Na/S 1990 data file represents the 1990 CSPL technology (as demonstrated in the 120-cell, 8-V module). Also included in the software package are data files based on the 200-A·h Ni/Fe modules (NIF200) and the 220-A·h Ni/Fe modules (NIF220) made by Eagle-Picher Industries (EPI); the advanced tubular lead-acid modules (3ET205) made by Chloride EV Systems Ltd; the 5-kWh, 48-V Zn/Br module made by S.E.A., Austria; the Ni/Cd modules (STM5-200) made by SAFT; and the nickel/metal-hydride (H-cell) made by Ovonic.

TABLE 7 Input for Power Profile Data File

Input Variable	Unit	Comment
Title		Limited to 75 characters
Cycle time, TC	s	
Cycle range, RC	km	Distance per profile
Second-by-second power demand, DP0(N)	W/kg	N=1 to TC; 2000 maximum entries (Format: 5E14.6)

TABLE 8 Input for Battery Data File

Input Variable	Unit	Comment
Title	-	Limited to 75 characters
Net cell weight, WC	kg	With no burden
Accessory weight/cell, WY	kg	
Number of parallel strings in battery, NPS	-	
Cell capacity at C/3 rate, C3	A·h	
Coefficient, DCOV1	V	Cell cutoff voltage $COV = DCOV1 + DCOV2 \cdot I_{max}$
Coefficient, DCOV2	V/A	I_{max} is cell max current in a cycle
Number of (DOD, V_o) data pairs, MV	-	Cell no-load voltages
Cell (DOD, V_o) data pairs	(-, V)	See Equation 2
Number of (DOD, R) data pairs, MR	-	Cell resistances
Cell (DOD, R) data pairs	(-, Ω)	See Equation 3
Number of (DOD, V_{or}) pairs, MVRG	-	Regenerative braking ^a
Cell (DOD, V_{or}) data pairs	(-, V)	See Equation 4
No. of (DOD, R_r) pairs, MRRG	-	Regenerative braking ^a
Cell (DOD, R_r) data pairs	(-, Ω)	See Equation 5
Battery efficiency, EFFB	-	
Parameter g_1	-	See Equation 6

^a Dummy data must be input even if the data are not used in the case where there is no regenerative braking.

3 SOFTWARE PROGRAM OPERATION AND OUTPUT INFORMATION

EAGLES 1.1 runs interactively on an IBM-compatible microcomputer. The following section describes the step-by-step operation of the software package.

3.1 STEP-BY-STEP OPERATION OF EAGLES VERSION 1.1

1. Copy the contents of the diskette into a subdirectory on your hard disk and run EAGLES 1.1 from the hard disk. If you do not have a hard disk, insert the diskette into drive A and set the default drive to A.
2. Enter EAGLES11.
3. You will be asked to specify the output device on which the calculational results are to be displayed or stored. Enter p (for printer), c (for console), or d (for disk). If you choose disk, you will be asked to provide a name for the output file (the default name DOUT will be used if you do not want a new file name).
4. You will then be asked to specify the type of analysis desired: 0 for EV and 1 for GV.
5. If you enter 0 for EV analysis, two options are available: 0 for EV simulation and 1 for battery sizing.

If you choose 0 (EV simulation), the following screen display will appear:

*** Select System for Analysis ***

Vehicle	Driving Profile	Battery
1: DSEP	1: J227aC	1: Na/S 1988
2: IDSEP	2: J227aD	2: Na/S 1989
3: Griffon	3: SFUDS	3: Na/S 1990
4: ETX-II	4: FUDS	4: NIF-200
5: G-Van	5: Highway	5: NIF-220
6: TEVan	6: NYCC	6: 3ET205 L/A
7: IETV-1	7: LA-92	7: Zn/Br
8: Impact	8: CARB	8: Ni/Cd
9: ECOSTAR	9: ECE-15	9: Ni/MH
10: User Input	10: Sydney	10: User Input
	11: Japan-10	
	12: 40kmph	
	13: 72kmph	
	14: 88kmph	
	15: User Input	

If you choose 1 (battery sizing), the following screen display will appear:

***** Select System for Analysis *****

Vehicle	Driving Profile
1: 2-Seater	1: J227aC
2: Compact	2: J227aD
3: Minivan	3: SFUDS
4: Van	4: FUDS
5: User Input	5: Highway
	6: NYCC
	7: LA-92
	8: CARB
	9: ECE-15
	10: Sydney
	11: Japan-10
	12: 40kmph
	13: 72kmph
	14: 88kmph
	15: User Input

If you enter 1 for **GV analysis**, two options are available: 1 for 1991 model cars and 3 for 1993 model cars.

If you enter 1 (1991 model cars), the following screen display will appear:

***** Select System for Analysis *****

Vehicle	Driving Profile
1: VW Jetta	1: J227aC
2: Beretta	2: J227aD
3: Camaro	3: SFUDS
4: Accord	4: FUDS
5: Cougar	5: Highway
6: Escort	6: NYCC
7: Taurus	7: LA-92
8: Thunderbird	8: CARB
9: User Input	9: ECE-15
	10: Sydney
	11: Japan-10
	12: 40kmph
	13: 72kmph
	14: 88kmph
	15: User Input

If you enter 3 (1993 model cars), the following screen display will appear, and you will be prompted to specify the type of transmission used:

***** Select System for Analysis *****

Vehicle	Driving Profile
1: BMW 325i	1: J227aC
2: Lumina	2: J227aD
3: Camry LE	3: SFUDS
4: Accord	4: FUDS
5: Taurus	5: Highway
6: Lexus	6: NYCC
7: Escort	7: LA-92
8: User Input	8: CARB
	9: ECE-15
	10: Sydney
	11: Japan-10
	12: 40kmph
	13: 72kmph
	14: 88kmph
	15: User Input

You can select a default data file by entering the corresponding number for vehicle, driving profile, and/or battery technology, respectively. Or, you can use your own data file by entering the number signifying user input, followed by the name of the data file.

6. For EV simulation, you can specify as input the power profile at the battery terminals (W/kg_battery) corresponding to the selected vehicle and driving profile, instead of calculating the power profile from the velocity profile.
7. Upon completion of Step 6, you can supply a title to identify the run.

8. Prior to the initiation of a simulation run, certain parameters can be changed interactively. These parameters are shown in the following screen display for sample problem 1 (IDSEP/SFUDES /Ni-Cd) of EV simulation:

Index	Parameter	Comment	Unit	Present Value
*	TW	Vehicle test wt. (computed)	kg	2397.000
1	CWNB	Vehicle curb wt. (no batt)	kg	1429.000
2	PLW	Vehicle payload	kg	273.000
3	PACC	Auxiliary power demand	kW	.000
4	EFFD	Drivetrain efficiency	-	.753
5	IPIN	>0: print input data	-	1
6	IPVP	>0: print speed/power	-	0
7	IACC	>0: accelerate @ max power	-	0
8	XKMPH	Count speed > xkmph	km/h	.000
9	GRADE	Grade	%	.000
10	BW	Battery wt. w/accessories	kg	695.000
11	WC	Net cell wt.	kg	4.900
12	WY	Accessory wt./cell	kg	.000
13	NC	No. of cells in battery	-	142.000
14	NPS	Parallel strings in batt.	-	1.000
15	C3	Cell Ah @ C/3	Ah	217.000
16	DCOV1 & 2	Cell cutoff voltage coefs	V,V/A	.7, .0000
17	RF	Resist. factor for aging	-	1.000
18	VF	NLV factor for aging	-	1.000
19	IRG,EFFR	>0: regenerative braking	-,-	1, .500
20	IPTTEST	>0: print profile results	-	1
21	IIV	>0: print S-by-S I & V	-	1

Enter index number to be changed (0 for no more changes):

The following comments are applicable to specific parameters in EV simulation (see screen display above for sample problem 1):

- Note that the program computes the test weight from the curb weight, payload, and for EVs, the battery weight. The user should make sure that the test weight does not exceed the maximum vehicle weight and that the battery does not exceed its volume limitation.
- If IPIN is a nonzero number (any one-digit integer), input data for vehicle, driving profile, and battery will be displayed.

- If IPVP is a nonzero number (any one-digit integer), the second-by-second power profile at the battery terminals (or engine shaft for GVs), computed on the basis of the input velocity profile and vehicle characteristics, will also be displayed. No velocity profile is displayed if the power profile is specified as input.
- If IACC is a nonzero number (any one-digit integer), the acceleration of a vehicle under the hypothetical case of maximum power (at a given battery DOD for EVs or for a specified power at the wheels for GVs) will be simulated. Second-by-second vehicle speed and distance will be displayed.
- If XKMPH is a nonzero real number, the time (in seconds) that the vehicle speed exceeds XKMPH in the driving profile will be counted and printed.
- GRADE applies to the entire driving cycle. A 100% grade corresponds to a 45° grade angle.
- The number of cells, NC, is calculated from the battery weight and the cell weight. If you change NC, the battery weight will be automatically recalculated.
- The cell cutoff voltage is assumed to be of the form $(DCOV1 + DCOV2 * I_{max})$, where I_{max} is the calculated maximum cell current in amperes. When the cell cutoff voltage falls below a user-specified limit, calculation stops.
- The resistance factor, RF, can be used to simulate changes in cell resistance due to battery aging. For a fresh battery, $RF = 1$. This factor applies to both the charging (during regenerative braking) and discharging processes.
- The no-load voltage factor, VF, can be used similarly to account for changes in cell no-load voltage due to aging. For a fresh battery, $VF = 1$. This factor applies to both the charging (during regenerative braking) and discharging processes.
- If IRG is a nonzero number (any one-digit integer), regenerative braking is considered in the calculation. You will be asked to provide a value for EFFR, the regenerative braking efficiency (from wheels to the battery terminals).
- If IPTTEST is a nonzero number (any one-digit integer), profile-by-profile calculational data (such as maximum current, minimum voltage, ampere-hours, and kilowatt-hours) will be displayed. Otherwise, an asterisk (*) will be displayed on the screen to signify the completion of a driving profile.
- If IIV is a nonzero number (any one-digit integer), second-by-second currents and voltages of the first and the last driving profiles will be displayed.

In the case of **battery sizing** for an EV application, a display similar to the following (sample problem 2: Compact Car/FUDS) will appear on-screen for interactive modification of parameters:

Index	Parameter	Comment	Units	Present Value
*	TW	Vehicle test wt.(computed)	kg	1772.000
1	CWNB	Vehicle curb wt.	kg	1110.000
2	PLW	Vehicle payload	kg	136.000
3	PACC	Auxiliary power demand	kW	.000
4	EFFD	Drivetrain efficiency	-	.900
5	IPIN	>0: print input data	-	1
6	IPVP	>0: print speed/power	-	0
7	IACC	>0: accelerate @ max power	-	1
8	XKMPH	count speed > xkmp	km/h	.000
9	GRADE	Grade	%	6.000
10	se	Battery specific energy	wh/kg	80.000
11	sp	Battery specific power	w/kg	150.000
12	effb	Battery efficiency	-	.750
13	rkm	Vehicle maximum range	km	200.000
14	dodt	Battery maximum DOD	-	.800
15	acckm	Vehicle accel. to speed	km/h	96.500
16	accts	Vehicle accel. time	s	13.000
17	tops	Vehicle top speed	km	105.000
18	freg	Braking energy recovered	-	.500
19	vg	Hill climbing speed	km/h	96.500

Enter index number to be changed (0 for no more changes):

The following comments are applicable to the **battery sizing** option (see the above screen display for sample problem 2):

- Both the battery specific energy, se , and specific power, sp , are defined at the maximum battery depth-of-discharge, $dodt$.
- The vehicle acceleration capability is defined as acceleration of vehicle from 0 to $acckm$ km/h in $accts$ seconds.
- $freg$ is defined as the fraction of braking energy converted to useful energy that reduces the average energy requirement at the wheels.
- The vehicle hill climbing capability is specified by $GRADE$ and v_g (i.e., climbing $GRADE$ at constant speed v_g). For this case, $GRADE$ associated with driving cycle is assumed to be zero.

For **GV analysis**, a display similar to the following (sample problem 3: 1991 Honda Accord with the EPA Highway Driving Cycle) will appear on-screen for interactive modification of parameters:

Index	Parameter	Comment	Units	Present Value
*	TW	Vehicle test wt.(computed)	kg	1474.000
1	CWNB	Vehicle curb wt.	kg	1239.000
2	PLW	Vehicle payload	kg	235.000
3	PACC	Auxiliary power demand	kW	.750
4	EFFD	Drivetrain efficiency	-	.900
5	IPIN	>0: print input data	-	1
6	IPVP	>0: print speed/power	-	0
7	IACC	>0: accelerate @ max power	-	0
8	XKMPH	count speed > xkmph	km/h	.000
9	GRADE	Grade	%	.000
10	VDISP	Engine displacement	liter	2.180
11	NIDLE	Engine idling speed	rpm	800.000
12	LGEAR	No. of gears	-	5
13	EFFE	Engine indicated eff.	-	.408
14	ICOLD	>0: engine cold start	-	0
15	fk	Engine friction factor	kJ/rev/L	.220

Enter index number to be changed (0 for no more changes):

The following comments are applicable to the **GV simulation** option (see the above screen display for sample problem 3):

- The default values for both the indicated engine efficiency, EFFE, and the engine friction factor, fk, are empirical values based on EPA test data for 1991 model year cars (EPA 1991).
- If ICOLD is a nonzero number (any one-digit integer), the engine friction factor will be multiplied by FCOLD to simulate engine cold start.

For all three options, to change the value of a particular parameter, enter the corresponding index number. Enter 0 to indicate that no more changes will be made and to instruct the program to start computing.

To change parameters not on the preceding lists, you can modify any default data file included in the software package by using a full-screen text editor. Unless you intend to permanently replace the default data file, be sure to assign a different name to your modified data file.

9. At the beginning of the calculation, a summary output similar to the following will be displayed on the screen for **EV Simulation**:

Vehicle type	IDSEP
Drive cycle	SFUDS
Battery type	Ni-Cd
Test wt. of EV (kg), TW	2397.000
Battery wt. (kg), BW	695.000
Net cell wt. (kg), WC	4.900
Accessory wt./cell (kg), WY	.000
No. of cells in battery, NC	142.000
No. of parallel strings in batt., NPS	1.000
Cell amp-hours @ C/3, C3	217.000
Power required at battery terminals (not including accessory power)	
(W/kg_batt)	74.105
(kW)	51.503
Accessory power demand (kW)	.000
Resistance factor for aging, RF	1.000
No-load voltage factor for aging, VF	1.000

For **EV specification (battery sizing)**, a display such as the following will appear on the screen:

Vehicle type	compact
Drive cycle	FUDS
Battery type	526.000
Test wt. of vehicle (kg)	1772.000
Accessory power demand (kW)	.000
Vehicle maximum range (km)	200.000
Maximum battery DOD (--)	.800
Vehicle acceleration to speed (km/h) ...	96.500
Vehicle acceleration time (s)	13.000
Vehicle top speed (km/h)	105.000
Grade (%)	6.000
Hill climbing speed (km/h)	96.500
Battery specific energy (Wh/kg)	80.000
Battery specific power (W/kg)	150.000

For **GV analysis**, a display similar to the following will appear on the screen:

Vehicle type	Accord
Drive cycle	Highway
Test wt. of vehicle (kg)	1474.000
Engineer power needed	
(W/kg_veh)	19.671
(kW)	28.994
Accessory power demand (kW)	.750

To temporarily halt display on the screen, simultaneously press the Ctrl and S keys; press any key to resume.

To interrupt computation and terminate program execution, simultaneously press the Ctrl and Break keys.

10. Calculational results similar to the following will be displayed on the screen at the conclusion of a case for the **EV simulation**:

Projected maximum range is	166.032 km (103.189 miles)
Capacity removed is	42.240 kWh or 246.555 A·h
Regeneration capacity is	6.296 kWh or 32.058 A·h

For **battery sizing**, output such as battery weight, vehicle speed vs. time, and achievable vehicle range are displayed.

For **GV analysis**, the following output data are displayed:

**** Fuel Economy with Hot Engine ****

Average rpm when engine at power	= 2390.340 rpm
Engine friction (at power)	= .791 kJ/m (1272.292 kJ/mi)
Engine friction (standing)	= .002 kJ/m (2.893 kJ/mi)
Engine friction (braking)	= .035 kJ/m (56.409 kJ/mi)
Tractive energy	= 1.089 kJ/m (1752.574 kJ/mi)
Tire energy loss	= .394 kJ/m (633.244 kJ/mi)
Drag energy loss	= .591 kJ/m (950.979 kJ/mi)
Brake energy loss	= .105 kJ/m (168.351 kJ/mi)
Energy for accessories	= .085 kJ/m (137.090 kJ/mi)
Fuel consumption	= 2.002 kJ/m (3221.259 kJ/mi)
Fuel consumption	= .027 gal/mile
Fuel efficiency	= 37.439 miles/gal

11. For EV analysis, if you are interested in heating/cooling energy consumption and range penalty estimation, the following screen will appear:

Index	Parameter	Comment	Units	Present Value
1	tamc	Ambient temp for cooling	deg C	28.500
2	tamh	Ambient temp for heating	deg C	-10.300
3	vorm	0: van; 1: car	-	1
4	vol	Vehicle interior volume	cu ft	104.000
5	whg	Waste heat generation	kW/kW	.260
6	whr	Waste heat recovered	-	.500
7	trigd	Continuous trip distance	km	3.095
8	tript	Continuous trip duration	s	360.000
9	ntc	No. of time constants	-	2

Enter index number to be changed (0 for no more changes):

You can specify a continuous trip distance or a trip duration as the basis for estimating range penalty. The default values are for one driving profile.

12. Upon completion of a run, you will be asked if you want to run another case for the same combination of vehicle, driving profile, and battery system. If you enter y (for yes), the interactive screen display shown in Step 8 will reappear, which allows you to change the values of the parameters before another run is made. You can also change the output device and title at this time.
13. If you do not want to make another run for the same system, press any key. You will then be asked if you want to choose another system for study. If you enter y, the program will go to Step 3 to let you select an output device and a new combination (vehicle, driving profile, battery technology) for study.

3.2 SAMPLE PROBLEMS

To demonstrate the use of EAGLES 1.1, three sample problems (listed in Table 9) are included in the software package. Detailed input and output of the sample problems can be found in data files, SAMPLE.1, SAMPLE.2, and SAMPLE.3, respectively, included in the EAGLES version 1.1 diskette.

Sample problem 1 is an EV simulation of the Improved DSEP with the simplified FUDS driving profile, using a Ni/Cd battery with characteristics similar to those of the SAFT STM5-200 battery. Estimation of the energy consumption and the range penalty due to heating/cooling is also made for a driving distance of 10 km in Chicago.

TABLE 9 Sample Problems

File Name	System Studied
SAMPLE.1	IDSEP/SFUDS/Nickel-Cadmium EV Simulation
SAMPLE.2	Compact Car/FUDS EV Specification (Battery Sizing)
SAMPLE.3	1991 Honda Accord/Highway GV Simulation

Sample problem 2 is an EV specification (battery sizing) for a compact passenger car with the FUDS driving profile, maximum range of 200 km, top speed of 105 km, acceleration from 0 to 96.5 km/h in 13 s, and hill climbing of 6% grade at 96.5 km/h. Battery characteristics similar to those of the U.S. Advanced Battery Consortium midterm goals (Automotive Engineering 1992) are assumed.

Sample problem 3 is a GV simulation of the 1991 Honda Accord with the federal highway driving profile.

4 VERIFICATION OF RESULTS

4.1 ELECTRIC VEHICLE ANALYSIS

EAGLES results of electric vehicle simulations for various combinations of vehicles, driving profiles, and batteries agree quite well with the projected ranges from laboratory test data (DeLuca et al. 1992; EPRI 1992b), as can be seen from Table 10.

4.2 GASOLINE VEHICLE ANALYSIS

The default data files for gasoline vehicles are based on parameter values for 1991 model year cars (EPA 1991; An and Ross 1993). Table 11 compares EAGLES results for eight cars with urban and highway driving profiles.

TABLE 10 Comparison of Calculated and Laboratory EV Simulation Results

Vehicle/Drive Cycle	Battery	Mileage		Error in EAGLES Result (%)
		EAGLES Result (mi)	Test Data (mi)	
IDSEP/SFUDS	Ni/Cd	103	102 ^{a,b}	1.0
	STM5-200			
IDSEP/SFUDS	Ni/Fe	82	87 ^a	-5.7
	NIF200			
IETV-1/J227aD	Ni/Cd	121	124 ^a	-2.4
	STM5-200			
IETV-1/J227aD	Ni/Fe	104	108 ^a	-3.7
	NIF220			
G-Van/J227aC	Ni/Cd	116	111 ^a	4.5
	STM5-200			
G-Van/J227aC	Ni/Fe	106	102 ^a	3.9
	NIF220			
TEVan/J227aC	Ni/Cd	156	166 ^a	-6.0
	STM5-200			
TEVan/J227aC	Ni/Fe	149	147 ^a	1.4
	NIF220			
IDSEP/SFUDS	Ni/MH	99	97 ^b	2.1
	H-Cell			

^a Source: EPRI (1992b).

^b Source: DeLuca et al. (1992).

TABLE 11 Comparison of EPA Unadjusted^a Mileage and EAGLES Results^b for Eight 1991 Model Year Cars

Make and Model of Vehicle	MPG, FUDS		Error In Eagles Result (%)	MPG, Highway		Error in EAGLES Result (%)
	EPA	EAGLES		EPA	EAGLES	
VW Jetta GL, 4-D	27.3	27.3	0.0	41.4	42.6	2.9
Chevrolet Beretta, 2-D	24.7	25.6	3.6	43.2	42.3	-2.1
Chevrolet Camaro, 2-D	19.4	20.8	7.2	33.4	33.9	1.5
Honda Accord, 4-D	25.5	23.6	-7.5	35.4	37.4	5.6
Mercury Cougar XR-7, 2-D	18.1	18.9	4.4	28.6	30.6	7.0
Ford Escort GT, 2-D	28.6	26.2	-8.4	39.8	40.6	2.0
Ford Taurus SHO, 4-D	20.1	20.2	0.5	33.8	32.8	-3.0
Thunderbird Supercoupe, 4-D	18.5	19.0	2.7	31.1	31.0	-0.3

^a EPA 1991 Test Car List.

^b Assumed drivetrain efficiencies: 0.7 (FUDS); 0.9 (Highway).

5 REFERENCES

An, F., and M. Ross, 1993, "A Model of Fuel Economy and Driving Patterns," Society of Automotive Engineers Paper No. 930328.

Austin, T.C., et al., 1992, "An Analysis of Driving Patterns in Los Angeles during 1992," presented at the Third Annual CRC-APRAC On-Road Vehicle Emissions Workshop, Dec. 3.

Automotive Engineering, 1992, "Battery and Electric Vehicle Update," Vol. 100, no. 9, pp. 17-25, Sept.

Cicero-Fernandez, P., and J.R. Long, 1993, "Modal Acceleration Testing on Current Technology Vehicles," presented at the Specialty Conference on the Emission Inventory: Perception and Reality, Pasadena, Calif.

DeLuca, W.H., et al., 1989, *Laboratory Evaluation of Advanced Battery Technologies for Electric Vehicle Applications*, International Congress and Exposition, Society of Automotive Engineers Paper No. 890820, Detroit, Mich., Feb. 27-March 3.

DeLuca, W.H., et al., 1992, *Results of Advanced Battery Technology Evaluations for Electric Vehicle Applications*, Future Transportation Technology Conference and Exposition, Society of Automotive Engineers Paper No. 921572, Costa Mesa, Calif., Aug. 10-13.

Dieckmann, J., and D. Mallory, 1991a, "Climate Control for Electric Vehicles," Electric Vehicle Design and Development, Society of Automotive Engineers Publication SP-862, SAE Paper No. 910250.

Dieckmann, J., and D. Mallory, 1991b, *Study of Long Term Options for Electric Vehicle Air Conditioning*, EGG-EP-9831, Idaho National Engineering Laboratory, Idaho Falls, Idaho.

DOE: see U.S. Department of Energy.

Electric Power Research Institute, 1992a, *Electric Vehicle Battery Testing and Development at Argonne National Laboratory, 1990 Annual Report*, EPRI TR-100665, prepared by Argonne National Laboratory, Argonne, Ill.

Electric Power Research Institute, 1992b, *Electric Vehicle Battery Testing and Development at Argonne National Laboratory, 1991 Annual Report*, EPRI TR-101371, prepared by Argonne National Laboratory, Argonne, Ill.

Environment Reporter, 1992, *EPA Urban Dynamometer Driving Schedule for Light-Duty Vehicles, Light-Duty Trucks, and Motorcycles with Engine Displacements Equal to or Greater than 170 cc (10.4 cu. in.)*, Federal Regulations, 128, p. 2114.

Environment Reporter, 1993, *EPA New York City Cycle for Light-Duty Vehicles and Light-Duty Trucks*, Federal Regulations, 128, p. 2132.

Environment Reporter, 1994, *Highway Fuel Economy Driving Schedule (Applicable to 1978 and Later Model Year Automobiles)*, Federal Regulations, 128, p. 4040.

EPA: see U.S. Environmental Protection Agency.

EPRI: see Electric Power Research Institute.

Evans, L., R. Herman, and T. Lam, 1976, *Multivariate Analysis of Traffic Factors Related to Fuel Consumption in Urban Driving*, GMR-1710, May.

Hewitt, R., and J. Bryant, 1982, *Testing of the Eagle-Picher Nickel-Iron, the Globe ISOA Lead-Acid, and the Westinghouse Nickel-Iron Battery Subsystems in an Electric-Vehicle Environment*, DOE/CS-54209-10, Jet Propulsion Laboratory, Pasadena, Calif.

Marr, W.W., and W.J. Walsh, 1984, "A Computerized System for Establishing Electric Vehicle Battery Requirements," *Proceedings of the 195th Intersociety Energy Conversion Engineering Conference*, San Francisco, Calif., Aug. 19-24.

Marr, W.W., and W.J. Walsh, 1992, "Life-Cycle Cost Evaluations of Electric/Hybrid Vehicles," *Energy Conversions and Management* 33(9):849-853.

Marr, W.W., W.J. Walsh, and P.C. Symons, 1987, *User's Guide to DIANE: A Microcomputer Program for Modeling Battery Performance in Electric Vehicles*, ANL/CNSV-TM-190, Argonne National Laboratory, Argonne, Ill.

Marr, W.W., W.J. Walsh, and P.C. Symons, 1990, *User's Guide to DIANE Version 2.1: A Microcomputer Software Package for Modeling Battery Performance in Electric Vehicle Applications*, ANL/ESD-8, Argonne National Laboratory, Argonne, Ill.

Marr, W.W., W.J. Walsh, and P.C. Symons, 1992, "Modeling Battery Performance in Electric Vehicle Applications," *Energy Conversions and Management* 33(9):843-847.

Milkins, E., and H. Watson, 1983, *Comparison of Urban Driving Patterns*, Society of Automotive Engineers Paper No. 830939, Warrendale, Penn.

Miller, J.F., 1989, unpublished information, Argonne National Laboratory, Argonne, Ill.

Santiago, A. J., 1993, "Vehicle Fuel-Consumption Maps and Passenger Vehicle Fleet Projections," *Energy Impacts of Geometrics — A Symposium*, Transportation Research Record 901.

Slusser, R.A., C.P. Chapman, and S.L. Chazanoff, 1982, *Electric/Hybrid Vehicle Simulation Program (ELVEC 7.3) User's Manual*, WL 5030-204, Rev. F, Jet Propulsion Laboratory, Pasadena, Calif.

U.S. Department of Energy, 1988, *EHP Battery Test Working Task Force, A Simplified Version of the Federal Urban Driving Schedule for Electric Vehicle Battery Testing*, DOE/ID-10146.

U.S. Environmental Protection Agency, 1991, *Control of Air Pollution from New Motor Vehicle and New Vehicle Engine — Federal Certification Results for 1991 Model Year.*

U.S. Environmental Protection Agency, 1993, *Control of Air Pollution from New Motor Vehicle and New Vehicle Engine — Federal Certification Results for 1993 Model Year.*

APPENDIX A:
CALCULATION OF POWER REQUIREMENTS AND PARAMETER g_1

APPENDIX A:

CALCULATION OF POWER REQUIREMENTS AND PARAMETER g_1

A.1 CALCULATION OF VEHICLE AND BATTERY POWER REQUIREMENTS

Power requirements at the battery terminals can be calculated from a specified velocity profile, provided that the vehicle characteristics (test weight, frontal area, drag coefficient, rolling resistance coefficients, the drivetrain efficiency, and the grade of the road) are given.

The instantaneous road-load power is calculated from the required force, which overcomes the drag force, the rolling resistance, and the grading effects while maintaining the vehicle at the specified speed. The equations for velocity, force, and power are given below.

The instantaneous speed of the vehicle at time t in any linear driving period can be expressed as

$$V = V_1 + a\Delta t \quad (\text{A.1})$$

where

$$a = \text{acceleration or deceleration} = (V_2 - V_1)/(t_2 - t_1);$$

$$V_1, V_2 = \text{the speed at time } t_1 \text{ and } t_2, \text{ respectively;}$$

$$\Delta t = t - t_1;$$

$$t = \text{time;}$$

$$t_1 = \text{the time at the beginning of the period; and}$$

$$t_2 = \text{the time at the end of the period.}$$

The distance at time t is given by

$$S = S_1 + V\Delta t + a(\Delta t)^2/2 \quad (\text{A.2})$$

where S_1 is the distance at time t_1 .

As shown in Figure A.1, the total required driving force, F_T is given by

$$F_T = F_D + F_R + F_G + F_A, \quad (\text{A.3})$$

FIGURE A.1 Schematic Diagram of Forces Acting on a Vehicle

with the air-drag force,

$$F_D = \rho C_D A_F V^2 / 2 \quad (\text{A.4})$$

the rolling resistance force,

$$F_R = W_T \cos \theta (K_0 + K_1 V + K_2 V^2) \quad (\text{A.5})$$

the force due to grade,

$$F_G = W_T \sin \theta \quad (\text{A.6})$$

and the acceleration force,

$$F_A = W_T a / g \quad (\text{A.7})$$

where

ρ = air density;

C_D = drag coefficient;

A_F = vehicle frontal area;

W_T = vehicle weight;

θ = grading angle, $\tan^{-1}(\% \text{ grade}/100)$;

K_0, K_1, K_2 = rolling resistance coefficients; and

g = gravitational acceleration.

The power at the wheels, P_{wh} is given by

$$P_{wh} = VF_T \quad (A.8)$$

for an electric vehicle; the power required at the battery terminals, P_B , is

$$P_B = P_{wh} / (\eta_D \eta_M) \quad (A.9)$$

where η_D and η_M are efficiencies of the transmission and the motor, respectively. The power required at the wall plug, P_{WALL} , is

$$P_{WALL} = P_B / (\eta_B \eta_C) \quad (A.10)$$

where η_B and η_C are efficiencies of the battery and the charger, respectively.

A.2 CALCULATION OF PARAMETER g_1 FOR EV SIMULATION

The parameter g_1 that simulates the effect of discharge rate on battery capacity in Equation 6 can be computed from the Peukert curve as follows:

For a complete discharge of the battery (i.e., DOD = 1.0) at a constant current I_i over the time period of T_i , Equation 6 becomes

$$C_3 = \int_0^{T_i} \left[1 + g_1 \left(\frac{I_i}{I_3} - 1 \right) \right] dt \quad ; \quad (A.11)$$

with $I_3 = C_3 / 3$, where C_3 is the capacity at a 3-h rate, and $(Ah)_i = I_i T_i$, Equation A.11 becomes

$$C_3 = (Ah)_i \left[1 + g_1 \left(\frac{3I_i}{C_3} - 1 \right) \right] \quad . \quad (A.12)$$

Equation A.12 can be solved for g_1 .

$$g_1 = \frac{\frac{C_3}{(Ah)_i} - 1}{\frac{3I_i}{C_3} - 1} \quad . \quad (A.13)$$

The value of g_1 can be computed from the Peukert curve, which is a plot of $(Ah)_i$ vs. I_i . Several data points can be used to yield an average value for g_1 .

APPENDIX B:
DEFAULT VEHICLE DATA FILES

TABLE B.a.1 Default Electric Vehicle Data File for the Eaton Dual-Shaft Electric Propulsion Van (DSEP)

Default vehicle dataset for DSEP	
curb wt. w/o battery (kg), cwnb =	.129300E+04
payload (kg), pLw =	.232000E+03
accessory power demand, (kW), pacc =	.000000E+00
drivetrain eff. (fraction), effd =	.819000E+00
rolling res. coeff., (--), k0 =	.100000E-01
rolling res. coeff., (s/m), k1 =	.000000E+00
rolling res. coeff., (s**2/m**2), k2 =	.000000E+00
frontal area, (m**2), farea =	.346000E+01
drag coeff., (--), cd =	.370000E+00
grade, (%), grade =	.000000E+00
battery wt. w/accessories, (kg), bw =	.700000E+03
motor eff. (fraction), effm =	.900000E+00
charger eff. (fraction), effc =	.900000E+00
regenerative braking eff., effr =	.500000E+00
controller current limit, (A), DCOI =	.400000E+03

TABLE B.a.2 Default Electric Vehicle Data File for the Improved Dual-Shaft Electric Propulsion Van (IDSEP)

Default vehicle dataset for IDSEP	
curb wt. w/o battery (kg), cwnb =	.142900E+04
payload (kg), pLw =	.273000E+03
accessory power demand, (kW), pacc =	.000000E+00
drivetrain eff. (fraction), effd =	.752600E+00
rolling res. coeff., (--), k0 =	.800000E-02
rolling res. coeff., (s/m), k1 =	.000000E+00
rolling res. coeff., (s**2/m**2), k2 =	.000000E+00
frontal area, (m**2), farea =	.297000E+01
drag coeff., (--), cd =	.370000E+00
grade, (%), grade =	.000000E+00
battery wt. w/accessories, (kg), bw =	.695000E+03
motor eff. (fraction), effm =	.900000E+00
charger eff. (fraction), effc =	.900000E+00
regenerative braking eff., effr =	.500000E+00
controller current limit, (A), DCOI =	.600000E+04

TABLE B.a.3 Default Electric Vehicle Data File for the Griffon Electric Van (GRIFFON)

Default vehicle dataset for Griffon	
curb wt. w/o battery (kg), cwnb =	.150200E+04
payload (kg), pLw =	.431000E+03
accessory power demand, (kW), pacc =	.000000E+00
drivetrain eff. (fraction), effd =	.750000E+00
rolling res. coeff., (--), k0 =	.830000E-02
rolling res. coeff., (s/m), k1 =	.000000E+00
rolling res. coeff., (s**2/m**2), k2 =	.000000E+00
frontal area, (m**2), farea =	.246000E+01
drag coeff., (--), cd =	.370000E+00
grade, (%), grade =	.000000E+00
battery wt. w/accessories, (kg), bw =	.113600E+04
motor eff. (fraction), effm =	.900000E+00
charger eff. (fraction), effc =	.900000E+00
regenerative braking eff., effr =	.500000E+00
controller current limit, (A), DCOI =	.300000E+03

TABLE B.a.4 Default Electric Vehicle Data File for the Second-Generation Single-Shaft Electric Propulsion System (ETX-II)

Default vehicle dataset for ETX-II	
curb wt. w/o battery (kg), cwnb =	.129800E+04
payload (kg), pLw =	.258000E+03
accessory power demand, (kW), pacc =	.000000E+00
drivetrain eff. (fraction), effd =	.819000E+00
rolling res. coeff., (--), k0 =	.100000E-01
rolling res. coeff., (s/m), k1 =	.000000E+00
rolling res. coeff., (s**2/m**2), k2 =	.000000E+00
frontal area, (m**2), farea =	.295000E+01
drag coeff., (--), cd =	.370000E+00
grade, (%), grade =	.000000E+00
battery wt. w/accessories, (kg), bw =	.500000E+03
motor eff. (fraction), effm =	.900000E+00
charger eff. (fraction), effc =	.900000E+00
regenerative braking eff., effr =	.500000E+00
controller current limit, (A), DCOI =	.480000E+03

TABLE B.a.5 Default Electric Vehicle Data File for G-Van (G-VAN)

Default Vehicle Datafile for G-VAN	
curb wt. w/o batt. (kg), cwnb =	.229800E+04
payload (kg), pLw =	.703000E+03
accessory power demand, (kW), pacc =	.000000E+00
drivetrain eff. (fraction), effd =	.794000E+00
rolling res. coeff., (--), k0 =	.100000E-01
rolling res. coeff., (s/m), k1 =	.000000E+00
rolling res. coeff., (s**2/m**2), k2 =	.000000E+00
frontal area, (m**2), farea =	.348000E+01
drag coeff., (--), cd =	.370000E+00
grade, (%), grade =	.000000E+00
battery wt. w/accessories, (kg), bw=	.118000E+04
motor eff. (fraction), effm =	.900000E+00
charger eff. (fraction), effc =	.900000E+00
regenerative braking eff., effr =	.500000E+00
controller current limit, (A), DCOI =	.300000E+03

TABLE B.a.6 Default Electric Vehicle Data File for TEVan (TEVAN)

Default vehicle dataset for TEVan	
curb wt. w/o battery (kg), cwnb =	.152000E+04
payload (kg), pLw =	.362000E+03
accessory power demand, (kW), pacc =	.000000E+03
drivetrain eff. (fraction), effd =	.900000E+00
rolling res. coeff., (--), k0 =	.830000E-02
rolling res. coeff., (s/m), k1 =	.000000E+00
rolling res. coeff., (s**2/m**2), k2 =	.000000E+00
frontal area, (m**2), farea =	.262000E+01
drag coeff., (--), cd =	.370000E+00
grade, (%), grade =	.000000E+00
battery wt. w/accessories, (kg), bw =	.839000E+03
motor eff. (fraction), effm =	.900000E+00
charger eff. (fraction), effc =	.900000E+00
regenerative braking eff., effr =	.500000E+00
controller current limit, (A), DCOI =	.300000E+03

TABLE B.a.7 Default Electric Vehicle Data File for the Improved Electric Test Vehicle (IETV-1)

Default vehicle dataset for IETV-1	
curb wt. w/o battery (kg), cwnb =	.103200E+04
payload (kg), pLw =	.158800E+03
accessory power demand, (kW), pacc =	.000000E+00
drivetrain eff. (fraction), effd =	.870000E+00
rolling res. coeff., (--), k0 =	.900000E-02
rolling res. coeff., (s/m), k1 =	.000000E+00
rolling res. coeff., (s**2/m**2), k2 =	.000000E+00
frontal area, (m**2), farea =	.174000E+01
drag coeff., (--), cd =	.310000E+00
grade, (%), grade =	.000000E+00
battery wt. w/accessories, (kg), bw =	.488000E+03
motor eff. (fraction), effm =	.900000E+00
charger eff. (fraction), effc =	.900000E+00
regenerative braking eff., effr =	.500000E+00
controller current limit, (A), DCOI =	.600000E+03

TABLE B.a.8 Default Electric Vehicle Data File for GM Impact (IMPACT)

Default Vehicle Data File for GM IMPACT 3

curb wt. w/o batt. (kg), cwnb =	.830900E+03
payload (kg), pLw =	.136000E+03
accessory power demand, (kW), pacc =	.600000E+00
drivetrain eff. (fraction), effd =	.840000E+00
rolling res. coeff., (--), k0 =	.480000E-02
rolling res. coeff., (s/m), k1 =	.000000E+00
rolling res. coeff., (s**2/m**2), k2 =	.000000E+00
frontal area, (m**2), farea =	.177900E+01
drag coeff., (--), cd =	.190000E+00
grade, (%), grade =	.000000E+00
battery wt. w/accessories, (kg), bw=	.488800E+03
motor eff. (fraction), effm =	.900000E+00
charger eff. (fraction), effc =	.900000E+00
regenerative braking eff., effr =	.500000E+00
controller current limit, (A), DCOI =	.500000E+03

TABLE B.a.9 Default Electric Vehicle Data File for Ford Ecostar (ECOSTAR)

Default vehicle dataset for ECOSTAR	
curb wt. w/o battery (kg), cwnb =	.105200E+04
payload (kg), pLw =	.385000E+03
accessory power demand, (kW), pacc =	.000000E+00
drivetrain eff. (fraction), effd =	.850000E+00
rolling res. coeff., (--), k0 =	.800000E-02
rolling res. coeff., (s/m), k1 =	.000000E+00
rolling res. coeff., (s**2/m**2), k2 =	.000000E+00
frontal area, (m**2), farea =	.220000E+01
drag coeff., (--), cd =	.330000E+00
grade, (%), grade =	.000000E+00
battery wt. w/accessories, (kg), bw =	.354000E+03
motor eff. (fraction), effm =	.850000E+00
charger eff. (fraction), effc =	.900000E+00
regenerative braking eff., effr =	.500000E+00
controller current limit, (A), DCOI =	.480000E+03

TABLE B.b.1 Default Data File for an EV Two-Seater Car for Battery Sizing (TWOSEATS)

EV Specification, 2-seater, L/A, 5/94	
curb wt. w/o batt. (kg), cwnb =	.809000E+03
payload (kg), pLw =	.102000E+03
accessory power demand, (kW), pacc =	.000000E+00
drivetrain eff. (fraction), effd =	.900000E+00
rolling res. coeff., (--), k0 =	.500000E-02
rolling res. coeff., (s/m), k1 =	.000000E+00
rolling res. coeff., (s**2/m**2), k2 =	.000000E+00
frontal area, (m**2), farea =	.180000E+01
drag coeff., (--), cd =	.220000E+00
grade, (%), grade =	.600000E+01
battery wt. w/accessories, (kg), bw=	.350000E+03
motor eff. (fraction), effm =	.900000E+00
charger eff. (fraction), effc =	.875000E+00
regenerative braking eff., effr =	.750000E+00
controller current limit, (A), DCOI =	.500000E+03
battery specific energy, (Wh/kg), se =	.450000E+02
battery specific power, (W/kg), sp =	.150000E+03
battery efficiency, (--), effb =	.780000E+00
vehicle maximum range, (km), rkm =	.120000E+03
battery maximum DOD, (--), dodt =	.800000E+00
vehicle accl. to speed (km/h), acckm =	.965000E+02
vehicle accl. time (s), accts =	.130000E+02
vehicle top speed (km/h), tops =	.105000E+03
vehicle hill climbing speed (km/h), vg =	.965000E+02

TABLE B.b.2 Default Data File for an EV Compact Car for Battery Sizing (COMPACT)

EV Specification, Compact Car, USABC Midterm Goals, 5/94

curb wt. w/o batt. (kg), cwnb =	.111000E+04
payload (kg), pLw =	.136000E+03
accessory power demand, (kW), pacc =	.000000E+00
drivetrain eff. (fraction), effd =	.900000E+00
rolling res. coeff., (--), k0 =	.500000E-02
rolling res. coeff., (s/m), k1 =	.000000E+00
rolling res. coeff., (s**2/m**2), k2 =	.000000E+00
frontal area, (m**2), farea =	.180000E+01
drag coeff., (--), cd =	.220000E+00
grade, (%), grade =	.600000E+01
battery wt. w/accessories, (kg), bw=	.526000E+03
motor eff. (fraction), effm =	.900000E+00
charger eff. (fraction), effc =	.875000E+00
regenerative braking eff., effr =	.756000E+00
controller current limit, (A), DCOI =	.500000E+03
battery specific energy, (Wh/kg), se =	.800000E+02
battery specific power, (W/kg), sp =	.150000E+03
battery efficiency, (--), effb =	.750000E+00
vehicle maximum range, (km), rkm =	.200000E+03
battery maximum DOD, (--), dodt =	.800000E+00
vehicle accl. to speed (km/h), acckm =	.965000E+02
vehicle accl. time (s), accts =	.130000E+02
vehicle top speed (km/h), tops =	.105000E+03
vehicle hill climbing speed (km/h), vg =	.965000E+02

TABLE B.b.3 Default Data File for an EV Minivan for Battery Sizing (MINIVAN)

EV Specification, Minivan, Ni-Cd, 5/94	
curb wt. w/o batt. (kg), cwnb =	.114100E+04
payload (kg), pLw =	.227000E+03
accessory power demand, (kW), pacc =	.000000E+00
drivetrain eff. (fraction), effd =	.900000E+00
rolling res. coeff., (--), k0 =	.700000E-02
rolling res. coeff., (s/m), k1 =	.000000E+00
rolling res. coeff., (s**2/m**2), k2 =	.000000E+00
frontal area, (m**2), farea =	.265000E+01
drag coeff., (--), cd =	.320000E+00
grade, (%), grade =	.600000E+01
battery wt. w/accessories, (kg), bw=	.308000E+03
motor eff. (fraction), effm =	.900000E+00
charger eff. (fraction), effc =	.875000E+00
regenerative braking eff., effr =	.756000E+00
controller current limit, (A), DCOI =	.500000E+03
battery specific energy, (Wh/kg), se =	.550000E+02
battery specific power, (W/kg), sp =	.175000E+03
battery efficiency, (--), effb =	.800000E+00
vehicle maximum range, (km), rkm =	.120000E+03
battery maximum DOD, (--), dodt =	.800000E+00
vehicle accl. to speed (km/h), acckm =	.965000E+02
vehicle accl. time (s), accts =	.180000E+02
vehicle top speed (km/h), tops =	.105000E+03
vehicle hill climbing speed (km/h), vg =	.965000E+02

TABLE B.b.4 Default Data File for an EV Full-Size Van for Battery Sizing (VAN)

EV Specification, Full-size Van, USABC Longterm Goals, 5/94

curb wt. w/o batt. (kg), cwnb =	.202000E+04
payload (kg), pLw =	.340000E+03
accessory power demand, (kW), pacc =	.000000E+00
drivetrain eff. (fraction), effd =	.900000E+00
rolling res. coeff., (--), k0 =	.700000E-02
rolling res. coeff., (s/m), k1 =	.000000E+00
rolling res. coeff., (s**2/m**2), k2 =	.000000E+00
frontal area, (m**2), farea =	.376000E+01
drag coeff., (--), cd =	.320000E+00
grade, (%), grade =	.600000E+01
battery wt. w/accessories, (kg), bw=	.632000E+03
motor eff. (fraction), effm =	.900000E+00
charger eff. (fraction), effc =	.875000E+00
regenerative braking eff., effr =	.756000E+00
controller current limit, (A), DCOI =	.500000E+03
battery specific energy, (Wh/kg), se =	.200000E+03
battery specific power, (W/kg), sp =	.400000E+03
battery efficiency, (--), effb =	.800000E+00
vehicle maximum range, (km), rkm =	.105000E+03
battery maximum DOD, (--), dodt =	.800000E+00
vehicle accl. to speed (km/h), acckm =	.965000E+02
vehicle accl. time (s), accts =	.180000E+02
vehicle top speed (km/h), tops =	.105000E+03
vehicle hill climbing speed (km/h), vg =	.965000E+02

TABLE B.c.1 Default Gasoline Vehicle Data File for 1991 VW Jetta (VWJETTA)

VW Jetta (4-D), 1991 Model, M5 Transmission

curb wt., (kg), cwnb =	.107400E+04
payload (kg), pLw =	.173000E+03
accessory power demand, (kW), pacc =	.750000E+00
drivetrain eff. (fraction), effd =	.900000E+00
rolling res. coeff., (--), k0 =	.100000E-01
rolling res. coeff., (s/m), k1 =	.000000E+00
rolling res. coeff., (s**2/m**2), k2 =	.000000E+00
frontal area, (m**2), farea =	.198000E+01
drag coeff., (--), cd =	.340000E+00
grade, (%), grade =	.000000E+00
engine displacement, (liter), vdisp =	.180000E+01
N/v, (rpm/mph), rpmmph =	.418000E+02
number of cylinder, (--), cyl =	.400000E+01
engine ind. power eff. (--), eta =	.408000E+00
engine friction factor (kJ/rev/l), fk =	.220000E+00
cold start fric. multiplier, (--), fcold =	.107000E+01
idle friction multiplier, (--), fidle =	.116000E+01
engine idle speed, (rpm), nidle =	.800000E+03
engine rpm at max torque, (rpm), nt =	.340000E+04
engine torque @ nt, (ft-lb), tmax =	.107000E+03
engine rpm at max power, (rpm), np =	.540000E+04
engine torque @ np, (ft-lb), tpmax =	.973000E+02
number of gears, (--), LGEAR =	5
shift schedule (mph, gear ratio) pairs:	
0.	3.50
15.	2.14
25.	1.36
40.	1.00
50.	0.78

TABLE B.c.2 Default Gasoline Vehicle Data File for 1991 Chevrolet Beretta (BERETTA)

Chev. Beretta(2-D), 1991 Model, M5 Transmission
 curb wt., (kg), cwnb = .120100E+04
 payload (kg), pLw = .160000E+03
 accessory power demand, (kW), pacc = .750000E+00
 drivetrain eff. (fraction), effd = .900000E+00
 rolling res. coeff., (--), k0 = .100000E-01
 rolling res. coeff., (s/m), k1 = .000000E+00
 rolling res. coeff., (s**2/m**2), k2 = .000000E+00
 frontal area, (m**2), farea = .206000E+01
 drag coeff., (--), cd = .280000E+00
 grade, (%), grade = .000000E+00
 engine displacement, (liter), vdisp = .221000E+01
 N/v, (rpm/mph), rpmmph = .366000E+02
 number of cylinder, (--), cyl = .400000E+01
 engine ind. power eff. (--), eta = .408000E+00
 engine friction factor (kJ/rev/l), fk = .220000E+00
 cold start fric. multiplier, (--), fcold = .107000E+01
 idle friction multiplier, (--), fidle = .116000E+01
 engine idle speed, (rpm), nidle = .800000E+03
 engine rpm at max torque, (rpm), nt = .320000E+04
 engine torque @ nt, (ft-lb), tmax = .130000E+03
 engine rpm at max power, (rpm), np = .520000E+04
 engine torque @ np, (ft-lb), tpmax = .960000E+02
 number of gears, (--), LGEAR = 5
 shift schedule (mph, gear ratio) pairs:
 0. 3.50
 15. 2.14
 25. 1.36
 40. 1.00
 50. 0.78

TABLE B.c.3 Default Gasoline Vehicle Data File for 1991 Chevrolet Camaro (CAMARO)

Chev. Camaro (2-D), 1991 Model, M5 Transmission
 curb wt., (kg), cwnb = .140800E+04
 payload (kg), pLw = .179000E+03
 accessory power demand, (kW), pacc = .750000E+00
 drivetrain eff. (fraction), effd = .900000E+00
 rolling res. coeff., (--), k0 = .100000E-01
 rolling res. coeff., (s/m), k1 = .000000E+00
 rolling res. coeff., (s**2/m**2), k2 = .000000E+00
 frontal area, (m**2), farea = .197000E+01
 drag coeff., (--), cd = .355000E+00
 grade, (%), grade = .000000E+00
 engine displacement, (liter), vdisp = .315000E+01
 N/v, (rpm/mpg), rpmmph = .347000E+02
 number of cylinder, (--), cyl = .600000E+01
 engine ind. power eff. (--), eta = .408000E+00
 engine friction factor (kJ/rev/l), fk = .220000E+00
 cold start fric. multiplier, (--), fcold = .107000E+01
 idle friction multiplier, (--), fidle = .116000E+01
 engine idle speed, (rpm), nidle = .700000E+03
 engine rpm at max torque, (rpm), nt = .360000E+04
 engine torque @ nt, (ft-lb), tmax = .180000E+03
 engine rpm at max power, (rpm), np = .440000E+04
 engine torque @ np, (ft-lb), tpmax = .167000E+03
 number of gears, (--), LGEAR = 5
 shift schedule (mph, gear ratio) pairs:
 0. 3.50
 15. 2.14
 25. 1.36
 40. 1.00
 50. 0.78

TABLE B.c.4 Default Gasoline Vehicle Data File for 1991 Honda Accord (ACCORD)

Honda Accord (4-D), 1991 Model, M5 Transmission

curb wt. (kg), cwnb =	.123900E+04
payload (kg), pLw =	.235000E+03
accessory power demand, (kW), pacc =	.750000E+00
drivetrain eff. (fraction), effd =	.900000E+00
rolling res. coeff., (--), k0 =	.100000E-01
rolling res. coeff., (s/m), k1 =	.000000E+00
rolling res. coeff., (s**2/m**2), k2 =	.000000E+00
frontal area, (m**2), farea =	.193000E+01
drag coeff., (--), cd =	.364000E+00
grade, (%), grade =	.000000E+00
engine displacement, (liter), vdisp =	.218000E+01
N/v, (rpm/mpg), rpmmph =	.416000E+02
number of cylinder, (--), cyl =	.400000E+01
engine ind. power eff. (--), eta =	.408000E+00
engine friction factor (kJ/rev/l), fk =	.220000E+00
cold start fric. multiplier, (--), fcold =	.107000E+01
idle friction multiplier, (--), fidle =	.116000E+01
engine idle speed, (rpm), nidle =	.800000E+03
engine rpm at max torque, (rpm), nt =	.400000E+04
engine torque @ nt, (ft-lb), tmax =	.137000E+03
engine rpm at max power, (rpm), np =	.520000E+04
engine torque @ np, (ft-lb), tpmax =	.126300E+03
number of gears, (--), LGEAR =	5
shift schedule (mph, gear ratio) pairs:	
0.	3.50
15.	2.14
25.	1.36
40.	1.00
50.	0.78

TABLE B.c.5 Default Gasoline Vehicle Data File for 1991 Ford Cougar (COUGAR)

```

Mercury Cougar(XR-7, 2-D), 1991 Model, L4 Transmission
curb wt., (kg), cwnb = .172300E+04
payload (kg), pLw = .907000E+02
accessory power demand, (kW), pacc = .750000E+00
drivetrain eff. (fraction), effd = .900000E+00
rolling res. coeff., (--), k0 = .100000E-01
rolling res. coeff., (s/m), k1 = .000000E+00
rolling res. coeff., (s**2/m**2), k2 = .000000E+00
frontal area, (m**2), farea = .206000E+01
drag coeff., (--), cd = .417000E+00
grade, (%), grade = .000000E+00
engine displacement, (liter), vdisp = .499000E+01
N/v, (rpm/mpg), rpmmph = .240000E+02
number of cylinder, (--), cyl = .800000E+01
engine ind. power eff. (--), eta = .408000E+00
engine friction factor (kJ/rev/l), fk = .220000E+00
cold start fric. multiplier, (--), fcold = .107000E+01
idle friction multiplier, (--), fidle = .116000E+01
engine idle speed, (rpm), nidle = .600000E+03
engine rpm at max torque, (rpm), nt = .300000E+04
engine torque @ nt, (ft-lb), tmax = .275000E+03
engine rpm at max power, (rpm), np = .400000E+04
engine torque @ np, (ft-lb), tpmax = .262600E+03
number of gears, (--), LGEAR = 4
shift schedule (mph, gear ratio) pairs:
0. 2.81
15. 1.55
25. 1.00
45. 0.71

```

TABLE B.c.6 Default Gasoline Vehicle Data File for 1991 Ford Escort (ESCORT)

Ford Escort (4-D, Crown Victoria), 1991 Model, M5 Transmission

curb wt. w/o battery (kg), cwnb =	.106800E+04
payload (kg), pLw =	.179000E+03
accessory power demand, (kW), pacc =	.750000E+00
drivetrain eff. (fraction), effd =	.900000E+00
rolling res. coeff., (--), k0 =	.100000E-01
rolling res. coeff., (s/m), k1 =	.000000E+00
rolling res. coeff., (s**2/m**2), k2 =	.000000E+00
frontal area, (m**2), farea =	.189000E+01
drag coeff., (--), cd =	.350000E+00
grade, (%), grade =	.000000E+00
engine displacement, (liter), vdisp =	.180000E+01
N/v, (rpm/mph), rpmmph =	.480000E+02
number of cylinder, (--), cyl =	.400000E+01
engine ind. power eff. (--), eta =	.408000E+00
engine friction factor (kJ/rev/l), fk =	.220000E+00
cold start fric. multiplier, (--), fcold =	.107000E+01
idle friction multiplier, (--), fidle =	.116000E+01
engine idle speed, (rpm), nidle =	.800000E+03
engine rpm at max torque, (rpm), nt =	.450000E+04
engine torque @ nt, (ft-lb), tmax =	.114000E+03
engine rpm at max power, (rpm), np =	.650000E+04
engine torque @ np, (ft-lb), tpmax =	.102600E+03
number of gears, (--), LGEAR =	5
shift schedule (mph, gear ratio) pairs:	
0.	3.50
15.	2.14
25.	1.36
40.	1.00
50.	0.78

TABLE B.c.7 Default Gasoline Vehicle Data File for 1991 Ford Taurus (TAURUS)

Ford Taurus (SHO 4-D), 1991 Model, M5 Transmission

curb wt., (kg), cwnb =	.150100E+04
payload (kg), pLw =	.200000E+03
accessory power demand, (kW), pacc =	.750000E+00
drivetrain eff. (fraction), effd =	.900000E+00
rolling res. coeff., (--), k0 =	.100000E-01
rolling res. coeff., (s/m), k1 =	.000000E+00
rolling res. coeff., (s**2/m**2), k2 =	.000000E+00
frontal area, (m**2), farea =	.206000E+01
drag coeff., (--), cd =	.351000E+00
grade, (%), grade =	.000000E+00
engine displacement, (liter), vdisp =	.302000E+01
N/v, (rpm/mph), rpmumph =	.370000E+02
number of cylinder, (--), cyl =	.600000E+01
engine ind. power eff. (--), eta =	.408000E+00
engine friction factor (kJ/rev/l), fk =	.220000E+00
cold start fric. multiplier, (--), fcold =	.107000E+01
idle friction multiplier, (--), fidle =	.116000E+01
engine idle speed, (rpm), nidle =	.700000E+03
engine rpm at max torque, (rpm), nt =	.480000E+04
engine torque @ nt, (ft-lb), tmax =	.200000E+03
engine rpm at max power, (rpm), np =	.620000E+04
engine torque @ np, (ft-lb), tpmax =	.186400E+03
number of gears, (--), LGEAR =	5
shift schedule (mph, gear ratio) pairs:	
0.	3.50
15.	2.14
25.	1.36
40.	1.00
50.	0.78

TABLE B.c.8 Default Gasoline Vehicle Data File for 1991 Ford Thunderbird (THUNDER)

Ford Thunderbird (Super Coupe 2-D), 1991 Model, M5 Transmission

curb wt., (kg), cwnb =	.169500E+04
payload (kg), pLw =	.232000E+03
accessory power demand, (kW), pacc =	.750000E+00
drivetrain eff. (fraction), effd =	.900000E+00
rolling res. coeff., (--), k0 =	.100000E-01
rolling res. coeff., (s/m), k1 =	.000000E+00
rolling res. coeff., (s**2/m**2), k2 =	.000000E+00
frontal area, (m**2), farea =	.206000E+01
drag coeff., (--), cd =	.423000E+00
grade, (%), grade =	.000000E+00
engine displacement, (liter), vdisp =	.381000E+01
N/v, (rpm/mph), rpmmph =	.268000E+02
number of cylinder, (--), cyl =	.600000E+01
engine ind. power eff. (--), eta =	.408000E+00
engine friction factor (kJ/rev/l), fk =	.220000E+00
cold start fric. multiplier, (--), fcold =	.107000E+01
idle friction multiplier, (--), fidle =	.116000E+01
engine idle speed, (rpm), nidle =	.700000E+03
engine rpm at max torque, (rpm), nt =	.260000E+04
engine torque @ nt, (ft-lb), tmax =	.315000E+03
engine rpm at max power, (rpm), np =	.400000E+04
engine torque @ np, (ft-lb), tpmax =	.275700E+03
number of gears, (--), LGEAR =	5
shift schedule (mph, gear ratio) pairs:	
0.	3.50
15.	2.14
25.	1.36
40.	1.00
50.	0.78

TABLE B.d.1 Default Gasoline Vehicle Data File for 1993 Manual BMW 325i (BMWM)

```

BMW 325i 4-D, 1993 Model, 5M Transmission
curb wt. (kg), cwnb = .140000E+04
payload (kg), pLw = .131000E+03
accessory power demand, (kW), pacc = .750000E+00
drivetrain eff. (fraction), effd = .900000E+00
rolling res. coeff., (--), k0 = .800000E-02
rolling res. coeff., (s/m), k1 = .000000E+00
rolling res. coeff., (s**2/m**2), k2 = .000000E+00
frontal area, (m**2), farea = .197000E+01
drag coeff., (--), cd = .355000E+00
grade, (%), grade = .000000E+00
engine displacement, (liter), vdisp = .250000E+01
N/v, (rpm/mph), rpmmph = .442000E+02
number of cylinder, (--), cyl = .600000E+01
engine ind. power eff. (--), eta = .408000E+00
engine friction factor (kJ/rev/l), fk = .220000E+00
cold start fric. multiplier, (--), fcold = .107000E+01
idle friction multiplier, (--), fidle = .116000E+01
engine idle speed, (rpm), nidle = .700000E+03
engine rpm at max torque, (rpm), nt = .420000E+04
engine torque @ nt, (ft-lb), tmax = .181000E+03
engine rpm at max power, (rpm), np = .590000E+04
engine torque @ np, (ft-lb), tpmax = .168000E+03
number of gears, (--), LGEAR = 5
shift schedule (mph, gear ratio) pairs:
0. 3.50
15. 2.14
25. 1.36
40. 1.00
50. 0.78

```

TABLE B.d.2 Default Gasoline Vehicle Data File for 1993 Automatic BMW 325i (BMWA)

```

BMW 325i 4-D, 1993 Model, 4A Transmission
curb wt. (kg), cwnb = .145600E+04
payload (kg), pLw = .131000E+03
accessory power demand, (kW), pacc = .150000E+01
drivetrain eff. (fraction), effd = .880000E+00
rolling res. coeff., (--), k0 = .800000E-02
rolling res. coeff., (s/m), k1 = .000000E+00
rolling res. coeff., (s**2/m**2), k2 = .000000E+00
frontal area, (m**2), farea = .197000E+01
drag coeff., (--), cd = .355000E+00
grade, (%), grade = .000000E+00
engine displacement, (liter), vdisp = .250000E+01
N/v, (rpm/mph), rpmmph = .395000E+02
number of cylinder, (--), cyl = .600000E+01
engine ind. power eff. (--), eta = .408000E+00
engine friction factor (kJ/rev/l), fk = .220000E+00
cold start fric. multiplier, (--), fcold = .107000E+01
idle friction multiplier, (--), fidle = .116000E+01
engine idle speed, (rpm), nidle = .700000E+03
engine rpm at max torque, (rpm), nt = .420000E+04
engine torque @ nt, (ft-lb), tmax = .181000E+03
engine rpm at max power, (rpm), np = .590000E+04
engine torque @ np, (ft-lb), tpmx = .168000E+03
number of gears, (--), LGEAR = 4
shift schedule (mph, gear ratio) pairs:
0. 2.81
15. 1.58
25. 1.00
45. 0.71

```

TABLE B.d.3 Default Gasoline Vehicle Data File for 1993 Manual Cutlass Supreme (LUMINAM)

Cutlass Supreme 4-D, 1993 Model, 5M	
curb wt. (kg), cwnb =	.144200E+04
payload (kg), pLw =	.259000E+03
accessory power demand, (kW), pacc =	.750000E+00
drivetrain eff. (fraction), effd =	.900000E+00
rolling res. coeff., (--), k0 =	.800000E-02
rolling res. coeff., (s/m), k1 =	.000000E+00
rolling res. coeff., (s**2/m**2), k2 =	.000000E+00
frontal area, (m**2), farea =	.207000E+01
drag coeff., (--), cd =	.300000E+00
grade, (%), grade =	.000000E+00
engine displacement, (liter), vdisp =	.340000E+01
N/v, (rpm/mph), rpmmph =	.345000E+02
number of cylinder, (--), cyl =	.600000E+01
engine ind. power eff. (--), eta =	.408000E+00
engine friction factor (kJ/rev/l), fk =	.220000E+00
cold start fric. multiplier, (--), fcold =	.107000E+01
idle friction multiplier, (--), fidle =	.116000E+01
engine idle speed, (rpm), nidle =	.700000E+03
engine rpm at max torque, (rpm), nt =	.400000E+04
engine torque @ nt, (ft-lb), tmax =	.215000E+03
engine rpm at max power, (rpm), np =	.500000E+04
engine torque @ np, (ft-lb), tpmax =	.210000E+03
number of gears, (--), LGEAR =	5
shift schedule (mph, gear ratio) pairs:	
0.	3.50
15.	2.14
25.	1.36
40.	1.00
50.	0.78

TABLE B.d.4 Default Gasoline Vehicle Data File for 1993 Automatic Lumina (LUMINAA)

Chev. Lumina 4-D, 1993 Model, 4A	
curb wt. (kg), cwnb =	.144200E+04
payload (kg), pLw =	.259000E+03
accessory power demand, (kW), pacc =	.150000E+01
drivetrain eff. (fraction), effd =	.880000E+00
rolling res. coeff., (--), k0 =	.800000E-02
rolling res. coeff., (s/m), k1 =	.000000E+00
rolling res. coeff., (s**2/m**2), k2 =	.000000E+00
frontal area, (m**2), farea =	.207000E+01
drag coeff., (--), cd =	.300000E+00
grade, (%), grade =	.000000E+00
engine displacement, (liter), vdisp =	.340000E+01
N/v, (rpm/mpg), rpmmpg =	.311000E+02
number of cylinder, (--), cyl =	.600000E+01
engine ind. power eff. (--), eta =	.408000E+00
engine friction factor (kJ/rev/l), fk =	.220000E+00
cold start fric. multiplier, (--), fcold =	.107000E+01
idle friction multiplier, (--), fidle =	.116000E+01
engine idle speed, (rpm), nidle =	.700000E+03
engine rpm at max torque, (rpm), nt =	.400000E+04
engine torque @ nt, (ft-lb), tmax =	.215000E+03
engine rpm at max power, (rpm), np =	.500000E+04
engine torque @ np, (ft-lb), tpmax =	.210000E+03
number of gears, (--), LGEAR =	4
shift schedule (mph, gear ratio) pairs:	
0.	2.81
15.	1.58
25.	1.00
45.	0.71

TABLE B.d.5 Default Gasoline Vehicle Data File for 1993 Manual Toyota Camry DX (CAMRYM)

Toyota Camry 4-D, 1993 Model, 5M	
curb wt. (kg), cwnb =	.133500E+04
payload (kg), pLw =	.196000E+03
accessory power demand, (kW), pacc =	.750000E+00
drivetrain eff. (fraction), effd =	.900000E+00
rolling res. coeff., (--), k0 =	.800000E-02
rolling res. coeff., (s/m), k1 =	.000000E+00
rolling res. coeff., (s**2/m**2), k2 =	.000000E+00
frontal area, (m**2), farea =	.207000E+01
drag coeff., (--), cd =	.350000E+00
grade, (%), grade =	.000000E+00
engine displacement, (liter), vdisp =	.220000E+01
N/v, (rpm/mph), rpmmph =	.402000E+02
number of cylinder, (--), cyl =	.400000E+01
engine ind. power eff. (--), eta =	.408000E+00
engine friction factor (kJ/rev/l), fk =	.220000E+00
cold start fric. multiplier, (--), fcold =	.107000E+01
idle friction multiplier, (--), fidle =	.116000E+01
engine idle speed, (rpm), nidle =	.800000E+03
engine rpm at max torque, (rpm), nt =	.440000E+04
engine torque @ nt, (ft-lb), tmax =	.145000E+03
engine rpm at max power, (rpm), np =	.540000E+04
engine torque @ np, (ft-lb), tpmax =	.126000E+03
number of gears, (--), LGEAR =	5
shift schedule (mph, gear ratio) pairs:	
0.	3.50
15.	2.14
25.	1.36
40.	1.00
50.	0.78

TABLE B.d.6 Default Gasoline Vehicle Data File for 1993 Automatic Camry LE (CAMRYA)

Toyota Camry 4-D, 1993 Model, 4A	
curb wt. (kg), cwnb =	.133500E+04
payload (kg), pLw =	.196000E+03
accessory power demand, (kW), pacc =	.150000E+01
drivetrain eff. (fraction), effd =	.880000E+00
rolling res. coeff., (--), k0 =	.800000E-02
rolling res. coeff., (s/m), k1 =	.000000E+00
rolling res. coeff., (s**2/m**2), k2 =	.000000E+00
frontal area, (m**2), farea =	.207000E+01
drag coeff., (--), cd =	.350000E+00
grade, (%), grade =	.000000E+00
engine displacement, (liter), vdisp =	.220000E+01
N/v, (rpm/mph), rpmmph =	.367000E+02
number of cylinder, (--), cyl =	.400000E+01
engine ind. power eff. (--), eta =	.408000E+00
engine friction factor (kJ/rev/l), fk =	.220000E+00
cold start fric. multiplier, (--), fcold =	.107000E+01
idle friction multiplier, (--), fidle =	.116000E+01
engine idle speed, (rpm), nidle =	.800000E+03
engine rpm at max torque, (rpm), nt =	.440000E+04
engine torque @ nt, (ft-lb), tmax =	.145000E+03
engine rpm at max power, (rpm), np =	.540000E+04
engine torque @ np, (ft-lb), tpmax =	.126000E+03
number of gears, (--), LGEAR =	4
shift schedule (mph, gear ratio) pairs:	
0.	2.81
15.	1.58
25.	1.00
45.	0.71

TABLE B.d.7 Default Gasoline Vehicle Data File for 1993 Manual Honda Accord (ACCORDM)

Honda Accord 4-D, 1993 Model, 5M	
curb wt. (kg), cwnb =	.126000E+04
payload (kg), pLw =	.327000E+03
accessory power demand, (kW), pacc =	.750000E+00
drivetrain eff. (fraction), effd =	.900000E+00
rolling res. coeff., (--), k0 =	.800000E-02
rolling res. coeff., (s/m), k1 =	.000000E+00
rolling res. coeff., (s**2/m**2), k2 =	.000000E+00
frontal area, (m**2), farea =	.191000E+01
drag coeff., (--), cd =	.400000E+00
grade, (%), grade =	.000000E+00
engine displacement, (liter), vdisp =	.220000E+01
N/v, (rpm/mph), rpmmph =	.437000E+02
number of cylinder, (--), cyl =	.400000E+01
engine ind. power eff. (--), eta =	.408000E+00
engine friction factor (kJ/rev/l), fk =	.220000E+00
cold start fric. multiplier, (--), fcold =	.107000E+01
idle friction multiplier, (--), fidle =	.116000E+01
engine idle speed, (rpm), nidle =	.800000E+03
engine rpm at max torque, (rpm), nt =	.400000E+04
engine torque @ nt, (ft-lb), tmax =	.137000E+03
engine rpm at max power, (rpm), np =	.520000E+04
engine torque @ np, (ft-lb), tpmax =	.126000E+03
number of gears, (--), LGEAR =	5
shift schedule (mph, gear ratio) pairs:	
0.	3.50
15.	2.14
25.	1.36
40.	1.00
50.	0.78

TABLE B.d.8 Default Gasoline Vehicle Data File for 1993 Automatic Honda Accord (ACCORDA)

Honda Accord 4-D, 1993 Model, 4A	
curb wt. (kg), cwnb =	.120400E+04
payload (kg), pLw =	.327000E+03
accessory power demand, (kW), pacc =	.150000E+01
drivetrain eff. (fraction), effd =	.880000E+00
rolling res. coeff., (--), k0 =	.800000E-02
rolling res. coeff., (s/m), k1 =	.000000E+00
rolling res. coeff., (s**2/m**2), k2 =	.000000E+00
frontal area, (m**2), farea =	.191000E+01
drag coeff., (--), cd =	.400000E+00
grade, (%), grade =	.000000E+00
engine displacement, (liter), vdisp =	.220000E+01
N/v, (rpm/mpg), rpmmph =	.439000E+02
number of cylinder, (--), cyl =	.400000E+01
engine ind. power eff. (--), eta =	.408000E+00
engine friction factor (kJ/rev/l), fk =	.220000E+00
cold start fric. multiplier, (--), fcold =	.107000E+01
idle friction multiplier, (--), fidle =	.116000E+01
engine idle speed, (rpm), nidle =	.800000E+03
engine rpm at max torque, (rpm), nt =	.400000E+04
engine torque @ nt, (ft-lb), tmax =	.137000E+03
engine rpm at max power, (rpm), np =	.520000E+04
engine torque @ np, (ft-lb), tpmax =	.126000E+03
number of gears, (--), LGEAR =	4
shift schedule (mph, gear ratio) pairs:	
0.	2.81
15.	1.58
25.	1.00
45.	0.71

TABLE B.d.9 Default Gasoline Vehicle Data File for 1993 Manual Ford Topaz (TAURUSM)

Ford Topaz, 1993 Model, 5M	
curb wt. (kg), cwnb =	.128100E+04
payload (kg), pLw =	.136000E+03
accessory power demand, (kW), pacc =	.750000E+00
drivetrain eff. (fraction), effd =	.900000E+00
rolling res. coeff., (--), k0 =	.800000E-02
rolling res. coeff., (s/m), k1 =	.000000E+00
rolling res. coeff., (s**2/m**2), k2 =	.000000E+00
frontal area, (m**2), farea =	.208000E+01
drag coeff., (--), cd =	.330000E+00
grade, (%), grade =	.000000E+00
engine displacement, (liter), vdisp =	.300000E+01
N/v, (rpm/mph), rpmmph =	.392000E+02
number of cylinder, (--), cyl =	.600000E+01
engine ind. power eff. (--), eta =	.408000E+00
engine friction factor (kJ/rev/l), fk =	.220000E+00
cold start fric. multiplier, (--), fcold =	.107000E+01
idle friction multiplier, (--), fidle =	.116000E+01
engine idle speed, (rpm), nidle =	.700000E+03
engine rpm at max torque, (rpm), nt =	.480000E+04
engine torque @ nt, (ft-lb), tmax =	.200000E+03
engine rpm at max power, (rpm), np =	.620000E+04
engine torque @ np, (ft-lb), tpmax =	.186000E+03
number of gears, (--), LGEAR =	5
shift schedule (mph, gear ratio) pairs:	
0.	3.50
15.	2.14
25.	1.36
40.	1.00
50.	0.78

TABLE B.d.10 Default Gasoline Vehicle Data File for 1993 Automatic Ford Taurus (TAURUSA)

Ford Taurus SHO 4-D, 1993 Model, 4A	
curb wt. (kg), cwnb =	.145100E+04
payload (kg), pLw =	.136000E+03
accessory power demand, (kW), pacc =	.150000E+01
drivetrain eff. (fraction), effd =	.880000E+00
rolling res. coeff., (--), k0 =	.800000E-02
rolling res. coeff., (s/m), k1 =	.000000E+00
rolling res. coeff., (s**2/m**2), k2 =	.000000E+00
frontal area, (m**2), farea =	.208000E+01
drag coeff., (--), cd =	.330000E+00
grade, (%), grade =	.000000E+00
engine displacement, (liter), vdisp =	.300000E+01
N/v, (rpm/mph), rpmmph =	.319000E+02
number of cylinder, (--), cyl =	.600000E+01
engine ind. power eff. (--), eta =	.408000E+00
engine friction factor (kJ/rev/l), fk =	.220000E+00
cold start fric. multiplier, (--), fcold =	.107000E+01
idle friction multiplier, (--), fidle =	.116000E+01
engine idle speed, (rpm), nidle =	.700000E+03
engine rpm at max torque, (rpm), nt =	.480000E+04
engine torque @ nt, (ft-lb), tmax =	.200000E+03
engine rpm at max power, (rpm), np =	.620000E+04
engine torque @ np, (ft-lb), tpmax =	.186000E+03
number of gears, (--), LGEAR =	4
shift schedule (mph, gear ratio) pairs:	
0.	2.81
15.	1.58
25.	1.00
45.	0.71

TABLE B.d.11 Default Gasoline Vehicle Data File for 1993 Manual Lexus (LEXUSM)

Lexus SC400 2-D, 1993 Model, 5M	
curb wt. (kg), cwnb =	.162500E+04
payload (kg), pLw =	.132000E+03
accessory power demand, (kW), pacc =	.750000E+00
drivetrain eff. (fraction), effd =	.900000E+00
rolling res. coeff., (--), k0 =	.800000E-02
rolling res. coeff., (s/m), k1 =	.000000E+00
rolling res. coeff., (s**2/m**2), k2 =	.000000E+00
frontal area, (m**2), farea =	.200000E+01
drag coeff., (--), cd =	.330000E+00
grade, (%), grade =	.000000E+00
engine displacement, (liter), vdisp =	.400000E+01
N/v, (rpm/mph), rpmmph =	.446000E+02
number of cylinder, (--), cyl =	.800000E+01
engine ind. power eff. (--), eta =	.408000E+00
engine friction factor (kJ/rev/l), fk =	.220000E+00
cold start fric. multiplier, (--), fcold =	.107000E+01
idle friction multiplier, (--), fidle =	.116000E+01
engine idle speed, (rpm), nidle =	.600000E+03
engine rpm at max torque, (rpm), nt =	.440000E+04
engine torque @ nt, (ft-lb), tmax =	.260000E+03
engine rpm at max power, (rpm), np =	.560000E+04
engine torque @ np, (ft-lb), tpmax =	.234000E+03
number of gears, (--), LGEAR =	5
shift schedule (mph, gear ratio) pairs:	
0.	3.50
15.	2.14
25.	1.36
40.	1.00
50.	0.78

TABLE B.d.12 Default Gasoline Vehicle Data File for 1993 Automatic Lexus (LEXUSA)

```

Lexus SC400 2-D, 1993 Model, 4A
curb wt. (kg), cwnb = .168200E+04
payload (kg), pLw = .132000E+03
accessory power demand, (kW), pacc = .150000E+01
drivetrain eff. (fraction), effd = .880000E+00
rolling res. coeff., (--), k0 = .800000E-02
rolling res. coeff., (s/m), k1 = .000000E+00
rolling res. coeff., (s**2/m**2), k2 = .000000E+00
frontal area, (m**2), farea = .200000E+01
drag coeff., (--), cd = .330000E+00
grade, (%), grade = .000000E+00
engine displacement, (liter), vdisp = .400000E+01
N/v, (rpm/mpg), rpmmph = .375000E+02
number of cylinder, (--), cyl = .800000E+01
engine ind. power eff. (--), eta = .408000E+00
engine friction factor (kJ/rev/l), fk = .220000E+00
cold start fric. multiplier, (--), fcold = .107000E+01
idle friction multiplier, (--), fidle = .116000E+01
engine idle speed, (rpm), nidle = .600000E+03
engine rpm at max torque, (rpm), nt = .440000E+04
engine torque @ nt, (ft-lb), tmax = .260000E+03
engine rpm at max power, (rpm), np = .560000E+04
engine torque @ np, (ft-lb), tpmax = .234000E+03
number of gears, (--), LGEAR = 4
shift schedule (mph, gear ratio) pairs:
0. 2.81
15. 1.58
25. 1.00
45. 0.71

```

TABLE B.d.13 Default Gasoline Vehicle Data File for 1993 Manual Ford Escort (ESCORTM)

Ford Escort 4-D, 1993 Model, 5M	
curb wt. (kg), cwnb =	.107000E+04
payload (kg), pLw =	.120000E+03
accessory power demand, (kW), pacc =	.750000E+00
drivetrain eff. (fraction), effd =	.900000E+00
rolling res. coeff., (--), k0 =	.800000E-02
rolling res. coeff., (s/m), k1 =	.000000E+00
rolling res. coeff., (s**2/m**2), k2 =	.000000E+00
frontal area, (m**2), farea =	.189000E+01
drag coeff., (--), cd =	.330000E+00
grade, (%), grade =	.000000E+00
engine displacement, (liter), vdisp =	.190000E+01
N/v, (rpm/mpg), rpmmph =	.406000E+02
number of cylinder, (--), cyl =	.400000E+01
engine ind. power eff. (--), eta =	.408000E+00
engine friction factor (kJ/rev/l), fk =	.220000E+00
cold start fric. multiplier, (--), fcold =	.107000E+01
idle friction multiplier, (--), fidle =	.116000E+01
engine idle speed, (rpm), nidle =	.800000E+03
engine rpm at max torque, (rpm), nt =	.380000E+04
engine torque @ nt, (ft-lb), tmax =	.108000E+03
engine rpm at max power, (rpm), np =	.440000E+04
engine torque @ np, (ft-lb), tpmax =	.105000E+03
number of gears, (--), LGEAR =	5
shift schedule (mph, gear ratio) pairs:	
0.	3.50
15.	2.14
25.	1.36
40.	1.00
50.	0.78

TABLE B.d.14 Default Gasoline Vehicle Data File for 1993 Automatic Ford Escort (ESCORTA)

Ford Escort 4-D, 1993 Model, 4A	
curb wt. (kg), cwnb =	.112700E+04
payload (kg), pLw =	.120000E+03
accessory power demand, (kW), pacc =	.150000E+01
drivetrain eff. (fraction), effd =	.880000E+00
rolling res. coeff., (--), k0 =	.800000E-02
rolling res. coeff., (s/m), k1 =	.000000E+00
rolling res. coeff., (s**2/m**2), k2 =	.000000E+00
frontal area, (m**2), farea =	.189000E+01
drag coeff., (--), cd =	.350000E+00
grade, (%), grade =	.000000E+00
engine displacement, (liter), vdisp =	.190000E+01
N/v, (rpm/mph), rpmmph =	.376000E+02
number of cylinder, (--), cyl =	.400000E+01
engine ind. power eff. (--), eta =	.408000E+00
engine friction factor (kJ/rev/l), fk =	.220000E+00
cold start fric. multiplier, (--), fcold =	.107000E+01
idle friction multiplier, (--), fidle =	.116000E+01
engine idle speed, (rpm), nidle =	.800000E+03
engine rpm at max torque, (rpm), nt =	.380000E+04
engine torque @ nt, (ft-lb), tmax =	.108000E+03
engine rpm at max power, (rpm), np =	.440000E+04
engine torque @ np, (ft-lb), tpmax =	.105000E+03
number of gears, (--), LGEAR =	4
shift schedule (mph, gear ratio) pairs:	
0.	2.81
15.	1.58
25.	1.00
45.	0.71

APPENDIX C:
DEFAULT DRIVING PROFILE DATA FILES

TABLE C.1 Driving Profile for SAE J227aC (J227AC)

SAE J227AC (JPL-Standardized) DRIVING PROFILE

cycle time (s), TC=

80

```
iflag(=0: s-by-s; >0: segments)=
```

0

s-by-s velocity, (km/h), for TC s

[illegible]

TABLE C.2 Driving Profile for SAE J227aD (J227AD)

SAE J227AD (JPL-Standardized) DRIVING PROFILE

cycle time (s), TC=

122

```
iflag(=0: s-by-s; >0: segments)=
```

0

s-by-s velocity, (km/h), for TC-TREST s

[illegible]

TABLE C.3 Simplified Federal Urban Driving Schedule (SFUDS)

Simplified FUDS (SFUDS)				
cycle time (s), TC=				
iflag(=0: s-by-s; >0: segments)=				
s-by-s velocity, (km/h), for TC s				
			360	
			0	
.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
.000000E+00	.240000E+01	.480000E+01	.720000E+01	.970000E+01
.111000E+02	.122000E+02	.134000E+02	.146000E+02	.158000E+02
.169000E+02	.179000E+02	.187000E+02	.195000E+02	.201000E+02
.208000E+02	.214000E+02	.220000E+02	.227000E+02	.233000E+02
.240000E+02	.245000E+02	.249000E+02	.256000E+02	.261000E+02
.275000E+02	.290000E+02	.303000E+02	.315000E+02	.328000E+02
.340000E+02	.351000E+02	.360000E+02	.370000E+02	.378000E+02
.388000E+02	.396000E+02	.378000E+02	.359000E+02	.341000E+02
.320000E+02	.301000E+02	.277000E+02	.253000E+02	.227000E+02
.171000E+02	.114000E+02	.580000E+01	.200000E+00	.000000E+00
.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
.000000E+00	.240000E+01	.480000E+01	.720000E+01	.970000E+01
.111000E+02	.122000E+02	.134000E+02	.146000E+02	.158000E+02
.169000E+02	.179000E+02	.187000E+02	.195000E+02	.201000E+02
.208000E+02	.214000E+02	.220000E+02	.227000E+02	.233000E+02
.240000E+02	.245000E+02	.249000E+02	.256000E+02	.261000E+02
.275000E+02	.290000E+02	.303000E+02	.315000E+02	.328000E+02
.340000E+02	.351000E+02	.360000E+02	.370000E+02	.378000E+02
.388000E+02	.396000E+02	.378000E+02	.359000E+02	.341000E+02
.320000E+02	.301000E+02	.277000E+02	.253000E+02	.227000E+02
.171000E+02	.114000E+02	.580000E+01	.200000E+00	.000000E+00
.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
.000000E+00	.240000E+01	.480000E+01	.720000E+01	.970000E+01
.111000E+02	.122000E+02	.134000E+02	.146000E+02	.158000E+02
.169000E+02	.179000E+02	.187000E+02	.195000E+02	.201000E+02
.208000E+02	.214000E+02	.220000E+02	.227000E+02	.233000E+02
.240000E+02	.245000E+02	.249000E+02	.256000E+02	.261000E+02
.275000E+02	.290000E+02	.303000E+02	.315000E+02	.328000E+02
.340000E+02	.351000E+02	.360000E+02	.370000E+02	.378000E+02
.388000E+02	.396000E+02	.378000E+02	.359000E+02	.341000E+02
.320000E+02	.301000E+02	.277000E+02	.253000E+02	.227000E+02
.171000E+02	.114000E+02	.580000E+01	.200000E+00	.000000E+00
.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
.000000E+00	.240000E+01	.480000E+01	.720000E+01	.970000E+01
.111000E+02	.122000E+02	.134000E+02	.146000E+02	.158000E+02
.169000E+02	.179000E+02	.187000E+02	.195000E+02	.201000E+02
.208000E+02	.214000E+02	.220000E+02	.227000E+02	.233000E+02
.240000E+02	.245000E+02	.249000E+02	.256000E+02	.261000E+02
.275000E+02	.290000E+02	.303000E+02	.315000E+02	.328000E+02
.340000E+02	.351000E+02	.360000E+02	.370000E+02	.378000E+02
.388000E+02	.396000E+02	.378000E+02	.359000E+02	.341000E+02
.320000E+02	.301000E+02	.277000E+02	.253000E+02	.227000E+02
.171000E+02	.114000E+02	.580000E+01	.200000E+00	.000000E+00
.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
.000000E+00	.240000E+01	.480000E+01	.720000E+01	.970000E+01
.111000E+02	.122000E+02	.134000E+02	.146000E+02	.158000E+02
.169000E+02	.179000E+02	.187000E+02	.195000E+02	.201000E+02
.208000E+02	.214000E+02	.220000E+02	.227000E+02	.233000E+02
.240000E+02	.245000E+02	.249000E+02	.256000E+02	.261000E+02

TABLE C.3 (Cont.)

.266000E+02	.270000E+02	.274000E+02	.278000E+02	.283000E+02
.288000E+02	.293000E+02	.296000E+02	.301000E+02	.304000E+02
.309000E+02	.312000E+02	.362000E+02	.407000E+02	.447000E+02
.483000E+02	.513000E+02	.543000E+02	.571000E+02	.597000E+02
.621000E+02	.644000E+02	.666000E+02	.681000E+02	.695000E+02
.708000E+02	.721000E+02	.732000E+02	.744000E+02	.755000E+02
.766000E+02	.777000E+02	.787000E+02	.797000E+02	.806000E+02
.814000E+02	.824000E+02	.832000E+02	.840000E+02	.848000E+02
.855000E+02	.863000E+02	.869000E+02	.875000E+02	.861000E+02
.847000E+02	.832000E+02	.818000E+02	.803000E+02	.789000E+02
.774000E+02	.760000E+02	.745000E+02	.731000E+02	.718000E+02
.703000E+02	.689000E+02	.676000E+02	.663000E+02	.649000E+02
.650000E+02	.653000E+02	.655000E+02	.657000E+02	.660000E+02
.661000E+02	.663000E+02	.665000E+02	.668000E+02	.669000E+02
.671000E+02	.673000E+02	.674000E+02	.676000E+02	.678000E+02
.679000E+02	.681000E+02	.682000E+02	.684000E+02	.686000E+02
.687000E+02	.689000E+02	.689000E+02	.690000E+02	.692000E+02
.694000E+02	.695000E+02	.695000E+02	.697000E+02	.698000E+02
.698000E+02	.700000E+02	.687000E+02	.673000E+02	.660000E+02
.645000E+02	.632000E+02	.618000E+02	.604000E+02	.591000E+02
.576000E+02	.562000E+02	.547000E+02	.533000E+02	.518000E+02
.502000E+02	.488000E+02	.472000E+02	.457000E+02	.441000E+02
.423000E+02	.406000E+02	.388000E+02	.370000E+02	.352000E+02
.333000E+02	.312000E+02	.291000E+02	.267000E+02	.243000E+02
.216000E+02	.182000E+02	.142000E+02	.930000E+01	.450000E+01
.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00

TABLE C.4 Federal Urban Driving Schedule (FUDS)

EPA Urban Dynamometer Driving Schedule for Light-Duty Vehicles

cycle time (s), TC =

1371

```
iflag(=0: s-by-s; >0: segments) =
```

0

s-by-s velocity, (km/h), for TC s

.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
4.80	9.50	13.80	18.50	23.00
27.20	27.80	29.10	33.30	34.90
36.00	36.20	35.60	34.60	33.60
32.80	31.90	27.40	24.00	24.00
24.50	24.90	25.70	27.50	30.70
34.00	36.50	36.90	36.50	36.40
34.30	30.60	27.50	25.40	25.40
28.50	31.90	34.80	37.30	38.90
39.60	40.10	40.20	39.60	39.40
39.80	39.90	39.80	39.60	39.60
40.40	41.20	41.40	40.90	40.10
40.20	40.90	41.80	41.80	41.40
42.00	43.00	44.30	46.00	47.20
48.00	48.40	48.90	49.40	49.40
49.10	48.90	48.80	48.90	49.60
48.90	48.10	47.50	48.00	48.80
49.40	49.70	49.90	49.70	48.90
48.00	48.10	48.60	49.40	50.20
51.20	51.80	52.10	51.80	51.00
46.00	40.70	35.40	30.10	24.80
19.50	14.20	8.90	3.50	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	5.30	10.60
15.90	21.20	26.60	31.90	35.70
39.10	41.50	42.50	41.40	40.40
39.80	40.20	40.60	40.90	41.50
43.80	42.60	38.60	36.50	31.20
28.50	27.70	29.10	29.90	32.20
35.70	39.40	43.90	49.10	53.90
58.30	60.00	63.20	65.20	67.80
70.00	72.60	74.00	75.30	76.40
76.40	76.10	76.00	75.60	75.60
75.60	75.60	75.60	76.00	76.30
77.10	78.10	79.00	79.70	80.50
81.40	82.10	82.90	84.00	85.60
87.10	87.90	88.40	88.50	88.40
87.90	87.90	88.20	88.70	89.30
89.60	90.30	90.60	91.10	91.20
91.20	90.90	90.90	90.90	90.90
90.90	90.90	90.80	90.30	89.80
88.70	87.90	87.20	86.90	86.40
86.30	86.70	86.90	87.10	87.10
86.60	85.90	85.30	84.70	83.80
84.30	83.70	83.50	83.20	82.90
83.00	83.40	83.80	84.50	85.30
86.10	86.90	88.40	89.20	89.50
90.10	90.10	89.80	88.80	87.70
86.30	84.50	82.90	82.90	82.90

TABLE C.4 (Cont.)

82.20	80.60	80.50	80.60	80.50
79.80	79.70	79.70	79.70	79.00
78.20	77.40	76.00	74.20	72.40
70.50	68.60	66.80	64.90	62.00
59.50	56.60	54.40	52.30	50.70
49.20	49.10	48.30	46.70	44.30
39.90	34.60	32.30	30.70	29.80
27.40	24.90	20.10	17.40	12.90
7.60	2.30	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	1.60	6.90	12.20	17.50
22.90	27.80	32.20	36.20	38.10
40.60	42.80	45.20	48.30	49.60
50.90	51.70	52.30	54.10	55.50
55.70	56.20	56.00	55.50	55.80
57.10	57.90	57.90	57.90	57.90
57.90	57.90	58.10	58.60	58.70
58.60	57.90	56.50	54.90	53.90
50.50	46.70	41.40	37.00	32.70
28.20	23.30	19.30	14.00	8.70
3.40	.00	.00	.00	.00
.00	.00	4.20	9.50	14.80
20.10	25.40	30.70	36.00	40.20
41.20	44.30	46.70	48.30	48.40
48.30	47.80	47.20	46.30	45.10
40.20	34.90	29.60	24.30	19.00
13.70	8.40	3.10	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	5.30	10.60	15.90
21.20	26.60	31.90	37.20	42.50
44.70	46.80	50.70	53.10	54.10
56.00	56.50	57.30	58.10	57.90
58.10	58.30	57.90	57.50	57.90
57.90	57.30	57.10	57.00	56.60
56.60	56.60	56.60	56.60	56.60
56.30	56.50	56.60	57.10	56.60
56.30	56.30	56.30	56.00	55.70
55.80	53.90	51.50	48.40	45.10
41.00	36.20	31.90	26.60	21.20
16.60	11.60	6.40	1.60	.00
.00	.00	.00	.00	.00
1.90	5.60	8.90	10.50	13.70
15.40	16.90	19.20	22.50	25.70
28.50	30.60	32.30	33.80	35.40
37.00	38.30	39.40	40.10	40.20
40.20	40.20	40.20	40.20	40.20
41.20	41.50	41.80	41.20	40.60
40.20	40.20	40.20	39.30	37.20
31.90	26.60	21.20	15.90	10.60
5.30	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	5.30	10.60
15.90	20.90	23.50	25.70	27.40
27.40	27.40	28.20	28.50	28.50
28.20	27.40	27.20	26.70	27.40
27.50	27.40	26.70	26.60	26.60
26.70	27.40	28.30	29.80	30.90
32.50	33.80	34.00	34.10	34.80

TABLE C.4 (Cont.)

35.40	36.00	36.20	36.20	36.20
36.50	38.10	40.40	41.80	42.60
43.50	42.00	36.70	31.40	26.10
20.80	15.40	10.10	4.80	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
3.20	7.20	12.60	16.40	20.10
22.50	24.60	28.20	31.50	33.80
35.70	37.50	39.40	40.70	41.20
41.80	43.90	43.10	42.30	42.50
42.60	42.60	41.80	41.00	38.00
34.40	29.80	26.40	23.30	18.70
14.00	9.30	5.60	3.20	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	2.30	5.30
7.10	10.50	14.80	18.20	21.70
23.50	26.40	26.90	26.60	26.60
29.30	30.90	32.30	34.60	36.20
36.20	35.60	36.50	37.50	37.80
36.20	34.80	33.00	29.00	24.10
19.30	14.50	10.00	7.20	4.80
3.40	.80	.80	5.10	10.50
15.40	20.10	22.50	25.70	29.00
31.50	34.60	37.20	39.40	41.00
42.60	43.60	44.40	44.90	45.50
46.00	46.00	45.50	45.40	45.10
44.30	43.10	41.00	37.80	34.60
30.60	26.60	24.00	20.10	15.10
10.00	4.80	2.40	2.40	.80
.00	4.80	10.10	15.40	20.80
25.40	28.20	29.60	31.40	33.30
35.40	37.30	40.20	42.60	44.30
45.10	45.50	46.50	46.50	46.50
46.30	45.90	45.50	45.50	45.50
45.40	44.40	44.30	44.30	44.30
44.30	44.30	44.30	44.40	45.10
45.90	48.30	49.90	51.50	53.10
53.10	54.10	54.70	55.20	55.00
54.70	54.70	54.60	54.10	53.30
53.10	52.30	51.50	51.30	50.90
50.70	49.20	48.30	48.10	48.10
48.10	48.10	47.60	47.50	47.50
47.20	46.50	45.40	44.60	43.50
41.00	38.10	35.40	33.00	30.90
30.90	32.30	33.60	34.40	35.40
36.40	37.30	38.60	40.20	41.80
42.80	42.80	43.10	43.50	43.80
44.70	45.20	46.30	46.50	46.70
46.80	46.70	45.20	44.30	43.50
41.50	40.20	39.40	39.90	40.40
41.00	41.40	42.20	43.30	44.30
44.70	45.70	46.70	47.00	46.80
46.70	46.50	45.90	45.20	45.10
45.10	44.40	43.80	42.80	43.50
44.30	44.70	45.10	44.70	45.10
45.10	45.10	44.60	44.10	43.30
42.80	42.60	42.60	42.60	42.30
42.20	42.20	41.70	41.20	41.20

TABLE C.4 (Cont.)

41.70	41.50	41.00	39.60	37.80
35.70	34.80	34.80	34.90	36.40
37.70	38.60	38.90	39.30	40.10
40.40	40.60	40.70	41.00	40.60
40.20	40.30	40.20	39.80	39.40
39.10	39.10	39.40	40.20	40.20
39.60	39.60	38.80	39.40	40.40
41.20	40.40	38.60	35.40	32.30
27.20	21.90	16.60	11.30	6.00
.60	.00	.00	.00	3.20
8.50	13.80	19.20	24.50	28.20
29.90	32.20	34.00	35.40	37.00
39.40	42.30	44.30	45.20	45.70
45.90	45.90	45.90	44.60	44.30
43.80	43.10	42.60	41.80	41.40
40.60	38.60	35.40	34.60	34.60
35.10	36.20	37.00	36.70	36.70
37.00	36.50	36.50	36.50	37.80
38.60	39.60	39.90	40.40	41.00
41.20	41.00	40.20	38.80	38.10
37.30	36.90	36.20	35.40	34.80
33.00	28.20	22.90	17.50	12.20
6.90	1.60	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	1.90	6.40	11.70
17.10	22.40	27.40	29.80	32.20
35.10	37.00	38.60	39.90	41.20
42.60	43.10	44.10	44.90	45.50
45.10	44.30	43.50	43.50	42.30
39.40	36.20	34.60	33.20	29.00
24.10	19.80	17.90	17.10	16.10
15.30	14.60	14.00	13.80	14.20
14.50	14.00	13.80	12.90	11.30
8.00	6.80	4.20	1.60	.00
.20	1.00	2.60	5.80	11.10
16.10	20.60	22.50	23.30	25.70
29.10	32.20	33.80	34.10	34.30
34.40	34.90	36.20	37.00	38.30
39.40	40.20	40.10	39.90	40.20
40.90	41.50	41.80	42.50	42.80
43.30	43.50	43.50	43.50	43.30
43.10	43.10	42.60	42.50	41.80
41.00	39.60	37.80	34.60	32.20
28.20	25.70	22.50	17.20	11.90
6.60	1.30	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	3.40	8.70
14.00	19.30	24.60	29.90	34.00
37.00	37.80	37.00	36.20	32.20
26.90	21.60	16.30	10.90	5.60
.30	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.30	2.40	5.60	10.50
15.80	19.30	20.80	20.90	20.30
20.60	21.10	21.10	22.50	24.90
27.40	29.90	31.70	33.80	34.60
35.10	35.10	34.60	34.10	34.60

TABLE C.4 (Cont.)

35.10	35.40	35.20	34.90	34.60
34.60	34.40	32.30	31.40	30.90
31.50	31.90	32.20	31.40	28.20
24.90	20.90	16.10	12.90	9.70
6.40	4.00	1.10	.00	.00
.00	.00	.00	.00	.00
.00	1.60	1.60	1.60	1.60
1.60	2.60	4.80	6.40	8.00
10.10	12.90	16.10	16.90	15.30
13.70	12.20	14.20	17.70	22.50
27.40	31.40	33.80	35.10	35.70
37.00	38.00	38.80	39.40	39.40
38.60	37.80	37.80	37.80	37.80
37.80	37.80	38.60	38.80	39.40
39.80	40.20	40.90	41.20	41.40
41.80	42.20	43.50	44.70	45.50
46.70	46.80	46.70	45.10	39.80
34.40	29.10	23.80	18.50	13.20
7.90	2.60	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	2.40	7.70	13.00
18.30	21.20	24.30	27.00	29.50
31.40	32.70	34.30	35.20	35.60
36.00	35.40	34.80	34.00	33.00
32.20	31.50	29.80	28.20	26.60
24.90	22.50	17.70	12.90	8.40
4.00	.00	.00	.00	.00
.00				

TABLE C.5 Federal Highway Driving Profile (HIGHWAY)

U.S. Federal Highway Cycle				
cycle time (s), TC=				
iflag(=0: s-by-s; >0: segments)=				
s-by-s velocity, (km/h), for TC s				
			765	
			0	
.000000E+00	.000000E+00	.322000E+01	.788000E+01	.130300E+02
.182000E+02	.233000E+02	.278000E+02	.315000E+02	.351000E+02
.386000E+02	.415000E+02	.436000E+02	.451000E+02	.467000E+02
.483000E+02	.494000E+02	.507000E+02	.518000E+02	.529000E+02
.539000E+02	.549000E+02	.557000E+02	.562000E+02	.565000E+02
.574000E+02	.578000E+02	.576000E+02	.568000E+02	.562000E+02
.555000E+02	.557000E+02	.559900E+02	.564800E+02	.574400E+02
.580800E+02	.582500E+02	.587300E+02	.590500E+02	.593700E+02
.595300E+02	.595300E+02	.595300E+02	.595300E+02	.595300E+02
.595300E+02	.596900E+02	.600200E+02	.608200E+02	.621100E+02
.632300E+02	.643600E+02	.654900E+02	.666100E+02	.679000E+02
.690300E+02	.699900E+02	.708000E+02	.712800E+02	.716000E+02
.720800E+02	.722400E+02	.724100E+02	.725700E+02	.730500E+02
.735300E+02	.740100E+02	.745000E+02	.748200E+02	.753000E+02
.754600E+02	.756200E+02	.757800E+02	.759400E+02	.761100E+02
.759400E+02	.757800E+02	.756200E+02	.754600E+02	.754600E+02
.754600E+02	.756200E+02	.757800E+02	.757800E+02	.759400E+02
.757800E+02	.756200E+02	.754600E+02	.748200E+02	.745000E+02
.743300E+02	.745000E+02	.748200E+02	.754600E+02	.757800E+02
.762700E+02	.767500E+02	.772300E+02	.775500E+02	.780400E+02
.785200E+02	.790000E+02	.791600E+02	.790000E+02	.790000E+02
.788400E+02	.788400E+02	.790000E+02	.791600E+02	.793200E+02
.794800E+02	.796500E+02	.796500E+02	.796500E+02	.794900E+02
.790000E+02	.786800E+02	.782000E+02	.778800E+02	.773900E+02
.767500E+02	.762700E+02	.761100E+02	.764300E+02	.769100E+02
.770700E+02	.772300E+02	.770700E+02	.770700E+02	.770700E+02
.772300E+02	.772300E+02	.772300E+02	.770700E+02	.761100E+02
.740100E+02	.696700E+02	.662900E+02	.635600E+02	.630700E+02
.627500E+02	.627500E+02	.629100E+02	.635600E+02	.645200E+02
.659700E+02	.675800E+02	.693500E+02	.703100E+02	.709600E+02
.712800E+02	.714400E+02	.717600E+02	.719200E+02	.722400E+02
.727300E+02	.735300E+02	.738500E+02	.745000E+02	.753000E+02
.754600E+02	.756200E+02	.757800E+02	.765900E+02	.770700E+02
.772300E+02	.772300E+02	.770700E+02	.769100E+02	.761000E+02
.751400E+02	.743400E+02	.738500E+02	.735300E+02	.732100E+02
.730500E+02	.728900E+02	.724100E+02	.708000E+02	.693500E+02
.679000E+02	.667700E+02	.667700E+02	.677400E+02	.690300E+02
.699900E+02	.706400E+02	.701500E+02	.696700E+02	.691900E+02
.693500E+02	.698300E+02	.706400E+02	.712800E+02	.717600E+02
.722400E+02	.720800E+02	.714400E+02	.706400E+02	.698300E+02
.695100E+02	.695100E+02	.693500E+02	.691900E+02	.691900E+02
.693500E+02	.698300E+02	.706400E+02	.708000E+02	.699900E+02
.685400E+02	.667700E+02	.654900E+02	.643600E+02	.643600E+02
.648400E+02	.659700E+02	.675800E+02	.687000E+02	.693500E+02
.695100E+02	.698300E+02	.706400E+02	.712800E+02	.719200E+02
.725700E+02	.730500E+02	.736900E+02	.748200E+02	.754600E+02
.759400E+02	.762700E+02	.761100E+02	.761100E+02	.759400E+02
.759400E+02	.759400E+02	.757800E+02	.756200E+02	.756200E+02
.754600E+02	.753000E+02	.754600E+02	.756200E+02	.759400E+02
.764300E+02	.770700E+02	.772300E+02	.772300E+02	.772300E+02
.772300E+02	.772300E+02	.773900E+02	.775500E+02	.775500E+02
.773900E+02	.782000E+02	.786800E+02	.794800E+02	.794800E+02
.794800E+02	.794800E+02	.794800E+02	.788400E+02	.786800E+02
.775500E+02	.767500E+02	.764300E+02	.759400E+02	.751400E+02
.743400E+02	.740100E+02	.736900E+02	.733700E+02	.730500E+02
.727300E+02	.724100E+02	.719200E+02	.716000E+02	.711200E+02

TABLE C.5 (Cont.)

.699900E+02	.688600E+02	.675700E+02	.645200E+02	.621100E+02
.603400E+02	.576000E+02	.558300E+02	.547100E+02	.535800E+02
.522900E+02	.510100E+02	.492400E+02	.476300E+02	.463400E+02
.457000E+02	.460200E+02	.474700E+02	.505200E+02	.537400E+02
.572800E+02	.603400E+02	.629200E+02	.646800E+02	.661300E+02
.672600E+02	.682200E+02	.688700E+02	.696700E+02	.704700E+02
.712800E+02	.719200E+02	.724100E+02	.727300E+02	.730500E+02
.732100E+02	.736900E+02	.740100E+02	.741700E+02	.748200E+02
.753000E+02	.757800E+02	.767500E+02	.777100E+02	.788400E+02
.799700E+02	.809300E+02	.820600E+02	.831900E+02	.843100E+02
.854400E+02	.865600E+02	.876900E+02	.888200E+02	.897800E+02
.907400E+02	.915500E+02	.917100E+02	.918700E+02	.922000E+02
.926800E+02	.930000E+02	.933200E+02	.934800E+02	.939600E+02
.944500E+02	.946100E+02	.947700E+02	.949300E+02	.949300E+02
.947700E+02	.946100E+02	.942900E+02	.939700E+02	.936400E+02
.934800E+02	.933200E+02	.931600E+02	.926800E+02	.923600E+02
.920300E+02	.918700E+02	.917100E+02	.917100E+02	.915500E+02
.915500E+02	.915500E+02	.917100E+02	.917100E+02	.917100E+02
.917100E+02	.917100E+02	.917100E+02	.917100E+02	.917100E+02
.917100E+02	.915500E+02	.913900E+02	.909100E+02	.904300E+02
.901000E+02	.901000E+02	.901000E+02	.902600E+02	.907500E+02
.912300E+02	.915500E+02	.918700E+02	.922000E+02	.923600E+02
.923600E+02	.920300E+02	.917100E+02	.915500E+02	.910700E+02
.905900E+02	.902600E+02	.907500E+02	.912300E+02	.918700E+02
.925200E+02	.930000E+02	.933200E+02	.933200E+02	.933200E+02
.933200E+02	.933200E+02	.933200E+02	.931600E+02	.930000E+02
.928400E+02	.928400E+02	.930000E+02	.931600E+02	.933200E+02
.934800E+02	.939700E+02	.947700E+02	.950900E+02	.955700E+02
.962200E+02	.963800E+02	.963800E+02	.962200E+02	.959000E+02
.955700E+02	.952500E+02	.950900E+02	.949300E+02	.947700E+02
.944500E+02	.942900E+02	.941200E+02	.939700E+02	.939700E+02
.938000E+02	.936400E+02	.934800E+02	.933200E+02	.931600E+02
.931600E+02	.931600E+02	.931600E+02	.931600E+02	.933200E+02
.934800E+02	.934800E+02	.936400E+02	.936400E+02	.936400E+02
.934800E+02	.933200E+02	.933200E+02	.933200E+02	.933200E+02
.933200E+02	.933200E+02	.931600E+02	.931600E+02	.933200E+02
.934800E+02	.934800E+02	.936400E+02	.938000E+02	.938000E+02
.938000E+02	.936400E+02	.934800E+02	.933200E+02	.930000E+02
.925200E+02	.918700E+02	.917100E+02	.910700E+02	.902600E+02
.901000E+02	.897800E+02	.893000E+02	.888200E+02	.886600E+02
.885000E+02	.883300E+02	.883300E+02	.883300E+02	.883300E+02
.883300E+02	.883300E+02	.884900E+02	.884900E+02	.884900E+02
.884900E+02	.884900E+02	.884900E+02	.886600E+02	.886600E+02
.884900E+02	.883300E+02	.883300E+02	.881700E+02	.880100E+02
.878500E+02	.875300E+02	.873700E+02	.873700E+02	.872100E+02
.870500E+02	.870500E+02	.870500E+02	.868900E+02	.868900E+02
.868900E+02	.868900E+02	.868900E+02	.868900E+02	.868900E+02
.868900E+02	.870500E+02	.872100E+02	.876900E+02	.881700E+02
.883300E+02	.885000E+02	.886600E+02	.888200E+02	.888200E+02
.889800E+02	.891400E+02	.893000E+02	.894600E+02	.896200E+02
.897800E+02	.899400E+02	.901000E+02	.901000E+02	.901000E+02
.901000E+02	.901000E+02	.901000E+02	.901000E+02	.901000E+02
.901000E+02	.901000E+02	.901000E+02	.901000E+02	.901000E+02
.901000E+02	.899400E+02	.899400E+02	.899400E+02	.897800E+02
.894600E+02	.891400E+02	.888200E+02	.886600E+02	.885000E+02
.883300E+02	.878500E+02	.875300E+02	.872100E+02	.870500E+02
.865600E+02	.859200E+02	.857600E+02	.854400E+02	.851200E+02
.846300E+02	.843100E+02	.839900E+02	.838300E+02	.836700E+02
.836700E+02	.836700E+02	.836700E+02	.838300E+02	.836700E+02
.836700E+02	.835100E+02	.830200E+02	.827000E+02	.822200E+02
.815800E+02	.809300E+02	.801300E+02	.793200E+02	.783600E+02

TABLE C.5 (Cont.)

.775500E+02	.773900E+02	.772300E+02	.772300E+02	.773900E+02
.778800E+02	.786800E+02	.788400E+02	.790000E+02	.790000E+02
.788400E+02	.788400E+02	.786800E+02	.782000E+02	.777100E+02
.772300E+02	.770700E+02	.769100E+02	.767500E+02	.770700E+02
.777100E+02	.788400E+02	.790000E+02	.788400E+02	.786800E+02
.772300E+02	.757800E+02	.743400E+02	.741700E+02	.741700E+02
.743400E+02	.754600E+02	.769100E+02	.788400E+02	.799700E+02
.814100E+02	.828600E+02	.839900E+02	.847900E+02	.852800E+02
.862400E+02	.868900E+02	.870500E+02	.875300E+02	.880100E+02
.886600E+02	.891300E+02	.891300E+02	.885000E+02	.876900E+02
.862400E+02	.844700E+02	.807700E+02	.775500E+02	.748200E+02
.743400E+02	.740100E+02	.740100E+02	.745000E+02	.753000E+02
.764300E+02	.775500E+02	.785200E+02	.796500E+02	.807700E+02
.815800E+02	.822200E+02	.831900E+02	.839900E+02	.844700E+02
.838300E+02	.830200E+02	.822200E+02	.820600E+02	.820600E+02
.822200E+02	.827000E+02	.831900E+02	.836700E+02	.839900E+02
.844700E+02	.849600E+02	.847900E+02	.846300E+02	.841500E+02
.841500E+02	.843100E+02	.844700E+02	.847900E+02	.847900E+02
.843100E+02	.838300E+02	.831900E+02	.822200E+02	.812500E+02
.806100E+02	.801300E+02	.799700E+02	.798100E+02	.796500E+02
.796500E+02	.799700E+02	.804500E+02	.807700E+02	.814200E+02
.822200E+02	.830200E+02	.835100E+02	.836700E+02	.838300E+02
.843100E+02	.851200E+02	.857600E+02	.864000E+02	.872100E+02
.876900E+02	.881700E+02	.885000E+02	.893000E+02	.899400E+02
.902600E+02	.905900E+02	.907500E+02	.909100E+02	.912300E+02
.915500E+02	.917100E+02	.922000E+02	.928400E+02	.936400E+02
.946100E+02	.950900E+02	.952500E+02	.950900E+02	.946100E+02
.941300E+02	.934800E+02	.928400E+02	.922000E+02	.918700E+02
.913900E+02	.909100E+02	.904300E+02	.893000E+02	.878500E+02
.870500E+02	.864000E+02	.856000E+02	.851200E+02	.844700E+02
.836700E+02	.825400E+02	.812500E+02	.796500E+02	.780400E+02
.765900E+02	.753000E+02	.733700E+02	.711200E+02	.683800E+02
.630700E+02	.577600E+02	.524500E+02	.471400E+02	.431200E+02
.394200E+02	.345900E+02	.313800E+02	.280000E+02	.243000E+02
.199500E+02	.156100E+02	.112600E+02	.804500E+01	.531000E+01
.321800E+01	.112600E+01	.000000E+00	.000000E+00	.000000E+00

TABLE C.6 (Cont.)

[illegible]

TABLE C.6 (Cont.)

.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00

TABLE C.7 LA-92 Driving Cycle (LA-92)

LA-92 Driving Cycle				
cycle time (s), TC=				
iflag(=0: s-by-s; >0: segments)=				
s-by-s velocity, (km/h), for TC s				
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	1.93
6.76	11.75	14.16	17.38	19.79
21.08	19.79	19.79	18.50	18.50
17.86	17.86	17.86	21.08	24.14
27.19	27.19	25.90	25.26	24.78
24.14	22.20	17.38	13.52	9.81
6.76	5.63	5.63	2.41	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	1.93	5.63	12.39	17.86
22.20	26.55	29.61	32.82	33.31
31.54	27.84	19.79	13.03	9.81
15.45	20.43	25.26	28.96	32.82
35.24	37.65	38.29	39.58	40.22
41.99	41.99	43.28	43.28	43.28
42.64	41.35	35.24	26.55	16.09
7.40	2.41	.64	.00	.00
.00	.00	.00	.00	.00
.00	.64	1.93	3.06	6.11
12.39	18.50	23.49	28.96	34.59
40.22	45.70	49.40	51.33	51.97
51.97	51.33	48.75	45.05	38.94
32.18	25.90	18.50	13.03	8.05
5.63	3.06	.00	.00	.00
.00	.00	.00	.00	.00
.00	2.41	11.10	20.43	26.55
32.18	37.01	41.35	45.05	49.40
52.45	55.03	56.80	59.37	59.37
59.85	60.50	60.50	60.50	59.85
59.85	59.37	58.73	58.73	56.15
53.74	51.33	46.98	40.22	40.22
41.99	44.41	46.98	50.04	51.97
55.03	56.15	57.44	58.73	59.37
59.37	59.85	60.50	59.85	60.50
61.14	61.79	63.07	63.72	64.20
65.49	64.84	66.13	66.13	65.49
51.33	38.46	25.58	12.71	4.34
.64	.64	4.34	6.11	6.11
2.41	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	2.41	8.05	14.16	18.50
22.85	24.78	25.90	25.90	27.19
26.55	27.19	28.96	30.89	32.82
32.82	33.95	33.95	35.88	37.01
38.29	38.94	39.58	40.22	41.35
41.35	42.64	44.41	45.70	46.98
48.75	50.04	50.04	49.40	50.04
47.63	46.98	46.98	46.34	45.05

TABLE C.7 (Cont.)

37.01	33.95	34.59	33.31	33.31
31.54	26.55	21.08	15.45	11.75
6.11	1.29	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.64	4.34	11.75	18.50
24.78	29.61	33.31	38.94	43.28
47.63	50.04	52.45	54.38	56.15
59.37	63.07	66.13	69.19	70.47
71.60	72.89	72.89	72.24	71.60
70.47	69.83	68.54	67.42	66.77
65.49	64.84	66.13	66.77	68.54
69.83	71.12	72.24	73.53	74.82
75.30	75.94	77.23	76.59	77.88
77.23	75.94	74.17	73.53	72.24
71.12	70.47	71.60	72.24	72.89
74.82	77.23	78.52	79.65	80.29
80.29	80.29	79.65	79.65	78.52
78.52	78.52	77.88	78.52	79.65
80.93	81.58	83.35	84.63	85.92
87.05	88.98	88.98	90.26	90.75
90.75	90.75	92.03	91.39	92.68
92.68	92.68	93.32	93.32	93.97
93.97	94.61	95.09	94.61	94.61
93.32	93.32	92.68	92.68	92.68
92.68	92.68	95.09	95.74	96.38
97.02	97.02	98.31	97.02	96.38
95.74	95.09	95.09	95.74	95.74
95.74	96.38	97.02	97.67	97.67
98.79	99.44	99.44	99.44	99.44
98.31	97.67	97.02	97.02	97.02
95.74	94.61	95.09	94.61	94.61
94.61	93.97	93.32	93.32	93.32
93.97	95.09	95.74	96.38	96.38
97.02	98.31	98.31	98.31	98.79
98.79	98.31	97.67	96.38	95.09
95.09	95.09	96.38	95.74	96.38
94.61	93.32	92.68	91.39	90.26
88.98	87.05	84.63	79.16	74.17
69.19	59.85	47.63	34.59	26.55
25.26	29.61	34.59	40.22	43.93
46.98	49.40	50.68	50.04	50.04
48.75	48.27	48.27	47.63	48.27
46.34	46.34	45.05	45.70	45.05
45.70	45.70	46.34	45.70	45.70
45.05	42.64	38.94	36.52	32.82
28.48	25.26	21.08	17.38	13.52
11.75	8.05	6.11	5.63	3.06
1.29	.00	.00	.00	1.29
3.06	6.11	11.10	15.45	17.86
17.86	16.73	14.16	14.80	16.09
16.73	16.73	8.69	3.06	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.64	2.41	5.63	9.81	16.73

TABLE C.7 (Cont.)

22.85	27.19	30.89	32.18	34.59
37.65	39.58	38.94	32.18	27.19
21.56	21.56	25.26	29.61	33.95
37.65	40.71	44.41	46.34	48.75
49.40	50.68	50.04	50.04	48.75
48.75	48.75	49.40	50.04	51.97
52.45	52.45	52.45	50.04	43.28
35.88	28.96	22.20	15.45	7.40
9.81	16.09	22.85	27.84	32.18
34.59	35.88	35.88	35.88	35.88
37.01	37.01	36.52	35.88	35.24
36.52	38.29	40.22	40.71	41.35
42.64	43.28	43.93	45.05	46.98
48.27	48.27	47.63	47.63	46.34
45.70	45.05	43.93	41.35	39.58
40.22	42.64	45.05	47.63	49.40
51.97	53.10	55.03	55.67	56.80
58.08	58.08	59.37	59.37	60.50
60.50	61.79	61.14	60.50	60.50
59.85	59.37	58.08	57.44	58.08
57.44	57.44	57.44	58.08	58.08
57.44	57.44	56.15	55.67	55.03
54.38	53.74	53.10	48.75	46.98
45.70	40.22	33.95	27.19	21.56
21.08	19.79	20.43	25.26	30.89
35.88	39.58	41.35	42.64	42.64
43.28	43.93	43.93	44.41	45.70
46.34	46.34	46.98	46.34	46.34
45.05	45.05	44.41	42.64	39.58
33.31	26.55	24.14	22.85	22.85
22.20	22.20	19.15	13.52	6.76
1.93	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	2.41	8.69	14.80	18.50
23.49	27.84	30.89	33.95	33.31
33.31	31.54	29.61	27.19	27.19
26.55	27.19	27.19	27.19	27.84
30.89	32.82	33.95	35.88	35.88
36.52	35.88	36.52	35.88	38.29
41.35	44.41	47.63	48.27	46.98
44.41	40.22	38.29	37.65	38.94
37.65	37.01	32.82	30.25	27.84
24.14	21.08	14.80	11.10	7.40
7.40	7.40	6.76	8.69	7.40
5.63	3.70	3.70	3.06	4.99
9.81	7.40	4.34	3.70	3.70
4.99	6.76	5.63	6.11	6.76
5.63	5.63	5.63	7.40	9.33
5.63	1.29	5.63	6.11	3.70
.00	1.93	11.10	22.20	30.25
38.29	43.93	49.40	54.38	60.50
65.49	70.47	74.17	77.23	79.65
82.86	85.28	87.69	89.62	91.39
93.32	95.09	97.02	98.31	99.44
99.44	99.44	99.44	100.72	102.01

TABLE C.7 (Cont.)

101.37	101.37	100.72	99.44	99.44
100.08	100.08	100.72	102.49	103.78
104.42	106.19	106.19	107.48	106.84
107.48	108.12	106.84	106.84	106.19
105.71	105.71	106.84	106.19	105.71
105.07	105.07	103.78	103.78	103.14
102.49	102.49	102.49	103.78	103.78
104.42	103.78	103.14	104.42	105.07
105.07	105.07	103.14	102.01	101.37
102.01	103.14	104.42	105.07	103.78
103.14	102.01	102.49	102.01	102.01
102.01	102.01	102.49	103.78	105.07
104.42	102.49	101.37	96.38	88.98
81.58	79.16	77.23	74.17	71.12
66.13	64.20	58.08	52.45	46.98
39.58	33.31	30.89	26.55	24.14
19.15	15.45	13.52	9.33	1.93
.00	.00	.00	1.93	4.99
8.05	13.52	18.50	23.49	27.19
30.25	33.95	38.29	42.64	45.05
47.63	49.40	52.45	55.03	56.80
58.08	59.37	61.14	61.14	61.14
61.14	61.14	59.85	59.37	58.08
57.44	56.15	56.15	54.38	50.68
46.34	41.35	39.58	37.65	35.88
34.59	32.18	32.18	30.89	30.89
28.96	19.15	11.10	4.34	1.29
.64	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.64	4.34	9.81	14.80
18.50	22.85	25.90	28.96	32.18
34.59	37.01	38.94	40.22	41.35
43.28	44.41	44.41	45.70	46.98
46.98	48.27	47.63	47.63	46.34
45.05	38.29	30.25	19.15	9.81
2.41	2.41	6.76	13.03	16.73
21.08	24.78	28.96	32.82	37.01
40.71	43.93	46.34	48.75	50.04
51.97	51.33	51.97	51.33	50.04
46.34	40.22	36.52	30.25	24.78
21.56	19.15	14.16	8.05	3.06
3.70	4.34	5.63	10.46	17.38
22.20	25.90	29.61	32.82	35.24
35.24	33.31	27.84	21.08	15.45
14.16	17.38	20.43	22.85	23.49
21.08	17.86	17.86	17.86	21.08
25.26	29.61	33.31	38.29	41.35
45.05	48.27	50.04	51.97	55.03
57.44	59.37	62.43	64.84	66.77
67.90	69.19	70.47	70.47	69.83
69.19	67.90	67.42	66.77	67.42
67.42	67.42	67.90	68.54	68.54
68.54	68.54	68.54	68.54	68.54
67.90	69.19	69.83	69.19	68.54
67.42	65.49	59.37	52.45	45.05
37.65	29.61	23.49	19.79	14.80
9.33	3.06	.64	.00	.00
.00	.00	.00	.64	6.76
14.80	19.15	22.85	25.26	24.14

TABLE C.7 (Cont.)

22.85	21.56	22.20	23.49	23.49
22.85	25.90	25.26	25.26	23.49
21.08	16.09	11.75	5.63	1.29
.00	.00	.00	.00	.64
4.34	11.75	18.50	24.78	30.89
35.24	38.29	40.22	41.99	43.93
46.34	48.27	47.63	47.63	46.34
41.99	35.88	30.89	26.55	20.43
15.45	11.10	6.76	3.70	1.29
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	.00	.00
.00	.00	.00	5.63	16.73
24.78	27.84	27.84	29.61	34.59
39.58	43.93	48.27	50.68	51.33
52.45	53.74	56.15	58.73	60.50
63.07	64.84	65.49	66.13	65.49
65.49	65.49	66.77	68.54	69.19
71.60	72.89	72.89	72.24	69.83
64.84	61.14	58.08	58.73	61.14
63.07	65.49	67.90	69.83	72.24
73.53	74.17	75.30	74.82	74.82
74.82	74.17	74.17	74.17	75.30
76.59	77.23	77.88	77.23	77.23
75.94	74.82	75.30	75.94	77.88
77.88	78.52	77.88	76.59	74.82
71.12	67.90	66.77	66.13	65.49
64.84	63.72	63.07	62.43	61.14
60.50	59.85	58.73	55.67	50.68
47.63	46.98	46.34	46.34	45.05
45.05	45.70	47.63	48.27	48.75
46.98	42.64	40.71	40.22	39.58
39.58	40.71	41.99	43.93	45.70
46.98	46.98	47.63	48.27	50.04
52.45	54.38	55.67	56.15	55.67
56.15	55.67	56.15	56.15	56.15
55.03	54.38	52.45	50.68	48.27
46.34	43.93	38.29	37.01	37.01
35.88	32.82	30.25	28.48	25.90
23.49	20.43	17.86	14.80	14.16
11.75	9.81	8.05	6.76	5.63
4.34	3.70	2.41	1.93	.00
1.93	6.76	11.75	14.16	17.38
19.79	21.08	19.79	19.79	18.50
18.50	17.86	17.86	17.86	21.08
24.14	27.19	27.19	25.90	25.26
24.78	24.14	22.20	17.38	13.52
9.81	6.76	5.63	5.63	2.41
.00	.00	.00	.00	.00
.00				

s-by-s velocity, (km/h), for TC s

[illegible]

TABLE C.8 (Cont.)

.724050E+02	.804500E+02	.884950E+02	.933220E+02	.981490E+02
.101367E+03	.104585E+03	.106194E+03	.104585E+03	.101367E+03
.965400E+02	.965400E+02	.965400E+02	.965400E+02	.965400E+02
.965400E+02	.965400E+02	.965400E+02	.965400E+02	.965400E+02
.965400E+02	.965400E+02	.965400E+02	.965400E+02	.965400E+02
.965400E+02	.965400E+02	.901040E+02	.836680E+02	.772320E+02
.707960E+02	.643600E+02	.579240E+02	.514880E+02	.579240E+02
.643600E+02	.707960E+02	.772320E+02	.836680E+02	.901040E+02
.965400E+02	.101367E+03	.104585E+03	.104585E+03	.104585E+03
.101367E+03	.965400E+02	.917130E+02	.868860E+02	.820590E+02
.772320E+02	.724050E+02	.675780E+02	.627510E+02	.643600E+02
.643600E+02	.643600E+02	.643600E+02	.643600E+02	.643600E+02
.643600E+02	.643600E+02	.643600E+02	.643600E+02	.643600E+02
.643600E+02	.643600E+02	.643600E+02	.595330E+02	.530970E+02
.482700E+02	.434430E+02	.386160E+02	.337890E+02	.289620E+02
.241350E+02	.209170E+02	.225260E+02	.241350E+02	.241350E+02
.241350E+02	.241350E+02	.241350E+02	.241350E+02	.241350E+02
.241350E+02	.241350E+02	.241350E+02	.241350E+02	.241350E+02
.241350E+02	.241350E+02	.241350E+02	.241350E+02	.241350E+02
.241350E+02	.241350E+02	.241350E+02	.321800E+02	.402250E+02
.482700E+02	.563150E+02	.643600E+02	.724050E+02	.804500E+02
.884950E+02	.965400E+02	.101367E+03	.102976E+03	.101367E+03
.997580E+02	.965400E+02	.965400E+02	.965400E+02	.965400E+02
.965400E+02	.965400E+02	.965400E+02	.901040E+02	.836680E+02
.772320E+02	.724050E+02	.691870E+02	.675780E+02	.675780E+02
.724050E+02	.772320E+02	.852770E+02	.933220E+02	.981490E+02
.101367E+03	.104585E+03	.104585E+03	.104585E+03	.104585E+03
.104585E+03	.104585E+03	.104585E+03	.104585E+03	.104585E+03
.104585E+03	.104585E+03	.104585E+03	.104585E+03	.997580E+02
.949310E+02	.901040E+02	.852770E+02	.804500E+02	.756230E+02
.707960E+02	.675780E+02	.675780E+02	.675780E+02	.675780E+02
.675780E+02	.659690E+02	.611420E+02	.563150E+02	.514880E+02
.466610E+02	.418340E+02	.370070E+02	.321800E+02	.273530E+02
.225260E+02	.176990E+02	.128720E+02	.965400E+01	.643600E+01
.321800E+01	.000000E+00	.000000E+00	.000000E+00	.000000E+00
.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
.000000E+00	.965400E+01	.193080E+02	.289620E+02	.386160E+02
.482700E+02	.579240E+02	.675780E+02	.772320E+02	.852770E+02
.917130E+02	.965400E+02	.997580E+02	.101367E+03	.101367E+03
.101367E+03	.965400E+02	.917130E+02	.868860E+02	.820590E+02
.772320E+02	.724050E+02	.675780E+02	.627510E+02	.579240E+02
.530970E+02	.482700E+02	.434430E+02	.386160E+02	.337890E+02
.289620E+02	.241350E+02	.193080E+02	.144810E+02	.965400E+01
.482700E+01	.000000E+00	.000000E+00	.000000E+00	.000000E+00

TABLE C.9 ECE-15 Driving Profile (ECE-15)

ECE-15 Driving Cycle (4x195 s)

cycle time (s), TC=

```
iflag(=0: s-by-s; >0: segments)=
```

$$\text{No. of velocity segments} + 1 =$$

195

1

22

.000000E+00	.000000E+00	.100000E+02	.000000E+00	.140000E+02
.150000E+02	.240000E+02	.150000E+02	.300000E+02	.000000E+00
.500000E+02	.000000E+00	.540000E+02	.150000E+02	.570000E+02
.150000E+02	.610000E+02	.300000E+02	.880000E+02	.300000E+02
.100000E+03	.000000E+00	.117000E+03	.000000E+00	.120000E+03
.150000E+02	.122000E+03	.150000E+02	.130000E+03	.300000E+02
.133000E+02	.300000E+02	.141000E+03	.500000E+02	.155000E+03
.500000E+02	.162000E+03	.350000E+02	.174000E+03	.350000E+02
.188000E+03	.000000E+00	.195000E+03	.000000E+00	

TABLE C.10 Sydney Driving Profile (SYDNEY)

Sydney Driving Profile

cycle time (s), TC=

637

iflag(=0: s-by-s; >0: segments)=

1

No. of velocity segments + 1 =

31

.000000E+00	.000000E+00	.350000E+02	.809000E+02	.600000E+02
.809000E+02	.800000E+02	.000000E+00	.103000E+03	.000000E+00
.130000E+03	.600000E+02	.160000E+03	.600000E+02	.180000E+03
.000000E+00	.190000E+03	.500000E+02	.210000E+03	.500000E+02
.220000E+03	.300000E+02	.250000E+03	.500000E+02	.265000E+03
.000000E+00	.270000E+03	.000000E+00	.290000E+03	.550000E+02
.320000E+03	.520000E+02	.340000E+03	.000000E+00	.370000E+03
.000000E+00	.380000E+03	.250000E+02	.395000E+03	.250000E+02
.400000E+03	.000000E+00	.422000E+03	.000000E+00	.440000E+03
.700000E+02	.480000E+03	.710000E+02	.500000E+03	.000000E+00
.520000E+03	.000000E+00	.540000E+03	.630000E+02	.600000E+03
.000000E+00	.610000E+03	.000000E+00	.620000E+03	.550000E+02
.637000E+03	.000000E+00			

TABLE C.11 Japan-10 Driving Profile (JAPAN-10)

Japanese-10 Driving Cycle (1/5 of 675 s Profile)

cycle time (s), TC=

135

iflag(=0: s-by-s; >0: segments)=

1

No. of velocity segments + 1

=

12

.000000E+00	.000000E+00	.180000E+02	.000000E+00	.250000E+02
.200000E+02	.400000E+02	.200000E+02	.450000E+02	.000000E+00
.600000E+02	.000000E+00	.700000E+02	.400000E+02	.850000E+02
.400000E+02	.900000E+02	.200000E+02	.110000E+03	.200000E+02
.115000E+03	.380000E+02	.135000E+03	.000000E+00	

TABLE C.12 Constant 40 km/h Driving Profile (40KMPH)

CONSTANT SPEED OF 40 KM/HR
 cycle time (s), TC= 10
 iflag (=0: s-by-s; >0: segments) = 0
 s-by-s velocity, (km/h), for TC s
 .400000E+02 .400000E+02 .400000E+02 .400000E+02 .400000E+02
 .400000E+02 .400000E+02 .400000E+02 .400000E+02 .400000E+02

TABLE C.13 Constant 72 km/h Driving Profile (72KMPH)

CONSTANT SPEED OF 72 KM/HR					
cycle time (s), TC=					10
iflag (=0: s-by-s; >0: segments) =					0
s-by-s velocity, (km/h), for TC s					
.720000E+02	.720000E+02	.720000E+02	.720000E+02	.720000E+02	.720000E+02
.720000E+02	.720000E+02	.720000E+02	.720000E+02	.720000E+02	.720000E+02

TABLE C.14 Constant 88 km/h Driving Profile (88KMPH)

CONSTANT SPEED OF 88 KM/HR
 cycle time (s), TC= 10
 iflag (=0: s-by-s; >0: segments) = 0
 s-by-s velocity, (km/h), for TC s
 .880000E+02 .880000E+02 .880000E+02 .880000E+02 .880000E+02
 .880000E+02 .880000E+02 .880000E+02 .880000E+02 .880000E+02

cycle time including rest, (s), TC= 360
driving distance in a cycle (km), RC = .310000E+01
s-by-s power, (W/kg batt), for TC s

[illegible]

TABLE C.16 (Cont.)[illegible]

APPENDIX D:
DEFAULT BATTERY DATA FILES

TABLE D.1 Default Data File for Sodium/Sulfur Batteries, 1988 Technology (NA-S.88)

```

Na/S battery - 1988 Technology: CSPL 24-cell module
wt. of a battery cell, (kg), WC=          .120000E+00
accessory wt./cell, (kg), WY=            .600000E-01
no. of parallell strings , NPS=          .300000E+02
cell amp-hours @ C/3, C3=                .833000E+01
cell cutoff voltage comp.1,DCOV1=        .190000E+01
cell cutoff voltage comp.2,DCOV2=        - .397500E-01
no. of (DOD,NLV) data pairs=              9
    .000          2.050
    .050          2.070
    .100          2.080
    .400          2.080
    .500          2.070
    .600          2.068
    .700          2.055
    .800          2.035
    1.000         1.935
no. of (DOD,R) data pairs=                 8
    .000          .495E-01
    .050          .383E-01
    .100          .371E-01
    .200          .371E-01
    .400          .383E-01
    .600          .404E-01
    .900          .457E-01
    1.000         .468E-01
Regen (DOD,NLV) data pairs=                 5
    .000          2.080
    .250          2.070
    .500          2.060
    .750          2.050
    1.000         1.950
Regen (DOD,R) data pairs=                 5
    .000          .360E-01
    .250          .370E-01
    .500          .370E-01
    .750          .380E-01
    1.000         .780E-01
battery efficiency, effb=                  .880000E-00
battery parameter, G1=                    .000000E-00

```

TABLE D.2 Default Data File for Sodium/Sulfur Batteries, 1989 Technology
(NA-S.89)

```

Na/S batteries - 1989 Technology: CSPL 960-cell, 1/3-battery
wt. of a battery cell, (kg), WC=                .126000E+00
accessory wt./cell, (kg), WY=                   .116000E+00
no. of parallell strings , NPS=                  .300000E+02
cell amp-hours @ C/3, C3=                       .103000E+02
cell cutoff voltage comp.1,DCOV1=                .190000E+01
cell cutoff voltage comp.2,DCOV2=                - .397500E-01
no. of (DOD,NLV) data pairs=                      9
    .000      2.053
    .050      2.069
    .100      2.075
    .400      2.075
    .500      2.072
    .600      2.066
    .700      2.056
    .800      2.038
    1.000     1.944
no. of (DOD,R) data pairs=                        8
    .000      .491E-01
    .050      .431E-01
    .100      .413E-01
    .200      .408E-01
    .400      .408E-01
    .600      .422E-01
    .900      .422E-01
    1.000     .422E-01
Regen (DOD,NLV) data pairs=                      5
    .000      2.080
    .250      2.070
    .500      2.060
    .750      2.050
    1.000     1.950
Regen (DOD,R) data pairs=                        5
    .000      .360E-01
    .250      .370E-01
    .500      .370E-01
    .750      .380E-01
    1.000     .780E-01
battery efficiency, effb=                        .880000E-00
battery parameter, G1=                          .000000E-00

```

TABLE D.3 Default Data File for Sodium/Sulfur Batteries, 1990 Technology (NA-S.90)

Na/S battery - 1990 Technology: CSPL 120-cell module (PB-MK3)

wt. of a battery cell, (kg), WC=	.126000E+00	
accessory wt./cell, (kg), WY=	.117000E+00	
no. of parallell strings , NPS=	.300000E+02	
cell amp-hours @ C/3, C3=	.973000E+01	
cell cutoff voltage comp.1,DCOV1=	.190000E+01	
cell cutoff voltage comp.2,DCOV2=	- .397500E-01	
no. of (DOD,NLV) data pairs=		7
.000	2.050	
.167	2.065	
.333	2.063	
.500	2.057	
.667	2.038	
.833	1.988	
1.000	1.908	
no. of (DOD,R) data pairs=		8
.000	.500E-01	
.050	.412E-01	
.167	.399E-01	
.333	.405E-01	
.500	.410E-01	
.667	.413E-01	
.833	.409E-01	
1.000	.403E-01	
Regen (DOD,NLV) data pairs=		5
.000	2.080	
.250	2.070	
.500	2.060	
.750	2.050	
1.000	1.950	
Regen (DOD,R) data pairs=		5
.000	.360E-01	
.250	.370E-01	
.500	.370E-01	
.750	.380E-01	
1.000	.780E-01	
battery efficiency, effb=	.880000E-00	
battery parameter, G1=	.000000E-00	

TABLE D.4 Default Data File for Nickel/Iron Batteries (NIF-200)

Default battery dataset for Ni/Fe NIF200 Batteries

wt. of a battery cell, (kg), WC=	.502000E+01	
accessory wt./cell, (kg), WY=	.000000E+00	
no. of paralell strings, NPS=	.100000E+01	
cell amp-hours @ C/3, C3=	.203000E+03	
cell cutoff voltage comp.1, DCOV1=	.700000E+00	
cell cutoff voltage comp.2, DCOV2=	.000000E+00	
no. of (DOD,NLV) data pairs=		9
.000	1.420	
.050	1.366	
.100	1.352	
.200	1.328	
.500	1.302	
.800	1.242	
.900	1.203	
.950	1.148	
1.000	1.060	
no. of (DOD,R) data pairs=		7
.000	.700E-03	
.100	.765E-03	
.500	.780E-03	
.700	.782E-03	
.800	.810E-03	
.900	.950E-03	
1.000	.150E-02	
Regen (DOD,NLV) data pairs=		9
.000	1.480	
.125	1.430	
.250	1.410	
.375	1.396	
.500	1.384	
.625	1.360	
.750	1.336	
.875	1.300	
1.000	1.260	
Regen (DOD,R) data pairs=		9
.000	.480E-03	
.125	.750E-03	
.250	.800E-03	
.375	.760E-03	
.500	.710E-03	
.625	.770E-03	
.750	.860E-03	
.875	.102E-02	
1.000	.125E-02	
battery efficiency, effb=	.580000E-00	
battery parameter, G1=	.000000E-00	

TABLE D.5 Default Data File for Nickel/Iron Batteries (NIF-220)

Default battery dataset for Ni/Fe NIF220 Batteries

wt. of a battery cell, (kg), WC=	.500000E+01	
accessory wt./cell, (kg), WY=	.000000E+00	
no. of paralell strings, NPS=	.100000E+01	
cell amp-hours @ C/3, C3=	.220000E+03	
cell cutoff voltage comp.1,DCOV1=	.900000E+00	
cell cutoff voltage comp.2,DCOV2=	.000000E+00	
no. of (DOD,NLV) data pairs=		9
.000	1.380	
.050	1.352	
.100	1.340	
.200	1.326	
.500	1.296	
.800	1.240	
.900	1.216	
.950	1.200	
1.000	1.164	
no. of (DOD,R) data pairs=		7
.000	.800E-03	
.100	.840E-03	
.500	.860E-03	
.700	.890E-03	
.800	.940E-03	
.900	.110E-02	
1.000	.150E-02	
Regen (DOD,NLV) data pairs=		9
.000	1.480	
.125	1.430	
.250	1.410	
.375	1.396	
.500	1.384	
.625	1.360	
.750	1.336	
.875	1.300	
1.000	1.260	
Regen (DOD,R) data pairs=		9
.000	.480E-03	
.125	.750E-03	
.250	.800E-03	
.375	.760E-03	
.500	.710E-03	
.625	.770E-03	
.750	.860E-03	
.875	.102E-02	
1.000	.125E-02	
battery efficiency, effb=	.700000E-00	
battery parameter, G1=	.000000E-00	

TABLE D.6 Default Data File for Tubular Lead/Acid Batteries (3ET205)

Default battery dataset for Tubular L/A 3ET205 Batteries

wt. of a battery cell, (kg), WC=	.109300E+02	
accessory wt./cell, (kg), WY=	.000000E+00	
no. of parallell strings, NPS=	.100000E+01	
cell amp-hours @ C/3, C3=	.186000E+03	
cell cutoff voltage comp.1, DCOV1=	.130000E+01	
cell cutoff voltage comp.2, DCOV2=	.000000E+00	
no. of (DOD,NLV) data pairs=		7
.000	2.150	
.050	2.150	
.400	2.090	
.700	2.020	
.800	2.000	
.900	1.960	
1.000	1.890	
no. of (DOD,R) data pairs=		8
.000	.110E-02	
.050	.933E-03	
.300	.917E-03	
.400	.933E-03	
.600	.103E-02	
.800	.123E-02	
.900	.143E-02	
1.000	.233E-02	
Regen (DOD,NLV) data pairs=		6
.000	2.450	
.125	2.150	
.250	2.133	
.500	2.083	
.750	2.033	
1.000	1.983	
Regen (DOD,R) data pairs=		6
.000	.100E-02	
.125	.940E-03	
.250	.910E-03	
.500	.880E-03	
.750	.860E-03	
1.000	.102E-02	
battery efficiency, effb=	.680000E-00	
battery parameter, G1=	.140000E-00	

TABLE D.7 Default Data File for Zinc/Bromine Batteries (ZN-BR)

Default Dataset for S.E.A. 48-V, 5-kWh Zn/Br Battery

wt. of a battery cell, (kg), WC=	.253100E+01
battery accessory wt. (kg), WY=	.000000E+00
no. of parallell strings, NPS=	.100000E+01
modular amp-hours @ C/3, C3=	.121000E+03
cell cutoff voltage comp.1, DCOV1=	.844000E+00
cell cutoff voltage comp.2, DCOV2=	.000000E+00
no. of (DOD,OCV) data pairs=	9
.000	1.828
.080	1.800
.170	1.778
.250	1.759
.330	1.747
.410	1.734
.500	1.725
.580	1.716
.660	1.706
no. of (DOD,R) data pairs=	9
.000	.469E-02
.080	.444E-02
.170	.438E-02
.250	.431E-02
.330	.444E-02
.410	.456E-02
.500	.481E-02
.580	.506E-02
.660	.547E-02
no. of (DOD,NLV) data pairs=	2
.000	1.900
.900	1.900
no. of (DOD,R) data pairs=	2
.000	.469E-02
.900	.469E-03
battery efficiency, effb=	.750000E-00
battery parameter, G1=	.000000E-00

TABLE D.8 Default Data File for Nickel/Cadmium Batteries (NI-CD)

Default dataset for SAFT STM5-200 Ni/Cd Batteries

wt. of a battery cell, (kg), WC=	.490000E+01	
accessory wt./cell, (kg), WY=	.000000E+00	
no. of parallell strings, NPS=	.100000E+01	
cell amp-hours @ C/3, C3=	.217000E+03	
cell cutoff voltage comp.1, DCOV1=	.700000E+00	
cell cutoff voltage comp.2, DCOV2=	.000000E+00	
no. of (DOD,NLV) data pairs=		9
.000	1.400	
.050	1.354	
.100	1.326	
.200	1.294	
.500	1.276	
.800	1.244	
.900	1.218	
.950	1.200	
1.000	1.024	
no. of (DOD,R) data pairs=		7
.000	.388E-03	
.100	.390E-03	
.500	.394E-03	
.700	.408E-03	
.800	.416E-03	
.900	.424E-03	
1.000	.680E-03	
Regen (DOD,NLV) data pairs=		9
.000	1.480	
.125	1.430	
.250	1.410	
.375	1.396	
.500	1.384	
.625	1.360	
.750	1.336	
.875	1.300	
1.000	1.260	
Regen (DOD,R) data pairs=		9
.000	.220E-03	
.125	.320E-03	
.250	.370E-03	
.375	.310E-03	
.500	.290E-03	
.625	.320E-03	
.750	.400E-03	
.875	.410E-02	
1.000	.580E-02	
battery efficiency, effb=	.780000E-00	
battery parameter, G1=	.000000E-00	

TABLE D.9 Default Data File for Nickel/Metal-Hydride Batteries (NI-MH)

Default dataset for Ovonics Ni-MH H Cell

wt. of a battery cell, (kg), WC=	.628000E+00
accessory wt./cell, (kg), WY=	.000000E+00
no. of parallell strings, NPS=	.500000E+01
cell amp-hours @ C/3, C3=	.275000E+02
cell cutoff voltage comp.1, DCOV1=	.700000E+00
cell cutoff voltage comp.2, DCOV2=	.000000E+00
no. of (DOD,NLV) data pairs=	9
.000	1.400
.050	1.350
.100	1.325
.200	1.304
.500	1.265
.800	1.220
.900	1.188
.950	1.170
1.000	1.126
no. of (DOD,R) data pairs=	7
.000	.260E-02
.100	.275E-02
.500	.310E-02
.700	.330E-02
.800	.350E-02
.900	.380E-02
1.000	.800E-02
Regen (DOD,NLV) data pairs=	9
.000	1.480
.125	1.430
.250	1.410
.375	1.396
.500	1.384
.625	1.360
.750	1.336
.875	1.300
1.000	1.260
Regen (DOD,R) data pairs=	9
.000	.150E-02
.125	.200E-02
.250	.270E-02
.375	.250E-02
.500	.280E-02
.625	.290E-02
.750	.310E-02
.875	.340E-02
1.000	.760E-02
battery efficiency, effb=	.800000E-00
battery parameter, G1=	.000000E-00

DISTRIBUTION FOR ANL/ESD-27**Internal**

ANL Technical Publications Services
N. Clodi (5)

R. Weeks
E. Hathaway
W.W. Marr (302)

External

U.S. Department of Energy Office of Scientific and Technical Information (12)
Manager, U.S. Department of Energy Chicago Field Office
ANL-E Libraries (2)
ANL-W Library