A PROCEDURE FOR ESTIMATING THE FREQUENCY DISTRIBUTION OF CO LEVELS IN THE MICRO-REGION OF A HIGHWAY

by

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(The opinions, findings, and conclusions expressed in this report are those of the author and not necessarily those of the sponsoring agencies.)

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ABSTRACT

This report demonstrates that the probability of violating a "not to be exceeded more than once per year", one-hour air quality standard can be bounded from above. This result represents a significant improvement over previous methods of ascertaining the impacts of pollution sources. Such methods essentially estimated the expected annual maximum concentration and then compared the estimate to that concentration "not to be exceeded more than once per year". The probabilistic method presented in this report is easy to use, inexpensive to implement, and it directly addresses the question of the likelihood of violating an air quality standard. Furthermore, employment of this probabilistic method eliminates the need for the subjective inputs and the subjective analyses of results which characterize the so-called "worst case" methods of determining air quality impact.

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INTRODUCTION

The U. S. Environmental Protection Agency (EPA), under the authority of the Clean Air Act of 1970 as amended, requires highway agencies to submit to it all proposals for new highway facilities for environmental review prior to construction. The environmental review process includes an assessment of the impact of carbon monoxide (CO) on the micro-region of the proposed highway facility.

The one-hour national ambient air quality standard (NAAQS) for CO, as presented in the Federal Register (1971), is "40 milligrams per cubic meter (35 ppm) maximum one-hour concentration not to be exceeded more than once per year". If an environmental review concludes that a proposed project will violate the one-hour NAAQS for CO, then the EPA may prohibit construction of the project. Thus the assessment of the CO impact of a proposed highway facility can have very significant economic and environmental consequences. If a relatively clean facility were incorrectly assessed as being environmentally unacceptable, the potential economic gains derivable from the facility would be lost; while if a relatively dirty facility were incorrectly assessed as being environmentally acceptable, the air quality in the micro-region of the facility would be damaged.

Air pollution levels are largely subject to the random influences of wind speed, wind direction and atmospheric turbulence. Thus the question of the environmental acceptability of a proposed facility with respect to the NAAQS for CO cannot be answered explicitly. The random nature of pollution levels limits statements concerning their magnitude to statements concerning their distributions.

Previous work on the problem of assessing the CO impact of a proposed facility has centered on fitting observed or simulated pollution levels to some distribution function such as the lognormal and making predictions about the order statistics from such a distribution. In 1965, Zimmer and Larsen (1965) cited empirical evidence from one-year data histories from Chicago, Cincinnati, Los Angeles, New Orleans, Philadelphia, San Francisco, and Washington, D. C., showing that pollution levels for a number of air pollutants were approximately lognormally distributed for all averaging times. In 1967, Larsen et al. (1967) presented empirical results from the analysis of five-year data histories from these same cities (excluding New Orleans) which again demonstrated that pollutant concentrations were approximately lognormally distributed for all cities for all averaging times. In 1971, the EPA published, as part of its air pollution series, a manual by Larsen (1971) in which he suggests that the expected annual maximum concentration, which he estimates as the exponential of the maximum order statistic from a normal distribution, be used as the design value when determining control strategies and implementation plans.

Later, Patel (1973) noted that in making the above suggestion Larsen had neglected the sequential dependence of air pollution levels, and had reversed the order of expectation and exponentiation in the determination of the maximum order statistic. Thus, Patel stated, Larsen's calculation of the expected annual maximum concentration, which was based on the assumption of a sequence of mutually independent, normally distributed random variables, was in error. In his response Larsen (1973) agreed that pollution levels are sequentially dependent, but argued that the use of his model was justified because it was an empirical model and because it was especially helpful for calculating a design value. Larsen also pointed out that by using the expected annual maximum rather than the expected annual second-maximum as the design value, his method would tend to minimize the frequency of violating the standards. Larsen also claimed in his response that the interchange of expectation and exponentiation would not produce significant errors. In a later article Larsen (1974) said that the data suggested his method underpredicted the expected annual maximum about as often as it overpredicted it and, therefore, his method was the recommended one. In commenting on the Larsen-Patel discussion, Neustadter and Sidik (1974) presented the results of a Monte Carlo simulation which indicated that for 24-hour averaged pollution levels (i.e., a yearly sample size of 365), Larsen's "expected annual maximum" could over-predict the observed average annual second-maximum by from 63% to 117%.

In the <u>Proceedings of the Symposium on Statistical Aspects of Air Quality Data</u> (1974), Gifford, Benarie, Lynn and Saltzman all supported the use of the lognormal distribution. Gifford (1959, 1974) presented a justification for the lognormal distribution in urban areas containing many sources by postulating that sequential air pollution levels in such areas constitute a first order multiplicative stochastic process. Such a process reduces to a first order autoregressive process in the logarithm of concentration and thus, from the Central Limit Theorem, the logarithm of concentration will be normally distributed. Benarie (1974) presented empirical evidence from southwest France indicating that air pollution levels were approximately lognormally distributed, and that the geometric standard deviation of wind velocity radially from a point source compared within a factor of about 2 to the geometric standard deviation of the monitored pollution levels. Lynn (1974) compared a number of frequency distributions with respect to their ability to fit observed urban air quality data. He concluded that while none of the theoretical distribution functions studied was obviously superior, the two- and three-parameter lognormal distributions were convenient to use and produced a reasonable fit of the data. Saltzman (1974) also showed that his data tended to fit a lognormal distribution.

Pollack (1975), in drawing on the data and results of this symposium for his report, concluded that the lognormal distribution is an acceptable approximation to the distribution of pollutant levels in urban areas in the absence of nearby strong point sources.

Bencala and Seinfeld (1976) note that several common distribution functions can be used to fit air pollution data, with the lognormal distribution being the most popular. They argue that the lognormal character of air pollution data can be partially justified by the approximate lognormality of radial wind speeds, and that, even though the wind speed distribution could not itself totally explain the distribution of pollutants, the lognormal distribution function is a useful approximation to the complex distribution of pollutant levels.

In 1976, Kalpasanou and Kurchatova (1976) reported that the lognormal distribution did not fit their air pollution data from Sofia, Bulgaria, as measured by goodness-of-fit tests. This result, as later explained by Mage and Ott (1979), was due to the fact that the "fit" of the lognormal distribution as used by Larsen and others was on an "engineering" basis rather than on a "statistical" basis.

Air pollution data cannot be said to be lognormally distributed on the basis of goodness-of-fit tests; however, their distribution functions do plot as approximate straight lines on lognormal probability paper, which has led many investigators to assume that the lognormal distribution is an acceptable approximation.

Mage and Ott (1975) and Ott and Mage (1976) hypothesize that air pollution data can be fitted (in an engineering sense) by a censored three-parameter lognormal distribution. They show, using data from ten studies of air quality, that the censored three-parameter, lognormal distribution produces a better fit, in the squared error sense, to the data than does the standard two-parameter lognormal distribution function. Larsen subsequently (1977) proposed that air pollution data be modeled as variables from a three-parameter lognormal distribution. However, as later observed by Mage and Ott (1978), Larsen did not use the censored model in his 1977 paper and thus had to consider negative pollution values which altered his determination of the mean concentration.

Snee and Pierrard (1977) pointed out that the annual average concentration was less subject to estimation errors than were the tail percentiles of observed data, and that the coefficient of variation of lognormal air pollution data seemed to be constant at about 0.5. Thus they proposed determining the expected annual maximum concentration from the lognormal distribution using the annual average concentration and a coefficient of variation of 0.5 to determine the parameters of the supposed underlying lognormal distribution.

Turner (1974) was the first to address the problem of predicting the impact of a proposed rather than an existing facility. He suggested using simulation to develop a simulated data base from which one could extract the annual maximum pollution level. Benarie (1974) and Venkatram (1978) have noted that such a simulation would be excessively expensive. Kumar et al. (1976) have suggested a method for assessing the impact of a proposed facility using the ideas developed by Larsen. Their approach is to predict the annual mean and mean square concentrations and use these to estimate the parameters of the supposed underlying lognormal distribution. They suggest that the annual mean and mean square concentrations could be efficiently calculated using a climatological weighting scheme. (For instance, see Calder [1971]). However, they made the same independence assumption made by Larsen in order to estimate the expected annual maximum concentration from the supposed underlying lognormal distribution. And the appropriateness of comparing an expected annual maximum to a standard based on the annual second-maximum is under question. Tikvart and Freas (1977) and Venkatram (1979) have proposed other simulation and distribution fitting methods, which again address the problem by finding some sort of order statistic to compare to the appropriate air pollution standard. These methods also rely on the independence assumption made by Larsen.

Hirtzel and Quon (1979), in analyzing data on one-hour CO concentrations in Chicago, found a high degree of persistent correlation among successive values of one-hour CO concentrations. This sequential dependence, they explain, increases the variability of the error of estimate of the annual mean concentration and other air quality parameters. Thus the sequential dependence of air pollution levels is responsible for increased uncertainty in the parameters of distributions fitted to real or simulated air pollution data, and is also responsible for the error resulting from the use of results for independent observations to estimate pollution order statistics.

Time series analysis as an alternative solution to the problem has not been extensively pursued, largely because of the resources needed to determine the parameters of a time series model and the uncertainty in both the chosen model and its parameters which would be manifested in the resulting estimate of an annual order statistic or probability of violating an air quality standard.

Other methods for estimating the impact of a proposed highway facility are the worst-case methods such as that proposed by Habegger and Wolsko (1974). These methods consist of making a single estimate of the pollution level, generally using a Gaussian dispersion model with source, background, and meteorological input parameters intended to maximize the estimated pollution level, which is then compared to the air quality standard. Just as the practice of comparing the maximum order statistic to a standard based on the annual second-maximum has been questioned, the practice of comparing the worst-case order statistic to such a second-maximum standard is also questionable. In particular, the NAAQS do not specify any limits on maximum pollution levels. Furthermore, because the source, background, and meteorological input parameters for worst-case analyses are subjective estimates, such analyses yield only rule-of-thumb estimates of environmental impact.

PURPOSE

From the work that has been done in determining the environmental acceptability of a proposed highway facility, two major problems are evident. The first is the assumption of the independence of sequential pollution levels in light of the high serial correlations which have been documented for atmospheric pollution levels, and the second is the general practice of determining the acceptability of a proposed highway facility by comparing the maximum order statistic to a standard which is based on the annual second-maximum. The object of this report is to develop a method for determining the CO impact of a proposed highway facility which does not require the independence assumption, the lognormal (or any other distribution function) assumption, or the comparison of an order statistic to the standard.

Since pollution levels are random variables it would be natural to answer the question of the environmental acceptability of a proposed facility with respect to CO by estimating the probability that such a facility would violate the one-hour NAAQS for CO in any given year. Estimating the impact of a proposed facility probabilistically would eliminate the need for rule-of-thumb comparisons of order statistics with the standard. The need for the generally applied assumption of sequential independence results from the fact that we are generally unable to describe mathematically the joint probability distributions of one-year sets of pollution levels. This report presents a method of determining an upper bound, over all joint probability distribution functions which describe positively correlated sequential pollution levels, on the probability that a proposed highway facility would violate the one-hour NAAQS for CO. While a distribution-fitting process such as Larsen's could be employed to evaluate this derived upper bound, this report will develop a procedure for evaluating this upper bound which will have a much smaller standard error of estimate than would be obtained by using a distribution-fitting method.

The next section of this report describes the development of the upper bound on the probability of violating a one-hour standard not to be exceeded more than once per year. Next is presented a procedure for evaluating this upper bound, and then the sensitivity of this procedure to both random errors in estimation and to true changes in input conditions is compared to the sensitivity of the probability of violation determined using a distribution-fitting method such as Larsen's.

AN UPPER BOUND ON THE PROBABILITY OF VIOLATION

This section demonstrates that the expected number of hours per year that the pollution level will exceed the one-hour standard is sufficient to establish an upper bound on the probability that a proposed facility will violate the one-hour NAAQS for CO. The demonstration entails an examination of the probabilistic behavior of the sequentially dependent pollution levels throughout a year.

A General Case Upper Bound

Let X(t) be an indicator function for hour t (t=1,2,...T) such that X(t) = 1 if the pollution level at time t is greater than the prescribed standard and X(t) = 0 otherwise.

Let $Y(T) = \sum_{j=1}^{T} X(j)$; then the probability of violating the NAAQS is the probability that $Y(T) \geq 2$, or

$$P(\text{Violation}) = P[Y(T) \geq 2] = 1 - P[Y(T)=0] - P[Y(T)=1], \quad \text{---(1)}$$

where $$P[Y(T)=0] = P[X(t) = 0, \text{ for all } t = 1,2,3...T], \quad \text{---(2)}$$

and $$P[Y(T) = 1] = \sum_{j=1}^{T} P[X(j) = 1 \text{ and } X(t) = 0 \text{ for all } t \neq j, t=1,2,...T]. \quad \text{---(3)}$$

We see from equations (1,2,3) that a complete determination of P(Violation) requires a knowledge of the joint distribution of the X(t)'s for the stochastic process [X(t),t=1,2,...T].

Let us consider, for a moment, the effect of the history of the stochastic air pollution process up until time t-1 on the state of the process X(t) at time t.

We will assume that the physical process generating the pollution level at time t is a persistant process (i.e., that the pollution level at time t is influenced by past levels through the persistance of the factors which generated the past levels). Thus we write

$$P[X(t)=1|X^{t-}=0] \equiv P[X(t)=1|X(1)=\ldots X(t-1)=0] \leq$$

$$P[X(t)=1|X^{t+}=0] \equiv P[X(t)=1|X(t+1)=\ldots X(T)=0] \leq$$

$$P_1(t) \equiv P[X(t)=1], \qquad \text{----(4)}$$

which states that the probability of exceeding the standard, given that the standard has not been exceeded in the past, is bounded above by the probability the standard was exceeded at time t, given that it was not exceeded after time t, which is then itself bounded above by the probability of exceeding the standard at time t, given no information about the state of the process at times other than t. (Note that the $P_1(t)$ are assumed to be knowns, while the conditional probabilities are assumed to be unknowns.)

The probability of being in the violating or "1" state at time t is very small in any practical problem. Thus $1-P(X(t)=1)$ can be approximated from above by $\exp\{-P[X(t)=1]\}$. If we assume that $\exp\{-P[X(t)=1]\}$ is a closer approximation to $1-P[X(t)=1]$ than $1-P[X(t)=1|X^{t-}=0]$ is for all $t>1$, then we can write

$$\{1-P[X(t)=1|X^{t-}=0]\} - \{1-P[X(t)=1]\} \geq$$

$$\exp\{-P[X(t)=1]\} - \{1-P[X(t)=1]\},$$

which implies, for all $t>1$, that

$$\{1-P[X(t)=1|X^{t-}=0]\} \geq \exp\{-P[X(t)=1]\}. \qquad \text{---(5)}$$

Although equation (5) does not hold for t=1, since

$$[1-P_1(t)] \leq \exp\,[-P_1(t)],$$

the error of approximation at t=1 is very small for small $P_1(t)$ and thus we assume, for T very large, that

$$\prod_{t=1}^{T} \{1-P[X(t)=1|X^{t-}=0]\} \geq \prod_{t=1}^{T} \exp[-P_1(t)]. \qquad \text{---(6)}$$

From equations (2,6) we can write, using the chain rule of probability, that

$$P[Y(T)=0] = \prod_{t=1}^{T} P[X(t)=0|X^{t-}=0],$$

$$= \prod_{t=1}^{T} \{1-P[X(t)=1|X^{t-}=0]\}$$

$$\geq \prod_{t=1}^{T} \exp[-P_1(t)]$$

$$= \exp[-\sum_{t=1}^{T} P_1(t)] = \exp(-\lambda), \qquad \text{---(7)}$$

where $\lambda = \sum_{t=1}^{T} P_1(t)$ is the expected number of times that X(t) will exceed the standard in T tries. Recalling equation (1), we see that

$$P(\text{Violation}) \leq 1-P[Y(T)=0], \text{ and}$$

thus from equation (7), the probability of violating the standard may be bounded from above as

$$P(\text{Violation}) \leq 1-\exp(-\lambda). \qquad \text{---(8)}$$

While equation (8) represents an upper bound on the probability that a proposed facility will violate the NAAQS, a tighter bound would result if we could incorporate $P(Y(T)=1)$, the probability of exceeding the prescribed standard value exactly once in a year.

An Upper Bound Using the Markovian Assumption

Pollack (1975) has presented empirical evidence from hourly carbon monoxide studies which shows that the partial autocorrelation function of air pollution levels is generally large for a one-hour lag time but is not significantly different from zero for lags greater than one hour. Thus he claims that the stochastic process of sequential air pollution levels is adequately modeled as a first order Markov process. Gifford (1974) has also suggested that sequential air pollution levels constitute a first order process. We will assume that the indicators $X(t)$ may be modeled adequately as a discrete Markov chain; i.e., that the stochastic process $(X(t),\ t=1,2...T)$ has the property that the conditional distribution of $X(t+1)$ given $X(1), X(2)...X(t)$ is equal to the conditional distribution of $X(t+1)$ given only $X(t)$,

$$P[X(t+1)=j|X(1),X(2)...X(t)]=P[X(t+1)=j|X(t)]. \qquad \text{---(9)}$$

We will now show that by modeling the stochastic air quality process as a discrete Markov chain, we can express both $P(Y(T)=0)$ and $P(Y(T)=1)$ as functions of only the $P_1(t)$'s and a variable $\bar{R}$, which will be defined next. We will then determine the maximum of P(Violation) over all values of $\bar{R}$ to determine the desired upper bound.

Let us define, for i and j equal to zero or one,

$$P_j(t) = P[X(t)=j], \text{ and}$$

$$P_{ij}(t) = \begin{cases} P[X(t)=j \mid X(t-1)=i], & \text{for } t=2,3,\ldots T, \text{ and} \\ P[X(t)=j], & \text{for } t=1. \end{cases} \qquad \text{---(10)}$$

The state probabilities, $P_j(t)$, the probabilities that the process X(t) will be in state j at time t, are assumed to be known. (A method for estimating the $P_1(t)$'s is described in section 3.) The transition probabilities, $P_{ij}(t)$, the probabilities that the process X(t) will be in state j at time t given that it was in state i at time t-1, are assumed to be unknown.

From equation (10) and the Markovian assumption, we may write

$$P(Y(T)=0) = \prod_{t=1}^{T} P_{00}(t),$$

$$= \prod_{t=1}^{T} (1-P_{01}(t)),$$

$$\leq \exp\left(-\sum_{t=1}^{T} P_{01}(t)\right). \qquad \text{---(11)}$$

Thus recalling that $P_{01}(t) \leq P_1(t) << 1$, there is a $\bar{K} \geq 1$ ($\bar{K}$ will be very nearly equal to 1) such that

$$P[Y(T)=0] = \exp\left[-\bar{K} \sum_{t=1}^{T} P_{01}(t)\right]. \qquad \text{---(12)}$$

Since we wish to express the probability of violating the standard in terms of the assumed known $P_j(t)$, we define

$$R(t) = P_{01}(t)/P_1(t). \qquad \text{---(13)}$$

(Note that $0 \leq R(t) \leq 1$ since $0 \leq P_{01}(t) \leq P_1(t)$.) From equation (13) we may now write equation (12) as

$$P[Y(T)=0] = \exp[-\bar{K} \sum_{t=1}^{T} R(t)P_1(t)], \qquad \text{---(14)}$$

which, since the $P_1(t)$ are non-negative and bonded, implies from the Mean Value Theorem of calculus that there exists an $\bar{R}(0 \leq \bar{R} \leq 1)$ defined as

$$\bar{R} = \sum_{t=1}^{T} P_{01}(t)/\lambda, \qquad \text{---(15)}$$

such that

$$P[Y(T)=0] = \exp[-\bar{K}\bar{R} \sum_{t=1}^{T} P_1(t)],$$

$$= \exp[-\bar{K}\bar{R}\lambda]. \qquad \text{---(16)}$$

Equation (16) expresses the probability that Y(T) will be exactly zero in terms of $\bar{R}$ and λ.

In a similar fashion, we will now develop an expression for the probability that Y(T) will be exactly one in terms of $\bar{R}$ and λ.

Recalling equation (3) we may use the chain rule of probability and equations (11,16) with the Markovian assumption to write

$$P[Y(T)=1] = \sum_{j=1}^{T-1} [\prod_{k=1}^{j-1} P_{00}(K)] P_{01}(j) P_{10}(j+1) [\prod_{k=j+2}^{T} P_{00}(k)]$$

$$+ [\prod_{k=1}^{T-1} P_{00}(k)] P_{01}(T),$$

$$= \prod_{k=1}^{T} P_{00}(K) \sum_{j=1}^{T-1} P_{01}(j) P_{10}(j+1)] / P_{00}(j) P_{00}(j+1)]$$

$$+ P_{01}(T)/P_{00}(T)\},$$

$$\geq \exp(-\bar{K}\bar{R}\lambda) [\sum_{j=1}^{T-1} P_{01}(j) P_{10}(j+1) + P_{01}(T)], \quad ---(17)$$

since the terms $P_{00}(t)$ are all ≤ 1. To evaluate the summation in equation (16) we recall equation (4) with the Markovian assumption,

$$P[X(t)=1] \geq P[X(t)=1|X(t+1)=0] \geq P\ [X(t)=1|X(t-1)=0], \quad ---(4)$$

which states that the condition of a history of not exceeding the standard has a greater influence on the probability of exceeding the standard at time t than the condition of a future of not exceeding the standard has. From equation (4) and the definition of conditional probability, we can write

$$P_{10}(t+1) = P[X(t)=1|X(t+1)=0]P_0(t+1)/P_1(t)$$

$$\geq P_{01}(t)P_0(t+1)/P_1(t). \qquad \text{---(18)}$$

Thus using equations (13,18), we can write the summation term in equation (17) as

$$\sum_{j=1}^{T-1} P_{01}(j)P_{10}(j+1) \geq \sum_{j=1}^{T-1} P_{01}(j)P_{01}(j)P_0(j+1)/P_1 j)$$

$$\geq \sum_{j=1}^{T-1} R^2(j)P_1(j)P_0(j+1),$$

$$\geq \bar{H} \sum_{j=1}^{T-1} R^2(j)P_1(j), \qquad \text{---(19)}$$

where $\bar{H}$ is defined as the minimum of $P_0(j)$ over all j. Since $\bar{H} \leq 1$ and $R(t) \leq 1$, we find that the term $P_{01}(T)$ in equation (17) may be bounded below as

$$P_{01}(T) \geq \bar{H}R^2(T)P_1(T). \qquad \text{---(20)}$$

Thus we can rewrite equation (17) using equations (19,20) as

$$P[Y(T)=1] \geq \exp(-\bar{K}\bar{R}\lambda)[\bar{H} \sum_{t=1}^{T} R^2(t)P_1(t)]. \qquad \text{---(21)}$$

Jensen's Inequality can now be used to reduce equation (21) to a function of $\bar{R}$ and λ. The R(t) are bounded $0 \le R(t) \le 1$; the $P_1(t)$ are positive, finite, and

$$\sum_{t=1}^{T} [P_1(t)/\lambda] = 1;$$

and the function $f(R(t)) = R^2(t)$ is a convex function of R(t). Thus from Jensen's Inequality we may write

$$\sum_{t=1}^{T} [R^2(t)P_1(t)/\lambda] \geq [\sum_{t=1}^{T} R(t)P_1(t)/\lambda]^2, \qquad \text{---(22)}$$

which implies from equation (15) that

$$\sum_{t=1}^{T} R^2(t)P_1(t) \geq \bar{R}^2\lambda. \qquad \text{---(23)}$$

From equations (21,23) we can now bound the probability of exceeding the standard exactly once per year by

$$P[Y(T)=1] \geq \bar{H} \exp(-\bar{K}\bar{R}\lambda)\bar{R}^2\lambda. \qquad \text{---(24)}$$

Recalling the definitions of $\bar{H}$ and $\bar{K}$, we note that $\bar{H}$ and $\bar{K}$ are very nearly equal to one with $\bar{H}$ slightly less than one and $\bar{K}$ slightly greater than one. Thus, to a very good approximation, we can bound the probability of violating the NAAQS from above using equations (1,12,24) as

$$P(\text{Violation}) \leq 1-\exp(-\bar{R}\lambda)[1+\bar{R}^2\lambda]. \qquad \text{---(25)}$$

We recall from equation (15)

$$\bar{R} = [\sum_{t=1}^{T} P_{01}(t)]/\lambda, \qquad ---(15)$$

that the variable $\bar{R}$ is a function of the unknown transition probabilities for the stochastic process (X(t),t=1,2,...T). Thus to maximize the probability of violating the NAAQS over all possible stochastic air pollution processes (X(t),t=1,2...T), we can simply maximize equation (25) over all possible values of $\bar{R}$.

Letting $P_V=1-\exp(-\bar{R}\lambda)(1+\bar{R}^2\lambda)$, differentiating with respect to $\bar{R}$, and setting the result equal to zero we find that the relative extrema of P_V occur at

$$\bar{R} = [1 \pm (1-\lambda)^{\frac{1}{2}}]/\lambda. \qquad ---(26)$$

We note from equation (26) that $\bar{R}$ will be a real number only when $\lambda \leq 1$. Therefore, for $\lambda > 1$, the end points $\bar{R}=0$ and $\bar{R}=1$ must be examined to find the max P_V. Also, we recall that $0 \leq \bar{R} \leq 1$, which implies, since

$$[1+(1-\lambda)^{\frac{1}{2}}]/\lambda \geq 1 \text{ for } \lambda \leq 1, \text{ that } \bar{R}=[1-(1-\lambda)^{\frac{1}{2}}]/\lambda$$

produces a relative extremum of P_V for $\lambda \leq 1$. Examination of the second derivative of P_V with respect to $\bar{R}$ shows that $\bar{R} = [1-(1-\lambda)^{\frac{1}{2}}]/\lambda$ produces a relative maximum of P_V when $\lambda \leq 1$. Furthermore, since there is only one extremum of P_V over $0 \leq \bar{R} \leq 1$, P_V evaluated at $\bar{R} = (1-(1-\lambda)^{\frac{1}{2}}]/\lambda$ is the global maximum of P_V for $\lambda \leq 1$. For the case of $\lambda > 1$, we see that P_V (at $\bar{R}=0$)=1-exp(-0)(1+0)=1-1=0, and P_V(at $\bar{R}=1$)=1-exp(-λ)(1+λ)$\geq P_V$ (at $\bar{R}=0$). Thus, we see that P_V (at $\bar{R}=1$) is a global maximum for P_V over the interval $0 \leq \bar{R} \leq 1$ when $\lambda > 1$.

We have seen that the probability of violating a "not more than once per year" NAAQS is bounded by

$$P(\text{Violation}) \leq 1-\exp(-\lambda) \text{ in the general case,} \quad \text{---(27)}$$

and by

$$P(\text{Violation}) \leq \begin{cases} 1-\exp[-1+(1-\lambda)^{\frac{1}{2}}]2[1-(1-\lambda)^{\frac{1}{2}}]/\lambda & \text{for } \lambda \leq 1, \\ 1-\exp(-\lambda)(1+\lambda) & \text{for } \lambda \geq 1 \end{cases} \quad \text{---(28)}$$

when the Markovian assumption is applicable.

Equations (27,28) have the advantages of being relatively simple and of depending only on λ. This dependence on only λ is important since the marginal probabilities, by their very definition, will contain all information (except that regarding the sequential dependence of pollution levels) relative to the air pollution problem at hand. Thus equations (27,28) are applicable to the problem of determining the probability of violating the NAAQS for any pollutant (reactive or nonreactive), emitted from any source or combination of sources, over any (non-overlapping) averaging time, as long as the marginal probabilities of exceeding the maximum allowable pollution level can be determined or estimated. In fact, equations (27,28) may be used in conjunction with an empirical procedure such as Larsen's, if it can be assumed that

$$N \times P \simeq \lambda = \sum_{j=1}^{N} P_1(j),$$

where P is Larsen's probability of exceeding the maximum allowable pollution level for each of the N time periods in a year.

EVALUATING THE UPPER BOUND ON P(VIOLATION)

In the previous section, it was seen that one can determine an upper bound on the probability that a facility will violate a "not to be exceeded more than once per year" air quality standard given either λ, the expected number of one-hour violations, or, equivalently, the $P_1(t)$'s, the marginal probabilities of exceeding the maximum specified pollution level for each hour in a year. In this section an efficient method for determining λ from the marginal probabilities of violating the one-hour NAAQS for CO for each hour in a year will be developed. This method is based on the idea that when a random variable such as pollutant concentration can be expressed as a function of several other random variables such as meteorological variables, then the cumulative probability function of the first random variable (pollutant concentration) can be expressed in terms of joint probability function of the other random variables (the meteorological variables).

In the following sections this idea will be developed to determine the marginal probabilities of exceeding a specified maximum CO concentration for each one-hour time period in a year. For this purpose the Gaussian dispersion formulation will be used as the functional relationship between CO concentration and meteorological, source, background, and geometric conditions.

The Functional Relationship

While there are numerous models of pollution levels as functions of meteorological, source, background, and geometric parameters, the Gaussian dispersion models are perhaps the best known. The Gaussian dispersion formulation will be used because of its simplicity and because its meteorological inputs are easily determined from readily available meteorological data such as those routinely collected by the National Oceanic and Atmospheric Administration (NOAA). Furthermore, it will be shown later that the final estimate of λ is rather insensitive to unbiased errors of estimation in the $P_1(t)$'s and thus the exact choice of dispersion model is relatively unimportant.

Equation (29) is a statement of the Gaussian dispersion formulation for short source-to-receptor distances. It expresses the hourly concentration of a nonreactive pollutant in terms of the geometry and the hourly meteorological, source, and background parameters.

$$\chi(t) = \{\max[1,\mu(t)]\}^{-1} \sum_{i=1}^{N} D_i[\alpha(t),C(t),RC,SC_i]S_i(t)+B(t), \quad \text{---(29)}$$

where

$\chi(t)$ = time-average pollutant concentration at location RC for hour t,

$\mu(t)$ = magnitude in meters/second of the time-averaged wind vector for hour t,

$\alpha(t)$ = direction of the time-averaged wind vector for hour t,

$C(t)$ = atmospheric stability for hour t,

RC = receptor coordinates,

N = number of sources,

SC_i = source coordinates for the ith source,

$S_i(t)$ = time-averaged emissions for the ith source for hour t,

$D_i(\cdot)$ = the dispersion function for the ith source, and

$B(t)$ = time-averaged background concentration at location RC for hour t.

The dispersion function $D_i(\cdot)$ exhibits different forms for different types of sources. For line, area, and volume sources the function $D_i(\cdot)$ will be the line, area, and volume integral, respectively, of the dispersion function for a point source. Point source dispersion functions are of the form, $\exp(-X^2)$, and dispersion functions for higher dimensional sources are of the form of integrals of $\exp(-X^2)$. Thus the dispersion functions are not analytical in general and must be evaluated by numerical algorithms. In the developments which follow only the numerical value and not the functional form (i.e., source-type) of the dispersion functions $D_i(\cdot)$ will be important. Therefore, the results here will apply to all source types.

The Variables

According to the Gaussian dispersion formulation, the time-averaged CO concentration for hour t is a random variable which is a function of the geometry and of the meteorological, source, and background conditions for hour t. Of the parameters determining pollutant concentration, the receptor location and the number and locations of the sources are constant and do not contribute to the random behavior of the time-averaged CO concentration for hour t. The source emissions and background concentration at time t are assumed to be deterministic variables of time, and thus while they would contribute to the variation of concentration over time, they would not contribute to the random character of concentration at any fixed time t. The meteorological parameters — wind speed, wind direction, and stability class — at time t are assumed to be random variables whose joint distribution function depends on time. The justification for treating the background and source terms as deterministic variables and treating the meteorological terms as random variables is discussed below.

Background concentrations and source emissions are directly related to the cycle of human activity, which is, in turn, related to time of day, day of week, season, and year. For all realizations of a given hour, day of week, season, and year, approximately the same people would be engaged in approximately the same travel activities such as driving to work, school, church, or the supermarket; approximately the same industries and businesses would be engaged in approximately the same level of manufacturing, shipping, and power generation; and approximately the same homes, offices, factories, and shops would have approximately the same space heating requirements; etc. Thus if we know the year, season, day of week, and hour of day we can estimate the background concentration and source emissions. The fact that there is a high correlation of human activities (and thus background concentrations and source emissions) with time, — i.e., year, season, day of week, and hour — allows us to assume that the source and background terms are deterministic variables. The error in λ resulting from this assumption will be a function of the individual errors of estimation in the source and background terms for each hour. In the next section of this report the sensitivity of the results for λ to errors of estimation in the source and background terms for each hour will be examined.

The meteorological variables — wind speed, wind direction, and stability class — while having a dependence on time (they vary with the hour of day and with season), also exhibit unexplained or random variation in addition to their patterned variation with time. To separate the variation in meteorology attributable to time — i.e., the diurnal and seasonal variations — from the random variation, we would (see for instance Calder [1971]) divide a year into some number of discrete categories (such as 96 categories for 24 one-hour periods per day in each of 4 seasons), and then subdivide and analyze historical meteorological data according to such categories. In this manner the variation with time will be manifested between subsets and the random variation will be manifested within subsets.

Under the assumption that with 96 categories the 24-hour lag time between sequential observations in any given data category is sufficient to ensure that the observations are independent observations from an underlying stationary distribution, one can infer from the Ergodic Principle that the temporal parameters of the data subsets approximate the parameters of the underlying stationary distribution. Calder (1971) used this approach to define for each meteorological subset (i.e., time category) a discrete joint probability mass function as an estimator of the true underlying meteorological distribution. However, it is possible to extend Calder's approach by considering the wind vector in its rectangular rather than polar form.

It follows from the Central Limit Theorem that time-averaged cartesian components of velocity under stationary turbulence can be modeled as bivariate-normal random variables. (See for instance Crutcher [1957], Pasquille [1974], and Seinfeld [1975].) Furthermore, atmospheric turbulence can be categorized into stationary turbulence regimes such as the familiar Pasquille-Gifford atmospheric stability categories. Thus the joint probability function of the rectangular form time-averaged wind vector and the atmospheric stability category can be modeled as a mixed probability function in a fashion similar to that described by Crutcher (1962, 1977). First the distribution of the Cartesian components of the time averaged wind vector can be described within a given stability category by a bivariate-normal probability distribution function, and second the distribution of stability category can be described by a discrete probability mass function over all stability categories.

Specifically, if $u(t)$ and $v(t)$ are the horizontal Cartesian velocity components of the time-averaged wind vector and $c(t)$ is the atmospheric stability category during time period t, then the probability density function of the vector $[u(t),v(t),c(t)]$ is given by

$$f[u(t),v(t),c(t)] = f[u(t),v(t)|c(t)]m[c(t)], \quad ---(30)$$

where

$f[u(t),v(t)|c(t)]$ is the conditional bivariate-normal probability density function of the Cartesian components of the wind vector and $m[c(t)]$ is the discrete probability mass function over the set of stability categories. The parameters of both $f[u(t),v(t)|c(t)]$ and $m[c(t)]$ in equation (30) can be easily estimated from historical meteorological data such as that collected by the NOAA. A set of computer programs for extracting such information from historical meteorological records has been developed by Carpenter et al. (1979) under the authority of the Virginia Highway and Transportation Research Council.

Now to find the joint probability function of wind speed, wind direction, and stability class $[\mu(t),\alpha(t),c(t)]$, we note, since $[\mu(t),\alpha(t)]$ is the polar equivalent of $[u(t),v(t)]$, that the inverse of the Jacobian of the transformation $[u(t),v(t)]\rightarrow[\mu(t),\alpha(t)]$ is $J^{-1} = \mu(t)$. Thus, from the Calculus we may write (see for instance Lindley [1969]) the conditional probability function of $[\mu(t),\alpha(t)]$ in terms of the conditional probability function of $[u(t),v(t)]$ as

$$f[\mu(t),\alpha(t)|c(t)] = f[u(t),v(t)|c(t)]\mu(t). \quad ---(31)$$

Equation (31), together with equation (30), demonstrates that the joint probability function of $\mu(t),\alpha(t)$, and $c(t)$ may be written as

$$f[\mu(t),\alpha(t),c(t)] = f[u(t),v(t)|c(t)]m[c(t)]\mu(t). \quad ---(32)$$

Determining $P(\chi(t)>q)$

From equation (29) and the fact that $\chi(t)$ is monotone non-increasing in $\mu(t)$, we see that the probability that $\chi(t)$ will exceed a given pollution level, q, may be written as

$$P[\chi(t)>q] = P(\{\max[1,\mu(t)]\}^{-1} \sum_{i=1}^{N} S_i(t)D_i(\cdot)+B(t)>q),$$

$$= P\{\max[1,\mu(t)]<Q(t)\}, \qquad ---(33)$$

where

$$Q(t) = [\sum_{i=1}^{N} S_i(t)D_i(\cdot)]/[q-B(t)]$$ is a function of the

random variables $\alpha(t)$ and $c(t)$. Equation (33), which cannot be evaluated as it stands, can be expanded as the expectation over all $\alpha(t)$ and $c(t)$ of the conditional probability that $\max[1,\mu(t)]$ is less than $Q(t)$ given $\alpha(t)$ and $c(t)$, i.e.,

$$P[\chi(t)>q] = E_{\alpha,c}P\{\max[1,\mu(t)]<Q(t)\,|\,\alpha(t),c(t)\}. \qquad ---(34)$$

Equation (34), with q equal to the maximum CO level specified in the air quality standard, defines the probability of exceeding the standard during time period t in terms of the cumulative conditional probability function of $\max[1,\mu(t)]$ and the joint probability function of $\alpha(t)$ and $c(t)$. Since we can estimate the joint probability function of $[\mu(t),\alpha(t),c(t)]$ from equations (30,32), we can proceed to evaluate equation (34).

Since the max $[1,\mu(t)]\geq 1$, the conditional cumulative probability function in equation (34) may be written as

$$P\{\max[1,\mu(t)]<Q(t)\,|\,\alpha(t),c(t)\} = \begin{cases} 0, \text{ if } 0\leq Q(t)\leq 1, \\ P[\mu(t)<Q(t)] \text{ if} > Q(t)\ 1, \\ \text{and} \\ 1, \text{ if } B(t)>q. \end{cases} \quad \text{---(35)}$$

Therefore, defining

$$\hat{Q} = \begin{cases} Q(t), \text{ if } Q(t)>1, \\ 0, \text{ if } 0\leq Q(t)\leq 1, \text{ and} \\ \infty \text{ if } B(t)\geq q, \end{cases}$$

equation (34) can be written in terms of the meteorological probability function as

$$P[\chi(t)>q] = \int_{\alpha}\int_{c}\int_{0}^{\hat{Q}} f[\mu(t)\,|\,\alpha(t),c(t)]f[\alpha(t),c(t)]d\mu d\alpha dc$$

---(36)

From the chainrule of probability, we can rewrite equation (36) in terms of the empirically determinable probability functions $f[u(t),v(t)\,|\,c(t)]$ and $m[c(t)]$ as

$$P[\chi(t)>q] = \int_{\alpha}\sum_{c}\int_{0}^{\hat{Q}} f[u(t),v(t)\,|\,c(t)]\mu(t)d\mu m[c(t)]d\alpha. \text{---(37)}$$

The function, $f[u(t),v(t)|c(t)]$, we recall, is assumed to be a bivariate-normal probability function whose parameters are

$$\bar{u} = E[u(t)|c(t)],$$

$$\bar{v} = E[v(t)|c(t)],$$

$$Var(u) = Var[u(t)|c(t)],$$

$$Var(v) = Var[v(t)|c(t)], \text{ and}$$

$$Cov(u,v) = Cov[u(t),v(t)|c(t)].$$

Therefore, noting that $\mu^2(t) = u^2(t)+v^2(t)$ and $\alpha(t) = \tan^{-1}[v(t)/u(t)]$, we can express the conditional joint probability function of $[u(t),v(t)]$ as

$$f[u(t),v(t)|c(t)] = (2\pi K_4)^{-1}\exp[-\tfrac{1}{2}(K_1\mu^2+K_2\mu+K_3)], \quad \text{---(38)}$$

where

$$K_1 = [\cos^2(\alpha)Var(v)+Sin^2(\alpha)Var(u)-2Sin(\alpha)Cos(\alpha)Cov(u,v)]/K_4^2,$$

$$K_2 = -2\{Cos(\alpha)\bar{u}Var(v)+Sin(\alpha)\bar{v}Var(u)-[cos(\alpha)\bar{v}+Sin(\alpha)\bar{u}]\ cov(u,v)/K_4$$

$$K_3 = [\bar{u}^2 var(v) + \bar{v}^2 var(u) - 2\bar{u}\bar{v} cov(u,v)]/K_1^2, \text{ and}$$

$$K_4 = [var(u) var(v) - cov^2(u,v)]^{\frac{1}{2}}.$$

Substituting equation (38) in equation (37) and carrying out the integration over μ yields

$$P[\chi(t)>q] = \int_\alpha \sum_c \{K_5[\exp(-K_6^2) - \exp(-K^2{}_7)]/K_1$$

$$+ \pi^{\frac{1}{2}} K_5 K_2 [\text{erf}(K_6) - \text{erf}(K_7)]/(2K_1)^{3/2}\} m[c(t)] d\alpha, \qquad \text{---(39)}$$

where

$$K_5 = (2\pi K_4)^{-1} \exp(K^2{}_6 - K_3/2),$$

$$K_6 = K_2/(8K_1)^{\frac{1}{2}}, \text{ and}$$

$$K_7 = (2K_1\hat{Q} + K_2)/(8K_1)^{\frac{1}{2}}.$$

Although the integrand in equation (39) is not an analytical function, equation (39) can be numerically integrated over α and c to determine the probability that the CO level during time period t will exceed the maximum level specified in the NAAQS.

Computing λ

Previously, we saw that λ, the expected number of hours that will have pollution levels above the standard, is both necessary and sufficient to determine an upper bound on the probability of violating a "not to be exceeded more than once per year" air quality standard. We will now see that λ can be computed without $P[\chi(t)>q]$ having to be computed for each t.

Recall that background concentrations and source emissions are deterministic functions of season, day of week, and hour of day, and that the joint probability function of the meteorological variables is a function of the season and hour of day. Thus, since every time t corresponds to some season, day of week, and hour of day, and since there are an average of 13.0357 Sundays, Mondays, etc., per season, we can write from the definition of λ that

$$\lambda \equiv \sum_{t=1}^{T} P[\chi(t)>q] \simeq \sum_{s=1}^{4} \sum_{d=1}^{7} \sum_{h=1}^{24} (13.0357)\hat{P}[\chi(s,d,h)>q], \quad \text{---}(40)$$

where

$\hat{P}[\chi(s,d,h)>q]$ is the estimate of $P[\chi(t)>q]$.

Equation (40) shows that there are only 672 unique estimates of the 8760 $P[\chi(t)>q]$'s, since each estimate will be repeated about 13 times per season. Thus, the computation of λ requires actually evaluating only about 7.67% of the possible 8760 marginal probabilities.

A computer program to estimate λ for highway applications has been developed according to the above principles. The program requires as input 1) the parameters of the joint meteorological probability functions for each of the 96 season-hour categories in a year, 2) the 672 season-day-hour background and source terms (the program will handle up to ten source roadways), and 3) the number and location of the highway line sources and the location of the receptor. The cost of running this program is less than about \$15. A listing and documentation of this computer program is contained in the Appendix. (Because it was thought to be of interest to relatively few readers, the Appendix has not been included in all copies of the report. It may be obtained upon request.)

SENSITIVITY ANALYSIS

In the previous section a method for determining λ, the expected number of hours per year during which the CO level will exceed 35 ppm, was examined. In this section it will be seen that this method is very insensitive to unbiased random errors while also being very sensitive to true parameter changes. It will also be seen that the estimation error of λ obtained when using this method is much less than that obtained when estimating λ from a distribution-fitting method such as Larsen's lognormal model.

To examine the sensitivity of estimates of λ and P(V) to changes (systematic or random) in the background, source, and dispersion terms in equation (29), we must find the derivations of $P_1(t)$ with respect to these terms. However, the $P_1(t)$'s are, we recall, not analytical functions and cannot, therefore, be analytically differentiated. Thus, we must approximate the $P_1(t)$'s by analytical functions in order to approximate the derivatives of the $P_1(t)$'s with respect to the above parameters. In particular, we will approximate $P_1(t) = P[\chi(t)>q]$ as an exponential function of q (concentration) which, since the derivatives of q are analytically defined from equation (29), will then allow us to obtain the desired derivatives.

The derivatives, $dP_1(t)/dX$ for $X = S_i(t), B(t), D_i(\cdot)$, respectively, cannot be determined analytically from our definition of the $P_1(t)$'s, but if we approximate the $P_1(t)$'s as analytical functions of q, then we may write

$$dP_1(t)/dX = -(dP_1(t)/dq)(dq/dX), \qquad \text{---(41)}$$

where the derivatives dq/dX are defined from equation (29) which states that

$$q = \max[1,\mu(t)]^{-1} \sum_{i=1}^{N} S_i(t)D_i(\cdot)+B(t). \qquad \text{---(29)}$$

The reason for the minus sign in equation (41) will be explained later. In order to approximate $dP_1(t)/dq$ in equation (41), we recall that the probability function of $\chi(t)$ can be approximated by several distribution functions. In this section we will approximate the distribution of $\chi(t)$ by the exponential distribution function.

There are two basic reasons for assuming that the exponential distribution describes the random behavior of $\chi(t)$. The first is that when the exponential distribution is used, the relationship between $P_1(t)$ and q,

$$P_1(t) = P[\chi(t)>q] = \exp[-a(t)q], \qquad \text{---(42)}$$

has only the single parameter, a(t), which is readily evaluated from equation (42) as

$$a(t) = -\ln\{P[\chi(t)>35]\}/35. \qquad \text{---(43)}$$

The second justification for using the exponential distribution results from the fact the values of the $P_1(t)$'s are much less than 1 and thus only the slopes of the upper tails of the distributions of the $\chi(t)$ are of interest. Since the slopes of the upper tails of the distribution of $\chi(t)$ will be very small, the absolute error in estimating $dP_1(t)/dq$ resulting from the use of equation (42) will also be very small.

Using equation (42) to define the relationship between $P_1(t)$ and q, we can write the derivatives of the $P_1(t)$ with respect to q as

$$dP_1(t)/dq = -a(t)\exp[-a(t)q],$$

$$= -a(t)P_1(t). \qquad \text{---(44)}$$

Similarly, from equation (29) we find (assuming a single emissions source) that

$$dq/dS(t) = [q-B(t)]/S(t), \qquad \text{---(45)}$$

$$dq/dB(t) = 1, \text{ and} \qquad \text{---(46)}$$

$$dq/dD(\cdot) = [q-B(t)]/D(\cdot). \qquad \text{---(47)}$$

To understand the need for the minus sign in equation (41), notice from equation (33) that a change in $P_1(t)$ induced by a given change in q can also be realized by a change in X $[X=S(t)_g B(t)$, or $D(\cdot)]$ of the opposite sign. In particular, if a change in q of Δq at constant X causes a change in $P_1(t)$ of $\Delta P_1(t)$, then at constant q a change in X of $\Delta X = -(dX/dq)\Delta q$ will also produce a change of $\Delta P_1(t)$ in $P_1(t)$, because ΔX is, from its definition, the change in X necessary to change q by the amount necessary to produce $\Delta P_1(t)$. Thus we can write from equations (44,45) that

$$dP_1(t)/dS(t) = a(t)P_1(t)[q-B(t)]/S(t), \qquad \text{---(48)}$$

and from equations (44,46) that

$$dP_1(t)/dB(t) = a(t)P_1(t), \qquad \text{---(49)}$$

and from equations (44,47) that

$$dP_1(t)/dD(\cdot) = a(t)P_1(t)[q-B(t)]/D(\cdot). \qquad \text{---(50)}$$

From Table 1 we can see that over the range of interesting λ, we may estimate a(t) as approximately 0.25. This approximation will allow us, in turn, to estimate the sensitivity of λ to S(t), B(t), and D(·).

Table 1

λ	$P_1(t)$	a(t)
10	10^{-3}	.20
1	10^{-4}	.26
10^{-1}	10^{-5}	.33

There are two sensitivity questions concerning X (X=S(t), B(t), or D(·)) and λ or X and P(V). First, we wish to find the sensitivity of λ and P(V) to systematic changes in X for each hour t, and second we wish to find the sensitivity of λ and P(V) to independent random errors of estimation in X for each hour t.

Since λ is defined as the sum of the $P_1(t)$'s, $\Delta\lambda$ is defined as

$$\Delta\lambda = \sum_{t=1}^{T} \Delta P_1(t). \qquad \text{---(51)}$$

For a given constant percentage change in the source emissions for every hour t, we find from equations (48,51) that

$$\Delta\lambda = \sum_{t=1}^{T} a(t)P_1(t)[q-B(t)][\Delta S(t)/S(t)],$$

$$\simeq 5[\Delta S(t)/S(t)]\lambda, \qquad \text{---(52)}$$

where $[q-B(t)] \simeq 20$, and $a(t) \simeq 0.25$ for all t, and $[\Delta S(t)/S(t)]$ is constant for all t. Thus we may write

$$\Delta\lambda/\lambda \simeq 5[\Delta S(t)/S(t)], \qquad \text{---(53)}$$

which states that for a given constant percentage change in S(t) for all t, the percentage response in λ is approximately five times as great as the constant percentage change in source emissions.

Recalling equation (28) for $\lambda \geq 1$,

$$P(V) = 1-\exp(-\lambda)(1+\lambda), \qquad \text{---(28)}$$

we see that

$$dP(V)/d\lambda = \lambda \exp(-\lambda). \qquad \text{---(54)}$$

Thus we may write

$$\Delta P(V) = 5\lambda^2[\Delta S(t)/S(t)]\exp(-\lambda)$$

$$\simeq 3[\Delta S(t)/S(t)], \qquad \text{---(55)}$$

for λ in the range of 2. Equation (55) states that for a given systematic percentage change in S(t) for all t, the absolute response in P(V) is approximately triple the constant percentage change in source emissions. Thus we see that both λ and P(V) are quite responsive to systematic changes in the source emissions.

The response of λ and P(V) to a constant change in background concentration for each hour t may be found starting from equations (49,51). First we find that

$$\Delta\lambda = \sum_{t=1}^{T} a(t)P_1(t)[\Delta B(t)/B(t)]B(t),$$

$$\simeq 4\lambda[\Delta B(t)/B(t)], \qquad \text{---(56)}$$

where $a(t) \simeq 0.25$, $B(t) \simeq 16$, and $[\Delta B(t)/B(t)]$ is constant for all t. Thus we may write

$$\Delta\lambda/\lambda \simeq 4\ [\Delta B(t)/B(t)]. \qquad \text{---(57)}$$

Equation (57) states that λ changes by about 4% for every 1% change in B(t) which is realized across all t. Also from equations (54,56) we may write

$$\Delta P(V) = 4\lambda^2[\Delta B(t)/B(t)]\exp(-\lambda),$$

$$\simeq 2[\Delta B(t)/B(t)], \qquad \text{---(58)}$$

for λ in the range of about 2. Equation (58) states that for a given constant percentage change in B(t) for all t, the absolute response in P(V) is approximately twice the fractional change in background emissions. Thus we see that both λ and P(V) are very responsive to systematic changes in background concentration.

Now let us consider the effects of random errors of estimation on $\hat{\lambda}$ and $\hat{P}(V)$. Let $\hat{P}_1(t)$ be our estimate of $P_1(t)$, the true probability that $\chi(t)>35$ppm, and let

$$\varepsilon(t) = P_1(t)-\hat{P}_1(t) \qquad \text{---(59)}$$

be the error of the estimate, $\hat{P}_1(t)$. We assume that $\varepsilon(t)$ is a random variable with mean zero and finite variance, and that the errors of estimation are mutually independent. Continuing, we define $\hat{\lambda}$, our estimate of λ, which is the sum of the $P_1(t)$'s, as

$$\hat{\lambda} = \sum_{t=1}^{T} \hat{P}_1(t), \quad \text{---(60)}$$

and we define the error of the estimate, $\hat{\lambda}$, as

$$\varepsilon(\hat{\lambda}) = \lambda - \hat{\lambda} = \sum_{t=1}^{T} P_1(t) - \hat{P}_1(t) = \sum_{t=1}^{T} \varepsilon(t). \quad \text{---(61)}$$

Equation (61) indicates, from the Central Limit Theorem, that $\varepsilon(\hat{\lambda})$, the error in estimating λ from the sum of the unbiased estimates of the $P_1(t)$'s, will be normally distributed with mean zero and variance equal to the sum of the variances of the $\varepsilon(t)$'s. Although the $V(\varepsilon(t))$'s — the variances of the $\varepsilon(t)$'s — are unknown, we can reasonably assume, since both the magnitudes of the $P_1(t)$'s and the range of the $P_1(t)$'s are $<<1$, that the standard deviations of the $\varepsilon(t)$'s are equal to $K \times P_1(t)$'s, where $K \simeq 1$; i.e., that the standard deviations are of about the same magnitude as the $P_1(t)$'s themselves. Thus we find the variance of the estimate, $\hat{\lambda}$, from

$$V(\varepsilon(\hat{\lambda})) = K^2 \sum_{t=1}^{T} P_1(t)^2, \quad \text{---(62)}$$

which is easily computed from the $\hat{P}_1(t)$'s for any fixed value of K.

To illustrate the magnitude of $V[\varepsilon(\hat{\lambda})]$, consider the following. The set of $\hat{P}_1(t)$ for t=1,2,3,...T has a sample variance defined as

$$V(\text{Sample}) = \sum_{t=1}^{T} \hat{P}_1(t)^2/T - (\sum_{t=1}^{T} \hat{P}_1(t)/_T)^2. \quad \text{---(63)}$$

If we assume that the sample standard deviation is approximately equal to the sample mean (the range of the sample and the mean of the sample will be <<1), then we find that

$$\sum_{t=1}^{T} \hat{P}_1(t)^2 = 2T(\sum_{t=1}^{T} \hat{P}_1(t)/_T)^2,$$

$$= 2T(\hat{\lambda}/_T)^2. \quad \text{---(64)}$$

Thus from equation (62) we can approximate the variance of the estimate, $\hat{\lambda}$, as

$$V[\varepsilon(\hat{\lambda})] \simeq K^2 2(8760)(\hat{\lambda}/8760)^2 = K^2 \times \hat{\lambda}^2 \times 2.3 \times 10^{-4}, \quad \text{---(65)}$$

and the standard deviation of the error as

$$STD[\varepsilon(\hat{\lambda})] \simeq K \times \hat{\lambda} \times 1.5 \times 10^{-2}. \quad \text{---(66)}$$

From equation (66) and the Central Limit Theorem, we can estimate the two-sigma confidence band for λ as $\hat{\lambda} \pm 3\% K\lambda$. Thus, λ estimated from the sum of the $\hat{P}_1(t)$'s over all t is very insensitive to unbiased random errors of estimation in the $P_1(t)$'s. For example, standard errors of the estimates $\hat{P}_1(t)$, equal to 100% of $\hat{P}_1(t)$ result in a standard error of the estimate, $\hat{\lambda}$, of only about 3% of $\hat{\lambda}$.

Recall that we let the standard deviation of $\varepsilon(t)$ be $K\hat{P}_1(t)$. Now analyzing $\varepsilon(t)$ with respect to the source, background, and dispersion terms, we see from equation (33) that the error of the estimate, $\hat{P}_1(t)$, can be approximated as

$$\varepsilon(t) \simeq [dP_1(t)/dS(t)]\varepsilon_S(t)+[dP_1(t)/dB(t)]\varepsilon_B(t)$$

$$+ [dP_1(t)/dD(\cdot)]\varepsilon_D(t), \qquad \text{---(67)}$$

where the errors of the estimates of the source, background, and dispersion terms, $S(t)$,$B(t)$, and $D(\cdot)$, respectively, are

$$\varepsilon_S(t) = S(t)-\hat{S}(t), \qquad \text{---(68)}$$

$$\varepsilon_B(t) = B(t)-\hat{B}(t), \text{ and} \qquad \text{---(69)}$$

$$\varepsilon_D(t) = D(\cdot)-\hat{D}(\cdot). \qquad \text{---(70)}$$

The estimation errors $\varepsilon_S(t)$,$\varepsilon_B(t)$, and $\varepsilon_D(t)$ are all assumed mutually independent and, therefore, the variance of their sum will equal the sum of their variances. Thus from equation (67) we can write the variance of the estimation error of $\hat{P}_1(t)$ in terms of the variances of the estimation errors of $\hat{S}(t)$,$\hat{B}(t)$, and $\hat{D}(\cdot)$ as

$$V(\varepsilon(t)) = [dP_1(t)/dS(t)]^2V[\varepsilon_S(t)]$$

$$+ [dP_1(t)/dB(t)]^2V[\varepsilon_B(t)]$$

$$+ [dP_1(t)/dD(\cdot)]^2V[\varepsilon_D(t)]. \qquad \text{---(71)}$$

Now from equation (48) and the assumptions that $a(t) \simeq 0.25$ ppm^{-1}, and $(q-B(t))/S(t) \simeq 100$ ppm-m-sec/gm,

$$[dP_1(t)/dS(t)]^2 \simeq [25P_1(t)]^2 \qquad ---(72)$$

and, from equation (49),

$$[dP_1(t)/dB(t)]^2 \simeq [.25P_1(t)]^2, \qquad ---(73)$$

and from equation (5) and the assumption that $[q-B(t)]/D(\cdot) \simeq 0.2$ ppm-m^2/gm, we can write $[dP_1(t)/dD(\cdot)]^2 \simeq [0.05P_1(t)]^2$. Thus we may write from equation (71) that

$$V(\varepsilon(t)) \simeq \hat{P}_1(t)^2 \times \{6.25\times10^2 V[\varepsilon_S(t)] + 6.25\times10^{-2} V[\varepsilon_B(t)] + 2.5\times10^{-3} V[\varepsilon_D(t)]\}, \qquad ---(74)$$

Recalling from equation (62) that the variance of the error of estimate in $\hat{P}_1(t)$ is $K^2\hat{P}_1(t)^2$, and assuming that the variances of estimates $V[\varepsilon_S(t)]$, $V[\varepsilon_B(t)]$, and $V[\varepsilon_D(t)]$ are about constant over all t, we can write from equation (66) that

$$STD[\varepsilon(\hat{\lambda})] \simeq \{6.25\times10^2 V[\varepsilon_S(t)] + 6.25\ 10^{-2} V[\varepsilon_B(t)] + 2.5\times10^{-3} V[\varepsilon_D(t)]\}^{\frac{1}{2}} 1.50\times10^{-2}\times\hat{\lambda}, \qquad ---(75)$$

which expresses the standard deviation of the estimation error of $\hat{\lambda}$ in terms of the variances of the estimation errors for the source, background, and dispersion terms.

Now we wish to estimate the magnitude of the variance terms in equation (75). Juneja (1977) has found a standard error of estimate for single vehicle emissions of about one-sixth of the mean vehicle emissions. Thus from the Central Limit Theorem, assuming that about 3,000 individual vehicles having independent estimation errors make up a highway line source, we can approximate the standard error of estimate of the total source emissions as about $3\times10^{-3}\times\hat{S}(t)$ for a known fleet of vehicles. Scaling by a factor of ten to account for uncertainties in the number, type, age, speed, and condition of vehicles actually using a highway, we can conservatively approximate $STD[\varepsilon_S(t)] \simeq 3\times10^{-2}$. Newstadter and Sidik (1974) place the standard deviation of typical air pollution concentration data as being between 1.3 and 2.7. Thus, we can conservatively assume that $STD[\varepsilon_B(t)] \simeq 3$. Turner (1974) suggests that the error in dispersion estimates can range between ± 100% of the estimate. Thus for $\hat{D}(\cdot) \simeq 100$ ppm-m^2/gm and assuming that the error range is the three sigma range, we can conservatively estimate $STD(\varepsilon_D(t)) \simeq 30$ ppm-m^2/gm. Using these estimates we can rewrite equation (75) as

$$STD[\varepsilon(\hat{\lambda})] \simeq (.56+.56+2.25)^{\frac{1}{2}}\times1.5\times10^{-2}\times\hat{\lambda},$$

$$\simeq 3\times10^{-2}\hat{\lambda}. \qquad \text{---(76)}$$

Thus we see that λ computed from the sum of the $P_1(t)$'s is very insensitive to random unbiased errors of estimation, and that, in particular, the two-sigma confidence limits on $\hat{\lambda}$ are $\hat{\lambda}\pm6\%$ of $\hat{\lambda}$.

To examine the sensitivity of P(V) — the probability of violating the NAAQS — to unbiased random errors of estimation we first let P(V) be our estimate of $\hat{P}(V)$, and let

$$\varepsilon(\hat{P}) = P(V)-\hat{P}(V), \qquad \text{---(77)}$$

be the error of the estimate $\hat{P}(V)$. For the case of $\lambda \geq 1$, we can see from equation (28) that

$$\varepsilon(\hat{P}) \simeq [dP(V)/d\lambda] \times \varepsilon(\hat{\lambda}), \qquad \text{---(78)}$$

and, therefore,

$$V[\varepsilon(\hat{P})] \simeq [dP(V)/d\lambda\ ]^2 \times V[\varepsilon(\hat{\lambda})], \qquad \text{---(79)}$$

and

$$STD[\varepsilon(\hat{P})] \simeq [dP(V)/d\lambda] \times STD[\varepsilon(\hat{\lambda})]. \qquad \text{---(80)}$$

Therefore, from equation (54), which gives the derivative of P(V) with respect to λ for $\lambda \geq 1$, and equation (76), which approximates the standard error of estimate of λ, we can write

$$STD[\varepsilon(\hat{P})] \simeq \hat{\lambda}^2 \exp(-\hat{\lambda}) \times 3 \times 10^{-2}. \qquad \text{---(81)}$$

Differentiating equation (81) with respect to $\hat{\lambda}$, setting the result equal to zero and solving for $\hat{\lambda}$ reveals that at $\hat{\lambda}=2$, the standard deviation of the error in the estimate of the probability of violating the NAAQS takes on its maximum value over all positive $\hat{\lambda}$. This maximum of $STD[\varepsilon(\hat{P})]$ is 0.016. Although the actual probability distribution of $\varepsilon(\hat{P})$ is not known, we can be reasonably certain from the above that the true P(V) will be within $\hat{P}(V) \pm 0.03$.

Now let us examine the sensitivity of $\hat{\lambda}_L$ and $\hat{P}_L(V)$, the estimates of λ and P(V) determined from some distribution-fitting procedure such as one of those proposed by Larsen, to changes (systematic and random) in the underlying parameters.

As discussed previously, a simulated set of air quality data can be fitted to a distribution function, such as the lognormal as proposed by Larsen, and the parameters of the distribution function used to calculate $\hat{\lambda}_L$, the estimate of the expected number of one-hour pollution levels >35ppm CO in a year. $\hat{P}_L(V)$, the estimate of the probability of violating the NAAQS, can then be calculated by using $\hat{\lambda}_L$ in equation (28).

If the simulated data set used to determine $\hat{\lambda}_L$ is generated from the same historical meteorological data and source and background terms as were used to determine $\hat{\lambda}$, and if the dispersion model given by equation (29) is used to generate the data set, the response of $\hat{\lambda}_L$ and $\hat{P}_L(V)$ to systematic changes in the source and background terms will be identical to the response of $\hat{\lambda}$ and $\hat{P}(V)$ to such changes. In particular, from equation (53) we find that

$$\Delta\hat{\lambda}_L/\hat{\lambda}_L \simeq 5[\Delta S(t)/S(t)], \qquad \text{---(82)}$$

which states that the percentage response in $\hat{\lambda}_L$ to a constant percentage change in source emissions is five times greater than the percentage emissions change. Similarly, we find from equation (55) that

$$\Delta\hat{P}_L(V) \simeq 3[\Delta S(t)/S(t)], \qquad \text{---(83)}$$

i.e., that the absolute change in the estimated probability of violating the NAAQS is approximately triple the constant percentage change in source emissions. From equation (57) we find that the percentage change in $\hat{\lambda}_L$ to a constant percentage change in B(t) is four times greater than the constant percentage change in the background concentration, i.e.,

$$\Delta\hat{\lambda}_L/\hat{\lambda}_L \simeq 4[\Delta B(t)/B(t)]. \qquad ---(84)$$

And from equation (58) we find that

$$\Delta\hat{P}_L(V) \simeq 2[\Delta B(t)/B(t)], \qquad ---(85)$$

which states that the absolute response of $\hat{P}_L(V)$ to a constant percentage change in B(t) is about twice the fractional change in the background concentration.

Although the responses of $\hat{\lambda}_L$ and $\hat{P}_L(V)$ to systematic changes in the source and background terms are identical to the responses of $\hat{\lambda}$ and $\hat{P}(V)$ to such systematic changes, we will see that the standard deviations of the errors of estimation STD $[\varepsilon(\hat{\lambda}_L)]$ and STD $[\varepsilon(\hat{P}_L)]$ are much greater than the standard deviations of the errors of estimation STD$[\varepsilon(\hat{\lambda})]$ and STD$[\varepsilon(\hat{P})]$. First let us consider STD$[\varepsilon(\hat{\lambda}_L)]$.

The Larsen estimate of λ is defined as

$$\hat{\lambda}_L = 8760 \times \hat{P}_L(\chi > 35), \qquad ---(86)$$

and the error of the estimate is defined as

$$\varepsilon(\hat{\lambda}_L) = \lambda - \hat{\lambda}_L, \qquad ---(87)$$

where $\hat{P}_L(\chi>35)$ is the probability that a randomly selected one-hour pollution level will be greater than 35 ppm as determined from the distribution function fitted to the data. The variance of the error of the Larsen estimate of λ is, from equations (86,87),

$$V[\varepsilon(\hat{\lambda}_L)]=V(\lambda-\hat{\lambda}_L)=V(\hat{\lambda}_L) = (8760)^2V[\hat{P}_L(\chi>35)]. \qquad \text{---(88)}$$

The variance of the Larsen estimate, $\hat{P}_L(\chi>35)$, can be determined from the properties of the binomial distribution (with N = the number of years of simulated data) as

$$V[\hat{P}_L(\chi>35)]=\hat{P}(\chi>35)[1-\hat{P}(\chi>35)]/(8760\times N),$$

$$\simeq \hat{P}_L(\chi>35)/(8760\times N), \qquad \text{---(89)}$$

since $1-\hat{P}(\chi>35) \simeq 1$. Thus, from equations (86,88,89), the variance of the error of the Larsen estimate of λ is approximately

$$V[\varepsilon(\hat{\lambda}_L)] \simeq 8760\times\hat{P}_L(\chi>35)/N,$$

$$= \hat{\lambda}_L/N, \qquad \text{---(90)}$$

and the standard deviation of the error is

$$STD[\varepsilon(\hat{\lambda}_L)] \simeq (\hat{\lambda}_L/N)^{\frac{1}{2}}. \qquad \text{---(91)}$$

Recalling equation (76), we see that

$$STD[\varepsilon(\hat{\lambda})] \simeq 3\times10^{-2}\hat{\lambda}. \qquad ---(76)$$

Therefore, we find (for a typical value of N=10 years), $STD[\varepsilon(\hat{\lambda}_L)]>STD[\varepsilon(\hat{\lambda}($] for $\lambda\leq 112$ and, in particular, for λ in the range of about 2, we find that

$$STD[\varepsilon(\hat{\lambda}_L)] = 0.45 \text{ and } STD[\varepsilon(\hat{\lambda})] = 0.06, \text{ or that}$$

$$STD[\varepsilon(\hat{\lambda}_L)]/STD[\varepsilon(\hat{\lambda})] = 7.5.$$

Similarly, the Larsen estimate of P(V), is defined by equation (28) as

$$\hat{P}_L(V) = 1-\exp(-\hat{\lambda}_L)(1+\hat{\lambda}_L), \qquad ---(28)$$

for $\hat{\lambda}_L\geq 1$, and the error of the estimate, $\hat{P}_L(V)$, is defined as

$$\varepsilon(\hat{P}_L) = P(V)-\hat{P}_L(V). \qquad ---(92)$$

We can approximate, as in equation (78), the error of the estimate, $\hat{P}_L(V)$, as

$$\varepsilon(\hat{P}_L) \simeq [d\hat{P}_L(V)/d\hat{\lambda}_L]\varepsilon(\hat{\lambda}_L), \qquad \text{---(93)}$$

for small errors of estimation, $\varepsilon(\hat{\lambda}_L)$. Thus, we can write the variance of the Larsen estimate of the probability of violating the standards from equation (93) as

$$V[\varepsilon(\hat{P}_L)] \simeq [d\hat{P}_L(V)/d\hat{\lambda}_L]^2 V[\varepsilon(\hat{\lambda}_L)], \qquad \text{---(94)}$$

and the standard deviation of estimation error, $\varepsilon(\hat{P}_L)$, as

$$STD[\varepsilon(\hat{P}_L)] \simeq [dP_L(V)/d\hat{\lambda}_L]STD[\varepsilon(\hat{\lambda}_L)]. \qquad \text{---(95)}$$

From equation (54), which defines $STD[\varepsilon(\hat{\lambda}_L)]$, we can now write equation (95) as

$$STD[\varepsilon(\hat{P}_L)] \simeq \hat{\lambda}_L \exp(-\hat{\lambda}_L)(\hat{\lambda}_L/N)^{\frac{1}{2}}. \qquad \text{---(96)}$$

Recalling equation (81) we see that for the method of computing λ from the sum of the $P_I(t)$'s,

$$STD[\varepsilon(\hat{P})] \simeq \hat{\lambda}^2 \exp(-\hat{\lambda}) \times 3 \times 10^{-2}. \qquad \text{---(81)}$$

Thus, for $N \simeq 10$

$STD[\varepsilon(\hat{P}_L)] > STD[\varepsilon(\hat{P})]$ for $\lambda \leq 112$ and in the range of $\lambda \simeq 2$

$STD[\varepsilon(\hat{P}_L)] \simeq 0.121$ and $STD[\varepsilon(\hat{P})] \simeq 0.016$ or

$STD[\varepsilon(\hat{P}_L)]/STD[\varepsilon(\hat{P})] = 7.5.$

SUMMARY AND FUTURE WORK

This report has demonstrated that the probability of violating a "not to be exceeded more than once per year" one-hour air quality standard can be bounded from above. This bound has been shown to be a simple function of λ. The parameter λ is the expected number of hours during which the hourly average pollution levels will exceed the standard. Furthermore, from the definition of λ and that of P (Violation) — the probability of violating the standard — this result applies not only to one-hour standards, but also to any n-hour standard for which the n-hour intervals do not overlap. In other words, for any case in which λ is well defined, and the Markov property holds, the upper bounds on the probability of violating a "not to be exceeded more than once per year" standard are those presented early in this report.

For the special case of the one-hour standard for CO it has been shown that λ and P(Violation) can be determined in a computationally efficient manner. This method of estimating λ and P(Violation) is sensitive to real systematic changes in the underlying parameters, but it is very insensitive to unbiased errors of estimation in the hourly pollution parameters. In particular, this report has shown that this proposed method produces λ and P(Violation) estimates having far smaller variabilities of estimate than λ and P(Violation) estimates from distribution-fitting methods.

An algorithm has been developed to analyze the impact of proposed highways on air quality with respect to the one-hour CO standard. This algorithm applies the results of this report to the specific problem of a particular nonreactive pollutant (CO), emitted from a particular source type (line sources), and time averaged over non-overlapping one-hour periods. These results can, however, also be applied to other pollutants with other averaging times and to other source types. The only restriction to estimating the upper bound on the probability of exceeding a "not to be exceeded more than once per year" standard for any pollutant over any averaging time from any source type is that the process must be Markovian and one must be able to estimate λ, the expected number of averaging periods during which the time-averaged pollution level exceeds the standard per year.

For the case of the eight-hour standard for CO, the results of this report are not applicable. Even though sequential one-hour pollution levels are Markovian, sequential eight-hour overlapping pollution levels are not Markovian. Thus the major assumption of this report is violated by the eight-hour averaged pollution process. Furthermore, there does not exist a formulation such as equation (29) which expresses eight-hour averaged pollution levels as a function of eight-hour averaged meteorological, source, and background conditions, since the stationarity assumption implicit in equation (29) cannot reasonably be extended to periods as long as eight hours.

The eight-hour problem will require further study for its solution. Simulation studies appear to offer promise as possible solutions to the problem. Also it may be possible to demonstrate that the indicator process for the eight-hour problem is Markovian even though the underlying eight-hour averaged pollution process is not Markovian. Such an approximation would allow the results of Chapter 2 to be applied to the eight-hour problem as well as to the one-hour problem.

Another possible approach to the eight-hour problem would be to consider non-overlapping eight-hour pollution averages. In this manner it may be possible to combine results for non-overlapping intervals into a composit result for overlapping intervals.

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APPENDIX

THE COMPUTER PROGRAM PROBCO1

The computer program PROBCO1 finds the probability that a highway line source (or a group of up to ten line sources) will cause a violation of the one-hour NAAQS for CO. PROBCO1, which uses the method developed in this report, is written in Fortran IV and implemented on a CDC Cyber 172 computer. The program requires less than four minutes of CPU time, and the maximum run cost is less than $15. The input requirements for PROBCO1 are described below.

The coordinate system used to locate the sources and receptors in PROBCO1 is oriented such that +X is East, +Y is North, and the origin is arbitrary. (Typically, one would simply use the Universal Traverse Mercator (UTM) coordinates found on all U. S. Geological Survey maps to specify the locations of the receptor and sources.) All distances (coordinates) inputted to PROBCO1 must be specified in meters, all concentration inputs must be specified in ppm CO, and all source emissions inputs must be specified in micrograms/meter-second. The data card requirements for PROBCO1 follow.

Card 1: Format (3(F6.0, 1X)).

Column 1: The X-coordinate of the receptor.
8: The Y-coordinate of the receptor.
15: The height of the receptor.

Card 2: Format (I2).

Column 1: The number of line sources included in this analysis.

Card 3: Format (4(F6.0,1X)), (Line Source 1).

Column 1: The X-coordinate of the West end point of Source 1.
8: The Y-coordinate of the West end point of Source 1.
15: The X-coordinate of the East end point of Source 1.
22: The Y-coordinate of the East end point of Source 1.

Card 4: Format (4(F6.0,1X)), (Line Source 2).

Column 1: The X-coordinate of the West end point of Source 2.
8: The Y-coordinate of the West end point of Source 2.
15: The X-coordinate of the East end point of Source 2.
22: The Y-coordinate of the East end point of Source 2.

Etcetera for each of the line sources in the analysis.

Card N: Format (F2.0).

Column 1: The one-hour CO standard (=35 ppm).

Card N+1: Format (I2).

Column 1: The number of Background/Source conditions (hereafter referred to as NBS) which can occur for each time period. (Typically equals seven for the seven days of the week. Although, for instance, a value of two for weekdays and weekends might be used.)

Following Card N+1 are 96 groups of cards, one group for each of the 96 time periods in a year. Each group contains NBS (recall that NBS = the number of B/S conditions) cards, one card for each of the NBS background/source conditions. The 96 one-hour time periods (TP) are defined as:

Time Periods	Months	Time
1 to 24	11, 12, 1	0000 to 0100 ST to 2300 to 2400 ST
25 to 48	2, 3, 4	0000 to 0100 ST to 2300 to 2400 ST
49 to 72	5, 6, 7	0000 to 0100 DST to 2300 to 2400 DST
73 to 96	8, 9, 10	0000 to 0100 DST to 2300 to 2400 DST

Notice that the one-hour shifts from Standard Time to Daylight Saving Time are incorporated in the definitions of the time periods. The (96 × NBS) background/source cards are specified as follows:

Card TP1, B/S condition 1: Format (F5.4,1X,F4.0,10 (1X,F6.0)).

Column 1: The fraction of the time that B/S condition 1 for TP1 will occur.
7: Background concentration for TP1, B/S condition 1.
12: Emissions for source 1, for TP1, B/S condition 1.
19: Emissions for source 2, for TP1, B/S condition 1.
26: Emissions for source 3, for TP1, B/S condition 1.
etc.
75: Emissions for source 10, for TP1, B/S condition 1.

Card TP1, B/S condition 2: Format (F5.4,1X,F4.0,10(1X,F6.0)).

Column 1: The fraction of the time that B/S condition 2 for TP1 will occur.
7: Background concentration for TP1, B/S condition 2.
12: Emissions for source 1, for TP1, B/S condition 2.
19: Emissions for source 2, for TP1, B/S condition 2.
etc
75: Emissions for source 10, for TP1, B/S condition 2.

Etcetera for each B/S condition for TP1 up to,

Card TP1, B/S condition NBS: Format (F5.4,1X,F4,0,10(1X,F6.0)).

Column 1: The fraction of the time that B/S condition NBS for TP1 will occur.
7: Background concentration for TP1, B/S condition NBS.
12: Emissions for source 1, for TP1, B/S condition NBS.
etc
75: Emissions for source 10, for TP1, B/S condition NBS.

Card TP2, B/S condition 1: Format (F5.4,1X,F4.0,10(1X,F6.0)).

Column 1: The fraction of the time that B/S condition 1 for TP2 will occur.
7: Background concentration for TP2, B/S condition 1.
12: Emissions for source 1, for TP2, B/S condition 1.
etc
75: Emissions for source 10, for TP2, B/S condition 1.

Etcetera for each B/S condition for TP2 up to,

Card TP2, B/S Condition NBS: Format (F5.4,1X,F4.0,10(1X,F6.0)).

Columnar information defined in same manner as above.

Etcetera for each B/S condition for each time period up to,

Card TP96, B/S condition NBS: Format (F5.4,1X,F4.0,10(1X,F6.0)).

A listing of the computer PROBCO1, its incorporated documentation, and a sample output for a six-lane roadway carrying heavy traffic and with the receptor located 15 meters from the nearest traffic lane follows.

```
      PROGRAM PROBCO1(INPUT,OUTPUT,TAPE4,TAPE5=INPUT,TAPE6=OUTPUT)
C
C
      INTEGER C,CLASS,I,J,K,NBS,NSOURC,TPS
C
      REAL ALFERR,ALPHA,BJ,CA,CONC,DUMMX,DUMMY,DY,EN,ENERR,GAMMA,IA,IA1,
     -IA6,IB,IB1,IB6,INTGRL,KIC,K3,LENGTH,OX,OY,OZ,PCC,PRERR,PROB,
     -PX,QK,SA,SUM,SUV,SV2,SXK1,UIC,VIC,WNDMIN,X,XK1,XK2,X1,X2,Y1,Y2
C
C
      REAL B(12),F(97),FBS(12),INT(10,96,5),K1(96,5),K2(96,5),M(96,5),
     -PC(5),SOURCE(10,12),STATIN(6),Y(7),Z(7)
C
      COMMON X1,Y1,X2,Y2,DX,DY,DZ,ALPHA,GAMMA,LENGTH,CLASS
C
      COMMON /H/ INT,WNDMIN,NSOURC
C
      DATA F/97*0.0/
      DATA WNDMIN/1.0/
C
C     ALFERR   REAL SCALAR -- CALCULATED.
C              = THE MAXIMUM ALPHA INTEGRATION ERROR IN THE EXPECTED
C              NUMBER OF EXCEEDENCES PER YEAR.
C
C     ALPHA    REAL SCALAR -- CALCULATED.
C              = THE WIND DIRECTION MEASURED CCW FROM EAST IN RADIANS.
C              ALPHA IS THE DIRECTION THE WIND IS COMMING FROM.
C
C     B        REAL ARRAY -- DIMENSION 12 -- INPUT.
C              CONTAINS THE BACKGROUND CONCENTRATIONS IN PPM CO,
C              INDEXED BY B/S CONDITION.
C
C     BJ       REAL SCALAR -- CALCULATED.
C              =B(J).
C
C     C        INTEGER SCALAR -- CALCULATED.
C              = STABILITY CLASS INDEX.
C
C     CA       REAL SCALAR -- CALCULATED.
C              = COS(ALPHA).
C
C     CLASS    INTEGER SCALAR -- CALCULATED.
C              = STABILITY CLASS INDEX.
C
C     CONC     REAL SCALAR -- INPUT.
C              = CONCENTRATION IN PPM CO USED TO FIND P(CO .LE. CONC).
C
C     DUMMX    REAL SCALAR -- CALCULATED.
C              A GENERAL PURPOSE DUMMY VARIABLE.
C
C     DUMMY    REAL SCALAR -- CALCULATED.
C              A GENERAL PURPOSE DUMMY VARIABLE.
C
C     DY       REAL SCALAR -- CALCULATED.
C              A GENERAL PURPOSE DUMMY VARIABLE.
C
C
```

```
C       EN        REAL SCALAR -- CALCULATED.
C                 = THE EXPECTED NUMBER OF EXCEEDENCES PER YEAR.
C
C       ENERR     REAL SCALAR -- CALCULATED.
C                 =ERROR BOUND ON EN.
C
C       F         REAL ARRAY -- DIMENSION 97 -- CALCULATED
C                 F(K) = THE VALUE AT ALPHA =K*0.065449847 OF THE
C                 PRODUCT OF THE PROBABILITY DENSITY FUNCTION OF ALPHA
C                 AND THE EXPECTED NUMBER OF EXCEEDENCES PER YEAR GIVEN
C                 ALPHA FOR A STANDARD VALUE OF CONC.
C
C       FBS       REAL ARRAY -- DIMENSION 12 -- INPUT.
C                 THE FREQUENCY OF A B/S CONDITION INDEXED BY B/S CONDITION.
C
C       GAMMA     REAL SCALAR -- CALCULATED.
C                 = ROAD ANGLE MEASURED CCW FROM EAST IN RADIANS.
C
C       I         INTEGER SCALAR -- CALCULATED.
C                 = AN INDEXING VARIABLE.
C
C       IA        REAL SCALAR -- CALCULATED.
C                 A GENERAL PURPOSE DUMMY VARIABLE.
C
C       IA1       REAL SCALAR -- CALCULATED.
C                 = THE EXPECTED NUMBER OF EXCEEDENCES PER YEAR FOUND BY
C                 A COTE#S FIRST ORDER INTEGRATION ON EVERY OTHER ALPHA.
C
C       IA6       REAL SCALAR -- CALCULATED.
C                 SAME AS IA1 BUT USING A COTE#S SIXTH ORDER INTEGRATION.
C
C       IB        REAL SCALAR -- CALCULATED.
C                 A GENERAL PURPOSE DUMMY VARIABLE.
C
C       IB1       REAL SCALAR -- CALCULATED.
C                 SAME AS IA1 BUT USING EVERY ALPHA.
C
C       IB6       REAL SCALAR -- CALCULATED.
C                 SAME AS IB1 BUT USING A COTE#S SIXTH ORDER INTEGRATION.
C
C       INT       REAL ARRAY -- DIMENSION 10,96,5 -- CALCULATED.
C                 = THE GAUSSIAN DISPERSION INTEGRAL IN METERS**-1 INDEXED
C                 BY ROADWAY, ALPHA, AND CLASS.
C
C       INTGRL    REAL SCALAR(FUNCTION) -- CALCULATED.
C                 = THE VALUE IN METERS**-1 OF THE GAUSSIAN DISPERSION
C                 INTEGRAL FOR GIVEN SOURCE LOCATION, RECEPTOR LOCATION,
C                 WIND DIRECTION, AND STABILITY CLASS.
C
C       J,K       INTEGER SCALARS -- CALCULATED.
C                 INDEXING VARIABLES.
C
C       KIC       REAL SCALAR -- CALCULATED.
C                 = A TERM IN THE EXPRESSION FOR F IN (METERS/SECOND)**4.
C
C
C
```

```
C     K1,K2     REAL ARRAYS -- DIMENSIONS 96,5 -- CALCULATED.
C               * TERMS IN THE EXPRESSION FOR F INDEXED BY ALPHA AND CLASS
C               K1 IS IN (METERS/SECOND)**-2,AND K2 IS IN
C               (METERS/SECOND)**-1.
C
C     K3        REAL SCALAR -- CALCULATED.
C               * A DIMENSIONLESS TERM IN THE EXPRESSION FOR F.
C
C     L         INTEGER SCALAR -- CALCULATED.
C               AN INDEXING VARIABLE.
C
C     LENGTH    REAL SCALAR -- CALCULATED.
C               * THE LENGTH IN METERS OF A ROADWAY.
C
C     M         REAL ARRAY -- DIMENSION 96,6,5 -- CALCULATED.
C               * A TERM IN THE EXPRESSION FOR F IN (METERS/SECOND)**-2.
C
C     NBS       INTEGER SCALAR -- INPUT.
C               * THE NUMBER OF BACKGROUND/SOURCE (B/S) CONDITIONS.
C
C     NSOURC    INTEGER SCALAR -- INPUT.
C               * THE NUMBER OF SOURCES (ROADWAYS) USED IN THE ANALYSES.
C
C     OX,OY,OZ  REAL SCALARS -- INPUTS.
C               * THE X, Y, AND Z COORDINATES OF THE RECEPTOR LOCATION
C               IN METERS.
C
C     PC        REAL ARRAY -- DIMENSION 5 -- INPUT.
C               CONTAINS THE PROBABILITY OF A CLASS, INDEXED BY CLASS.
C
C     PCC       REAL SCALAR -- CALCULATED.
C               * PC(C).
C
C     PRERR     REAL SCALAR -- CALCULATED.
C               ERROR BOUND ON PROB.
C
C     PROB      REAL SCALAR -- CALCULATED.
C               * P(CO .GT. CONC TWICE OR MORE IN A YEAR).
C
C     PX        REAL SCALAR -- CALCULATED.
C               A GENERAL PURPOSE DUMMY VARIABLE.
C
C     QK        REAL SCALAR -- CALCULATED.
C               * THE WIND SPEED REQUIRED TO PRODUCE A CONCENTRATION,
C               CONC, AT THE RECEPTOR GIVEN THE RECEPTOR LOCATION, THE
C               SOURCE LOCATIONS AND STRENGTHS, THE BACKGROUND CONCENTRA-
C               TION, THE STABILITY CLASS, AND THE WIND DIRECTION.
C
C     SA        REAL SCALAR -- CALCULATED.
C               * SIN(ALPHA).
C
C     SOURCE    REAL ARRAY -- DIMENSION 10,12 -- INPUT.
C               CONTAINS THE SOURCE STRENGTHS IN MICROGRAMS(CO)/METER-SECOND,
C               INDEXED BY ROADWAY AND B/S CONDITION.
C
C
C
```

```
C      STATIN   REAL ARRAY -- DIMENSION  6 -- INPUT.
C               CONTAINS THE PARAMETERS OF THE METEOROLOGICAL DATA
C               DISTRIBUTION FOR A SINGLE CLASS AND TIME PERIOD.
C
C      SUM      REAL SCALAR -- CALCULATED.
C               = THE SUM OVER K OF F(K).
C
C      SUV      REAL SCALAR -- CALCULATED.
C               THE COVARIANCE IN (METERS/SECOND)**2 OF WIND SPEEDS IN
C               THE X AND Y DIRECTIONS = STATIN(5).
C
C      SU2      REAL SCALAR -- CALCULATED.
C               THE VARIANCE IN (METERS/SECOND)**2 OF THE WIND SPEED IN
C               THE X DIRECTION = STATIN(4).
C
C      SV2      REAL SCALAR -- CALCULATED.
C               THE VARIANCE IN (METERS/SECOND)**2 OF THE WIND SPEED IN
C               THE Y DIRECTION = STATIN(6).
C
C      SXK1     REAL SCALAR -- CALCULATED.
C               = SQRT(K1(K,C)), IN (METERS/SECOND)**-1.
C
C      TPS      INTEGER SCALAR -- CALCULATED.
C               =AN INDEXING VARIABLE.
C
C      UIC      REAL SCALAR -- CALCULATED.
C               THE AVERAGE WIND SPEED IN THE X DIRECTION IN
C               METERS/SECOND = STATIN(2).
C
C      VIC      REAL SCALAR -- CALCULATED.
C               THE AVERAGE WIND SPEED IN THE Y DIRECTION IN
C               METERS/SECOND = STATIN(3).
C
C      WNDMIN   REAL SCALAR -- DATA.
C               THE MINUMUM WIND SPEED, IN METERS/SECOND, TO BE USED IN
C               THE GAUSSIAN DISPERSION FORMULATION.
C
C      X        REAL SCALAR -- CALCULATED.
C               A GENERAL PURPOSE UTILITY VARIABLE.
C
C      XK1      REAL SCALAR -- CALCULATED.
C               = K1(K,C) IN (METERS/SECOND)**-2.
C
C      XK2      REAL SCALAR -- CALCULATED.
C               = K2(K,C) IN (METERS/SECOND)**-1.
C
C      X1,Y1    REAL SCALARS -- INPUTS.
C               THE X AND Y COORDINATES OF THE WEST-MOST END POINT OF A
C               ROADWAY, IN METERS.
C
C      X2,Y2    REAL SCALARS -- INPUTS.
C               THE X AND Y COORDINATES OF THE EAST-MOST END POINT OF A
C               ROADWAY IN METERS.
C
C
C
C
```

```
C
C     Y         REAL ARRAY -- DIMENSION 7 -- CALCULATED.
C               = THE SEVEN COTE#S VARIABLES FOR INTEGRATING F USING
C               EVERY OTHER ALPHA.
C
C     Z         REAL ARRAY -- DIMENSION 7 -- CALCULATED.
C               = THE SEVEN COTE#S VARIABLES FOR INTEGRATING F USING
C               EVERY ALPHA.
C
 5000 FORMAT(4(F6.0,1X))
 5001 FORMAT(I2)
 5002 FORMAT(F2.0)
 5003 FORMAT(F5.4,1X,F4.2,10(1X,6PF6.0))
C
 6000 FORMAT(1H1/#0#,40X,#INPUT DATA LISTING#)
 6001 FORMAT(/#0TP#,I3)
 6002 FORMAT(#1#/#0#,40X,#RESULTS#//#0#,5X,#FOR A STANDARD OF #,F4.1,# P
     +PM#//#0#,10X,#THE AVERAGE NUMBER OF VIOLATIONS PER YEAR IS #,F7.3,
     +# WITH A STANDARD ERROR OF #,F5.3//11X,#THE MAXIMUM PROBABILITY OF
     + TWO OR MORE VIOLATIONS PER YEAR IS #,F6.2,# O/O WITH A STANDARD E
     +RROR OF #,F5.2,# O/O#)
 6400 FORMAT(#0#,5X,#CLASS #,I1,#, STATIN(1 TO 6) = #,I6,5F13.5)
 6500 FORMAT(/#0THE RECEPTOR, OX, OY, OZ = #,2(F6.0,#, #),F6.0)
 6503 FORMAT(#0#,5X,#B/S CONDITION #,I2,F10.3,F6.2,6P10F6.0)
 6550 FORMAT(#0ROADWAY#,I2,#, X1, Y1, X2, Y2 = #,3(F6.0,#, #),F6.0)
 6600 FORMAT(1H1)
C
      WRITE(6,6000)
C
C     READ THE CARTESIAN COORDINATES OF THE RECEPTOR.
C
    1 READ(5,5000) OX,OY,OZ
C
      WRITE(6,6500) OX,OY,OZ
C
C     READ THE NUMBER OF SOURCES (IE ROADWAYS).
C
    2 READ(5,5001) NSOURC
      DO 200 I=1,NSOURC
C
C     FOR EACH ROADWAY READ THE COORDINATES OF ITS END POINTS.
C
      READ(5,5000) X1,Y1,X2,Y2
      IF(X1 .LE. X2) GO TO 170
C
C     IF THE FIRST END POINT IS EAST OF THE SECOND, REVERSE THEM.
C
      DUMMX=X1
      DUMMY=Y1
      X1=X2
      Y1=Y2
      X2=DUMMX
      Y2=DUMMY
C
C     SET GAMMA TO PIE/2.
C
  170 GAMMA=1.5707963
```

```
      WRITE(6,6550) I,X1,Y1,X2,Y2
C
C     DETERMINE GAMMA IF IT IS NOT PIE/2.
C
C
      IF(X1 .NE. X2) GAMMA=ATAN((Y2-Y1)/(X2-X1))
C
C     CALCULATE THE ROADWAY LENGTH.
C
      LENGTH=SQRT((X2-X1)**2+(Y2-Y1)**2)
C
C     FOR EACH ROADWAY, STABILITY CLASS, AND WIND ANGLE, COMPUTE AND
C     STORE THE GAUSSIAN DISPERSION INTEGRAL RELATIVE TO THE RECEPTOR.
C
      ALPHA=-0.065449847
      DO 190 K=1,96
      ALPHA=ALPHA+0.065449847
      DO 180 J=1,5
      CLASS=J
      INT(I,K,CLASS)=INTGRL(7.2220521E-3)
C
C     A TOLERANCE OF +7.2220521E-3 AND -7.2220521E-3 ON INTGRL YIELDS
C     A MAX TOLERANCE OF +1 AND -1 PPM ON THE PREDICTION OF CO
C     CONCENTRATION.
C
  180 CONTINUE
  190 CONTINUE
  200 CONTINUE
C
C     READ THE CONCENTRATION TO BE ANALYZED.
C
      READ(5,5002) CONC
C
C     READ THE NUMBER OF BACKGROUND/SOURCE CONDITIONS.
C
C
      READ(5,5001) NBS
C
      N=20
      DO 600 TPS=1,96
C
C
C     FOR EACH TIME PERIOD READ AND ECHO THE PARAMETERS OF THE
C     METEOROLOGICAL DISTRIBUTION AND THE NBS B/S CONDITIONS.
C
      WRITE(6,6001) TPS
      N=N+3
      IF(N.LT.57) GO TO 210
      WRITE(6,6600)
      N=0
  210 DUMMY=0.0
      DO 300 C=1,5
C
      READ(4) STATIN
      I=STATIN(1)
      IF(I.EQ.0) GO TO 270
      WRITE(6,6400) C,I,(STATIN(J),J=2,6)
```

```
      N=N+2
      IF(N.LT.57) GO TO 270
      WRITE(6,6600)
      N=0
  270 DUMMY=DUMMY+I
      PC(C)=I
      IF(I.EQ.0) GO TO 300
      UIC=STATIN(2)
      VIC=STATIN(3)
      SU2=STATIN(4)
      SUV=STATIN(5)
      SV2=STATIN(6)
C
C     FOR EACH CLASS AND WIND ANGLE, COMPUTE THE COMPONENTS OF
C     THE PROBABILITY FUNCTION F(.).
C
      KIC=SU2*SV2-SUV**2
      K3=(UIC**2*SV2+VIC**2*SU2-2.0*UIC*VIC*SUV)/KIC
      ALPHA=-0.065449847
      DO 280 J=1,96
      ALPHA=ALPHA+0.065449847
      CA=COS(ALPHA)
      SA=SIN(ALPHA)
      K1(J,C)=(CA**2*SV2+SA**2*SU2-2.0*CA*SA*SUV)/KIC
      K2(J,C)=-2.0*(CA*UIC*SV2+SA*VIC*SU2-(CA*VIC+SA*UIC)*SUV)/KIC
      X=0.5*(K2(J,C)**2/(4.0*K1(J,C))-K3)
      M(J,C)=0.0
      IF(X.GT.-32.0) M(J,C)=EXP(X)/(6.2831853*SQRT(KIC))
  280 CONTINUE
  300 CONTINUE
C
C     COMPUTE THE NORMALIZED VALUES OF PC(.) FROM THE ABSOLUTE VALUES.
C     PC(C) IS READ IN AS THE NUMBER OF OCCURANCES OF CLASS C AND
C     DUMMY IS THE SUM OF PC(C) OVER C.
C
      DO 301 C=1,5
      PC(C)=PC(C)/DUMMY
  301 CONTINUE
C
      DO 310 I=1,NBS
C
C     FOR EACH B/S CONDITION, READ THE FREQUENCY OF THE CONDITION,
C     THE BACKGROUND CONCENTRATION FOR THE CONDITION, AND THE NSOURC
C     SOURCE STRENGTHS FOR THE CONDITION.
C
      READ(5,5003) FBS(I),B(I),(SOURCE(J,I),J=1,NSOURC)
      WRITE(6,6503) I,FBS(I),B(I),(SOURCE(J,I),J=1,NSOURC)
      N=N+2
      IF(N.LT.57) GO TO 310
      WRITE(6,6600)
      N=0
  310 CONTINUE
C
C     FIND THE EXPECTED NUMBER OF TIMES CO WILL
C     EXCEED CONC IN THIS TP.
C
      DO 500 C=1,5
```

```
      IF(PC(C).EQ.0) GO TO 500
      DO 480 J=1,NBS
      PX=91.25*PC(C)*FBS(J)
      BJ=B(J)
      IF(BJ .LT. 0.0) BJ=0.0
      DO 470 K=1,96
C
C     IF BJ EXCEEDS CONC THEN CONC WILL BE EXCEEDED WITH PROBABILITY 1.
C
      IF(BJ .GE. CONC) GO TO 450
      XK1=K1(K,C)
      XK2=K2(K,C)
      SXK1=SQRT(XK1)
      DY=XK2/(2.0*SXK1)
      QK=0.0
C
C     FIND THE SUM OF THE SOURCE*INTEGRAL PRODUCTS.
C
      DO 440 L=1,NSOURC
      QK=QK+SOURCE(L,J)*INT(L,K,C)
  440 CONTINUE
C
C     NORMALIZE BY 870/PIE AND (CONC-BJ) TO GET QK IN METERS/SEC.
C
      QK=QK*276.92960/(CONC-BJ)
C
C     IF QK.LE.WNDMIN THEN CONC WILL BE EXCEEDED WITH PROBABILITY 0.
C
      IF(QK .LE. WNDMIN) GO TO 470
      DUMMX=(SXK1*QK+DY)*0.70710678
      DUMMY=DY*0.70710678
      IA=0.0
      IF(ABS(DUMMY) .LT. 8.0) IA=EXP(-DUMMY**2)
      IB=0.0
      IF(ABS(DUMMX) .LT. 8.0) IB=EXP(-DUMMX**2)
      F(K)=F(K)+PX*((H(K,C)/XK1)*((IA-IB)+XK2*0.62665707*
     -(ERF(DUMMY)-ERF(DUMMX))/SXK1))
      GO TO 470
  450 F(K)=F(K)+PX
  470 CONTINUE
      F(97)=F(1)
  480 CONTINUE
  500 CONTINUE
  600 CONTINUE
C
C     DETERMINE THE EXPECTED NUMBER OF TIMES CONC WILL BE EXCEEDED IN
C     A YEAR BY INTEGRATING F(.) OVER ALPHA USING COTES 1ST AND 6TH
C     ORDER NUMERICAL TECHIQUES.
C
      SUM=0.0
      DO 610 I=1,96,2
      SUM=SUM+F(I)
  610 CONTINUE
      IA1=SUM*0.13089969
C
C     0.13089969=(2*PI)/48.
C
```

```
      DO 630 K=1,7
      X=0.0
      DO 620 L=1,8
      X=X+F(2*K+12*L-13)
  620 CONTINUE
      Y(K)=X
  630 CONTINUE
      IA6=9.3499781E-4*(41.0*(Y(1)+Y(7))+216.0*(Y(2)+Y(6))+27.0*(Y(3)+
     -Y(5))+272.0*Y(4))
      DO 640 I=2,96,2
      SUM=SUM+F(I)
  640 CONTINUE
      IB1=SUM*0.65449847E-1
      Z(1)=Y(1)+Y(4)
      Z(3)=Y(2)+Y(5)
      Z(5)=Y(3)+Y(6)
      Z(7)=Y(4)+Y(7)
      DO 660 K=2,6,2
      X=0.0
      DO 650 L=1,16
      X=X+F(K+6*(L-1))
  650 CONTINUE
      Z(K)=X
  660 CONTINUE
      IB6=4.6749891E-4*(41.0*(Z(1)+Z(7))+216.0*(Z(2)+Z(6))+27.0*(Z(3)+
     -Z(5))+272.0*Z(4))
C
C     DETERMINE EN FROM THE ALPHA INTEGRATION WITH THE SMALLEST ERROR
C     USING RICHARDSONS DEFERRED APPROACH TO THE LIMIT.
C
      IF(ABS(IA1-IB1)/3.0 .LT. ABS(IA6-IB6)/255.0) GO TO 670
      EN=IB6+(IB6-IA6)/255.0
      ALFERR=ABS(IB6-IA6)/255.0
      GO TO 680
  670 EN=IB1+(IB1-IA1)/3.0
      ALFERR=ABS(IB1-IA1)/3.0
  680 CONTINUE
C
C     0.03*EN BOUNDS THE STANDARD ERROR IN EN DUE TO THE RANDOM ERRORS
C     INVOLVED IN ESTIMATING THE INDIVIDUAL PROBABILITIES FOR EACH TIME
C     PERIOD OF EXCEEDING CONC.  ALFERR/3 BOUNDS THE STANDARD ERROR IN
C     EN DUE TO THE RANDOM ERROR IN THE NUMERICAL INTEGRATION OVER ALPHA
C     ASSUMING THESE TWO ERRORS ARE INDEPENDENT, THE TOTAL VARIANCE OF
C     ESTIMATE OF EN WILL BE THE SUM OF THE TWO ERROR VARIANCES, AND THE
C     STANDARD ERROR OF THE ESTIMATE WILL BE GIVEN BY ENERR.
C
      ENERR=SQRT((0.03*EN)**2+(ALFERR/3)**2)
C
C     CALCULATE PROBABILITY OF EXCEEDING CONC MORE THAN ONCE PER YEAR
C     AND PRERR=(D(P)/D(EN))*ENERR.
C
      IF(EN.GE.1) GO TO 700
C
C     IF EN IS VERY SMALL NUMBER, THE EQUATIONS FOR PROB AND PRERR WILL
C     BECOME UNSTABLE.
C
      IF(EN.LT.10E-6) GO TO 750
```

```
      X=1-SQRT(1-EN)
      PROB=1-2*X*EXP(-X)/EN
      PRERR=(ENERR*2*X*EXP(-X)/EN)*(1/EN+(1-X)/2-(1-X)/(2*X))
      GO TO 800
  700 PROB=1-EXP(-EN)*(1+EN)
      PRERR=ENERR*EN*EXP(-EN)
      GO TO 800
  750 PROB=0.0
      PRERR=0.0
  800 PROB=100*PROB
      PRERR=100*PRERR
      WRITE(6,6002) CONC,EN,ENERR,PROB,PRERR
  999 STOP
      END
```

42000B CM STORAGE USED 2.511 SECONDS

```
      REAL FUNCTION INTGRL(TOLER)
C
C     INTGRL COMPUTES THE GAUSSIAN DISPERSION INTEGRAL RELATIVE TO A
C     RECEPTOR AT (OX,OY,OZ) FOR A GROUND LEVEL LINE SOURCE RUNNING FROM
C     (RX1,RY1) TO (RX2,RY2) GIVEN THE WIND ANGLE AND THE STABILITY
C     CLASS. NOTE THAT (EXCEPT FOR THE DESIRED TOLERANCE) THE PARAMETERS
C     OF INTGRL ARE PASSED THROUGH BLANK COMMON TO SPEED EXECUTION.
C
C
      LOGICAL FIRST
C
      INTEGER CLASS,ID,IR,IRO,JR,KR
C
C
      REAL AHC,ALPHA,BHC,CA,CAG,CG,COTES1,DA,DB,DIST,DISTR,DLSTAR,DR,
     -DSTAR,DUMMY,ER,FR,FREXP,FRO,FR1,FR2,GAMMA,HC,INTGRX,L,LAST,LAST1,
     -OX,OY,OZ,P,PR,R,RA,RB,RO,RSTAR,RX,RX1,RX2,RY1,RY2,R1,R2,SA,SAG,SG,
     -SIGMAH,SIGMAV,STEP,STEP2,STEP3,SUM,TOLER,TOLER1,TOLER2,TOLER3,
     -VC,ZR
C
      INTEGER INDEX(101)
C
      REAL AH(6),AV(9,6),BH(6),BV(9,6),HOFSET(6),VOFSET(6),Y(7),Z(7)
C
      COMMON RX1,RY1,RX2,RY2,OX,OY,OZ,ALPHA,GAMMA,L,CLASS
C
C
C     AH         REAL ARRAY -- DIMENSION 6 -- CONSTANT.
C                CONTAINS THE LOG-LOG INTERCEPTS IN METERS FOR THE
C                HORIZONTAL DISPERSION PARAMETER, INDEXED BY CLASS.
C
C     AHC        REAL SCALAR -- CALCULATED.
C                = AH(C), IN METERS.
C
C     ALPHA      REAL SCALAR -- PARAMETER/COMMON.
C                = THE WIND DIRECTION MEASURED CCW IN RADIANS FROM EAST.
C                ALPHA IS THE DIRECTION THE WIND IS COMMING FROM.
C
C     AV         REAL ARRAY -- DIMENSION 9,6 -- CONSTANT.
C        .       CONTAINS THE LOG-LOG INTERCEPTS IN METERS FOR THE
C                VERTICLE DISPERSION PARAMETER INDEXED BY DIST AND CLASS.
C
C     BH         REAL ARRAY -- DIMENSION 6 -- CONSTANT.
C                CONTAINS THE LOG-LOG SLOPES FOR THE HORIZONTAL DISPERSION
C                PARAMETER, INDEXED BY CLASS.
C
C     BHC        REAL SCALAR -- CALCULATED.
C                = BH(C).
C
C     BV         REAL ARRAY -- DIMENSION 9,6 -- CONSTANT.
C                CONTAINS THE LOG-LOG SLOPES FOR THE VERTICLE DISPERSION
C                PARAMETER INDEXED BY DIST AND CLASS.
C
C     CA         REAL SCALAR -- CALCULATED.
C                = COS(ALPHA).
C
C
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C     CAG       REAL SCALAR -- CALCULATED.
C               = COS(ALPHA-GAMMA).
C
C     CG        REAL SCALAR -- CALCULATED.
C               = COS(GAMMA).
C
C     CLASS     INTEGER SCALAR -- PARAMETER/COMMON.
C               = ATMOSPHERIC STABILITY CLASS.
C
C     COTES1    REAL SCALAR -- CALCULATED.
C               = THE TEMPORARY INTEGRAL OVER EITHER R1 TO RO OR RO TO R2
C               COMPUTED FROM COTE#S METHOD OF ORDER 1 IN METERS**-1.
C
C     DA        REAL SCALAR -- CALCULATED.
C               = THE DERIVATIVE OF F AT RA, WHERE F IS THE GAUSSIAN
C               INTEGRAND.
C
C     DB        REAL SCALAR -- CALCULATED.
C               = THE DERIVATIVE OF F AT RB.
C
C     DIST(R)   REAL SCALAR (STATEMENT FUNCTION) -- CALCULATED.
C               = THE DISTANCE MEASURED ALONG THE WIND VECTOR IN METERS
C               FROM THE RECEPTOR TO THE ROADWAY POINT R.
C
C     DISTR     REAL SCALAR -- CALCULATED.
C               = DIST(R), IN METERS.
C
C     DLSTAR    REAL SCALAR -- CALCULATED.
C               = DIST(L), IN METERS.
C
C     DR        REAL SCALAR -- CALCULATED.
C               = THE DERIVATIVE OF F AT R.
C
C     DSTAR     REAL SCALAR -- CALCULATED.
C               = DIST(O), IN METERS.
C
C     DUMMY     REAL SCALAR -- CALCULATED.
C               A TEMPORARY STORAGE VARIABLE.
C
C     ER        REAL SCALAR -- CALCULATED.
C               = THE APPROXIMATE AREA UNDER F(R) FROM R TO AN END POINT.
C
C     FIRST     LOGICAL SCALAR -- CALCULATED.
C               = .TRUE. WHEN SUBPROGRAM IS INTEGRATING OVER THE FIRST
C               HALF OF THE INTERVAL (R1,R2), IE OVER THE INTERVAL
C               (R1,RO).
C
C     FR        REAL SCALAR -- CALCULATED.
C               = F(R), IN METERS.
C
C     FREXP     REAL SCALAR -- CALCULATED.
C               = THE EXPONENT OF THE EXPONENTIAL PART OF F(R).
C
C     FRO       REAL SCALAR -- CALCULATED.
C               = F(RO), IN METERS.
C
C
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C      FR1       REAL SCALAR -- CALCULATED.
C                * F(R1), IN METERS.
C
C      FR2       REAL SCALAR -- CALCULATED.
C                * F(R2), IN METERS.
C
C      GAMMA     REAL SCALAR -- PARAMETER/COMMON.
C                * THE ROAD ANGLE MEASURED CCW IN RADIANS FROM EAST.
C
C      HC        REAL SCALAR -- CALCULATED.
C                * HOFSET(CLASS), IN METERS.
C
C      HOFSET    REAL ARRAY -- DIMENSION 6 -- CONSTANT.
C                CONTAINS THE OFFSET DISTANCES IN METERS FOR THE
C                HORIZONTAL DISPERSION PARAMETER, INDEXED BY CLASS.
C
C      ID        INTEGER SCALAR -- CALCULATED.
C                * INDEX(MIN1(101.0,(DISTRO+VC)/100.0+1.0)).
C
C      INDEX     INTEGER ARRAY -- DIMENSION 101 -- CONSTANT.
C                CONTAINS THE INDICES FOR THE FIRST SUBSCRIPT IN AV AND BV
C                INDEXED BY DIST.
C
C      INTGRX    REAL SCALAR -- CALCULATED.
C                * THE TEMPORARY VALUE OF EITHER THE INTEGRAL FROM R1 TO
C                RO OR THE INTEGRAL FROM RO TO R2, IN METERS**-1.
C
C      IR        INTEGER SCALAR -- CALCULATED.
C                * THE COUNT OF THE NUMBER OF BISECTIONS USED TO REFINE AN
C                INTEGRATION END POINT, AND
C                * THE COUNT (IN POWERS OF TWO) OF THE NUMBER OF COTE#S
C                INTERVALS USED TO DO AN INTEGRATION.
C
C      IRO       INTEGER SCALAR -- CALCULATED.
C                * THE COUNT OF THE NUMBER OF BISECTIONS USED TO FIND RO.
C
C      JR        INTEGER SCALAR -- CALCULATED.
C                * THE LOOP STARTING POINT FOR CALCULATING THE NEXT GROUP
C                OF ELEMENTS OF Y.
C
C      KR        INTEGER SCALAR -- CALCULATED.
C                * THE LOOP INCREMENT FOR CALCULATING THE NEXT GROUP OF
C                ELEMENTS OF Y.
C
C      L         REAL SCALAR -- PARAMETER/COMMON.
C                * THE ROADWAY LENGTH, IN METERS.
C
C      LAST      REAL SCALAR -- CALCULATED.
C                * THE PREVIOUS VALUE OF INTGRX IN THE ITERATION OF THE
C                COTE#S INTEGRATION.
C
C      LAST1     REAL SCALAR -- CALCULATED.
C                * THE PREVIOUS VALUE OF COTES1 IN THE ITERATION OF THE
C                COTE#S FIRST ORDER INTEGRATION.
C
C
C
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C     UX,UY,UZ REAL SCALARS -- PARAMETERS/COMMON.
C              * THE X, Y, AND Z COORDINATES OF THE RECEPTOR LOCATION,
C              IN METERS.
C
C     P(R)     REAL SCALAR (STATEMENT FUNCTION) -- CALCULATED.
C              * THE DISTANCE MEASURED PERPENDICULAR TO THE WIND VECTOR
C              IN METERS FROM THE RECEPTOR TO THE WIND VECTOR THROUGH
C              THE ROADWAY POINT R.
C
C     PR       REAL SCALAR -- CALCULATED.
C              * P(R), IN METERS.
C
C     R        REAL SCALAR -- CALCULATED.
C              * THE DISTANCE IN METERS FROM (RX1,RY1) AS MEASURED
C              ALONG THE ROADWAY.
C
C     RA,RB    REAL SCALARS -- CALCULATED.
C              * THE LEFT AND RIGHT-HAND END POINTS IN THE SEVERAL
C              BISECTION TECHNIQUES AND INTEGRATIONS USED, MEASURED
C              ALONG THE ROADWAY FROM (RX1,RY1) IN METERS.
C
C     RO       REAL SCALAR -- CALCULATED.
C              * THE DISTANCE MEASURED ALONG THE ROADWAY IN METERS FROM
C              (RX1,RY1) TO THE POINT WHERE F(R) REACHES ITS MAXIMUM.
C
C     RSTAR    REAL SCALAR -- CALCULATED.
C              * THE DISTANCE MEASURED ALONG THE ROADWAY IN METERS
C              FROM (RX1,RY1), TO THE POINT WHERE DIST(R) = 0.
C
C     RX       REAL SCALAR -- CALCULATED.
C              * EITHER R1 OR R2 DEPENDING ON WHETHER WE ARE DOING A
C              COTE#S INTEGRATION ON (R1,RO) OR (RO,R2).
C
C     RX1,RY1  REAL SCALARS -- PARAMETERS/COMMON.
C              * THE X AND Y COORDINATES OF THE WEST-MOST ROADWAY END
C              POINT, IN METERS.
C
C     RX2,RY2  REAL SCALARS -- PARAMETERS/COMMON.
C              * THE X AND Y COORDINATES OF THE EAST-MOST ROADWAY END
C              POINT, IN METERS.
C
C     R1       REAL SCALAR -- CALCULATED.
C              * THE DISTANCE MEASURED ALONG THE ROADWAY IN METERS
C              FROM (RX1,RY1) TO THE LEFT-HAND END POINT OF THE
C              INTEGRATION INTERVAL.
C
C     R2       REAL SCALAR -- CALCULATED.
C              * THE DISTANCE MEASURED ALONG THE ROADWAY IN METERS FROM
C              (RX1,RY1) TO THE RIGHT-HAND END POINT OF THE INTEGRATION
C              INTERVAL.
C
C     SA       REAL SCALAR -- CALCULATED.
C              * SIN(ALPHA).
C
C     SAG      REAL SCALAR -- CALCULATED.
C              * SIN(ALPHA-GAMMA).
C
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C      SG       REAL SCALAR -- CALCULATED.
C               * SIN(GAMMA).
C
C      SIGMAH   REAL SCALAR -- CALCULATED.
C               * THE HORIZONTAL DISPERSION PARAMETER, IN METERS.
C
C      SIGMAV   REAL SCALAR -- CALCULATED.
C               * THE VERTICLE DISPERSION PARAMETER IN METERS.
C
C      STEP     REAL SCALAR -- CALCULATED.
C               * THE STEP SIZE USED IN THE COTE*S INTEGRATION.
C
C      STEP2    REAL SCALAR -- CALCULATED.
C               * STEP/2.0.
C
C      STEP3    REAL SCALAR -- CALCULATED.
C               * STEP*3.
C
C      SUM      REAL SCALAR -- CALCULATED.
C               * (APPROXIMATELY) THE SUM OF THE INTEGRAND VALUES USED TO
C               DETERMINE COTES1.
C
C      TOLER    REAL SCALAR -- PARAMETER.
C               * THE DESIRED PRECISION OF THE VALUE RETURNED BY INTGRL.
C
C      TOLER1   REAL SCALAR -- CALCULATED.
C               * LN(TOLER).
C
C      TOLER2   REAL SCALAR -- CALCULATED.
C               * TOLER/2.
C
C      TOLER3   REAL SCALAR -- CALCULATED.
C               * (APPROXIMATELY) LN(TOLER/2/1500) WHICH REPRESENTS THE
C               LN OF THAT ERROR WHICH COULD BE TOLERATED IN THE
C               INTEGRAND OVER AN INTERVAL OF 1500 METERS AND STILL
C               YEILD AN INTEGRATION ERROR .LT. TOLER/2.
C
C      VC       REAL SCALAR -- CALCULATED.
C               * VOFSET(CLASS), IN METERS.
C
C      VOFSET   REAL ARRAY -- DIMENSION 6 -- CONSTANT.
C               CONTAINS THE OFFSET DISTANCES IN METERS FOR THE VERTICLE
C               DISPERSION PARAMETER, INDEXED BY CLASS.
C
C      Y        REAL ARRAY -- DIMENSION 7 -- CALCULATED.
C               * THE SEVEN COTE*S VARIABLES USED IN THE INTEGRATION.
C
C      Z        REAL ARRAY -- DIMENSION 7 -- CONSTANT.
C               CONTAINS THE SEVEN COTE*S CONSTANTS.
C
C      ZR       REAL SCALAR -- CALCULATED.
C               * THE LENGTH IN METERS OF A COTE*S INTEGRATION SUB
C               INTERVAL DIVIDED BY 840.
C
C
       DATA AH /0.4998,0.3399,0.2001,0.1137,0.09524,0.06387/
C
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```
      DATA AV /0.1161,0.04661,0.01164,6*0.0001818,3*0.1301,6*0.05566,
     -9*0.1103,3*0.08671,2*0.1646,4*0.4533,2*0.07748,3*0.1375,2*0.3038,
     -2*0.8287,4*0.05943,0.1060,0.1859,2*0.5836,1.5252/
C
      DATA BH /0.8679,0.8760,0.8961,0.9251,0.9011,0.9000/
C
      DATA BV /1.0401,1.2155,1.4587,6*2.1280,3*0.9596,6*1.0962,9*0.9119,
     -3*0.8647,2*0.7614,4*0.6149,2*0.8299,3*0.7293,2*0.6146,2*0.4936,
     -4*0.7976,0.7042,0.6256,2*0.4751,0.3708/
C
      DATA HOFSET /7.8848,12.0129,20.5217,34.3906,45.9989,72.0415/
C
      DATA INDEX /2*1,2,2*3,4,4*5,10*6,20*7,60*8,9/
C
      DATA VOFSET /11.5155,12.7796,17.4995,27.0231,35.5362,57.2639/
C
      DATA Z /41.0,216.0,27.0,272.0,27.0,216.0,41.0/
C
C
C     STATEMENT FUNCTIONS P(R) AND DIST(R) ARE DEFINED AS FOLLOWS.
C
      P(R)=R*SAG+SA*(RX1-DX)-CA*(RY1-DY)
      DIST(R)=R*CAG+CA*(RX1-DX)+SA*(RY1-DY)
C
C     INITIALIZE INTGRL, SET UP VARIOUS TOLERANCE LIMITS BASED ON TOLER,
C     AND ASSIGN FREQUENTLY USED ARRAY ELEMENTS AND FUNCTION CALLS TO
C     SCALARS TO SPEED EXECUTION.
C
      INTGRL=0.0
      TOLER1=ALOG(TOLER)
      TOLER2=TOLER/2.0
      TOLER3=TOLER1-8.0
      VC=VOFSET(CLASS)
      HC=HOFSET(CLASS)
      AHC=AH(CLASS)
      BHC=BH(CLASS)
      CA=COS(ALPHA)
      SA=SIN(ALPHA)
      CG=COS(GAMMA)
      SG=SIN(GAMMA)
      CAG=COS(ALPHA-GAMMA)
      SAG=SIN(ALPHA-GAMMA)
C
C     RSTAR IS THE R AT WHICH DIST(R) = 0.
C
C
C     INITIALIZE RSTAR TO A LARGE VALUE.
C
      RSTAR=1.0E70
      IF(CAG .NE. 0.0) RSTAR=(CA*(DX-RX1)+SA*(DY-RY1))/CAG
C
C     WE WISH TO INTEGRATE OVER ALL R SUCH THAT DIST(R) .GE. 0, TO DO
C     THIS WE FIND R1 AND R2, THE POINTS BETWEEN WHICH DIST(R) .GE. 0.
C
      IF(RSTAR .LT. 0.0) GO TO 20
      IF(RSTAR .EQ. 0.0) GO TO 30
C
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C     DSTAR IS THE VALUE OF DIST(0).
C
      DSTAR=-RSTAR*CAG
      IF(DSTAR .LT. 0.0) GO TO 10
C
C     IF RSTAR .GT. 0 AND DSTAR .GE. 0, R1 = 0 AND R2 = MIN(RSTAR,L).
C
      R1=0.0
      R2=AMIN1(RSTAR,L)
      GO TO 40
C
C     IF RSTAR .GT. 0 AND DSTAR .LT. 0, R1 = RSTAR AND R2 = L.
C
 10   R1=RSTAR
      R2=L
C
C     R1 .GE. R2 IMPLIES THAT THE INTERVAL OVER WHICH DIST(R) .GE. 0 IS
C     NOT CONTAINED WITHIN THE ROADWAY LENGTH.  THUS THE INTEGRAL = 0.
C
      IF(R1 .GE. R2) RETURN
      GO TO 40
C
C     DSTAR IS THE VALUE OF DIST(0).
C
 20   DSTAR=-RSTAR*CAG
C
C     RSTAR .LT. 0 AND DSTAR .LT. 0 IMPLIES THAT THE INTERVAL OVER WHICH
C     DIST(R) .GE. 0 IS NOT CONTAINED WITHIN THE ROADWAY LENGTH.  THUS
C     THE INTEGRAL = 0.
C
      IF(DSTAR .LT. 0.0) RETURN
C
C     IF RSTAR .LT. 0 AND DSTAR .GE. 0, R1 = 0 AND R2 = L.
C
      R1=0.0
      R2=L
      GO TO 40
C
C     DLSTAR IS THE VALUE OF DIST(L).
C
 30   DLSTAR=L*CAG+CA*(RX1-OX)+SA*(RY1-OY)
C
C     RSTAR .EQ. 0 AND DLSTAR .LT. 0 IMPLIES THAT THE INTERVAL OVER
C     WHICH DIST(R) .GE. 0 IS NOT CONTAINED WITHIN THE ROADWAY LENGTH.
C     THUS THE INTEGRAL = 0.
C
      IF(DLSTAR .LT. 0.0) RETURN
C
C     IF RSTAR .EQ. 0 AND DLSTAR .GE. 0, R1 = 0 AND R2 = L.
C
      R1=0.0
      R2=L
C
C     FIND R0, THE R SUCH THAT THE DERIVATIVE OF F(R) = 0.
C
C
C
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```
C     FIND DA, THE DERIVATIVE OF F AT R1.
C
   40 PR=P(R1)
      DISTR=DIST(R1)
      ID=INDEX(MIN1(101.0,(DISTR+VC)/100.0+1.0))
      SIGMAH=AHC*(DISTR+HC)**BHC
      SIGMAV=AV(ID,CLASS)*(DISTR+VC)**BV(ID,CLASS)
      DA=(-PR*SAG/SIGMAH**2)+(((PR/SIGMAH)**2-1.0)*(BHC/(DISTR+HC))+
     -((UZ/SIGMAV)**2-1.0)*(BV(ID,CLASS)/(DISTR+VC)))*CAG
C
C     IF DA .EQ. 0, WE HAVE FOUND RO.
C
      IF(DA .EQ. 0.0) GO TO 110
C
C     FIND DB, THE DERIVATIVE OF F AT R2.
C
      PR=P(R2)
      DISTR=DIST(R2)
      ID=INDEX(MIN1(101.0,(DISTR+VC)/100.0+1.0))
      SIGMAH=AHC*(DISTR+HC)**BHC
      SIGMAV=AV(ID,CLASS)*(DISTR+VC)**BV(ID,CLASS)
      DB=(-PR*SAG/SIGMAH**2)+(((PR/SIGMAH)**2-1.0)*(BHC/(DISTR+HC))+
     -((UZ/SIGMAV)**2-1.0)*(BV(ID,CLASS)/(DISTR+VC)))*CAG
C
C     IF DB .EQ. 0, WE HAVE FOUND RO.
C
      IF(DB .EQ. 0.0) GO TO 110
C
C     STARTING WITH THE ROADWAY END POINTS AND ROADWAY POINT CLOSEST TO
C     THE RECEPTOR, USE THE BISECTION TECHNIQUE (THE DERIVATIVE OF F
C     CHANGES SIGN ONLY AT RO) TO LOCATE RO.
C
      RA=R1
      RB=R2
C
C     THIS VALUE OF RO IS THE ROAD POINT CLOSSEST TO THE OBSERVER
C
      RO=CA*(RY1-OY)-SA*(RX1-OX)
      IF(RO .LE. RA .OR. RO .GE. RB) RO=(RA+RB)/2.0
C
C     IRO IS A COUNTER.  WE WILL PERFORM A MAXIMUM OF 20 BISECTIONS TO
C     LOCATE RO.
C
      IRO=1
C
C     IF THE INTERVAL CONTAINING RO IS STILL LARGE, AND WE HAVE NOT YET
C     DONE 20 BISECTIONS, WE CONTINUE THE BISECTION PROCESS.
C
   50 IF((RB-RA) .LT. 1.0 .OR. IRO .GT. 20) GO TO 110
      IRO=IRO+1
      PR=P(RO)
      DISTR=DIST(RO)
      ID=INDEX(MIN1(101.0,(DISTR+VC)/100.0+1.0))
      SIGMAH=AHC*(DISTR+HC)**BHC
      SIGMAV=AV(ID,CLASS)*(DISTR+VC)**BV(ID,CLASS)
      DR=(-PR*SAG/SIGMAH**2)+(((PR/SIGMAH)**2-1.0)*(BHC/(DISTR+HC))+
     -((UZ/SIGMAV)**2-1.0)*(BV(ID,CLASS)/(DISTR+VC)))*CAG
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      IF(DR .EQ. 0.0) GO TO 110
      IF(SIGN(1.0,DA) .NE. SIGN(1.0,DR)) GO TO 60
C
C     SIGN(DA) .EQ. SIGN(DR) IMPLIES THAT RO LIES BETWEEN RO AND RB.
C     THUS WE SET RA TO RO AND BISECT TO OBTAIN THE NEXT RO.
C
      DA=DR
      RA=RO
      RO=(RA+RB)/2.0
      GO TO 50
C
C     SIGN(DA) .NE. SIGN(DR) IMPLIES THAT RO LIES BETWEEN RA AND RO.
C     THUS WE SET RB TO RO AND BISECT TO OBTAIN THE NEXT RO.
C
   60 DB=DR
      RB=RO
      RO=(RA+RB)/2.0
      GO TO 50
C
C     RO HAS BEEN FOUND.
C
  110 DISTR=DIST(RO)
      ID=INDEX(MIN1(101.0,(DISTR+VC)/100.0+1.0))
      SIGMAH=AHC*(DISTR+HC)**BHC
      SIGMAV=AV(ID,CLASS)*(DISTR+VC)**BV(ID,CLASS)
      FREXP=-0.5*((P(RO)/SIGMAH)**2+(DZ/SIGMAV)**2)
C
C     SINCE THE INTEGRAL .LT. F(RO)*(R2-R1) (THAT IS .LT. THE PEAK
C     INTEGRAND VALUE TIMES THE LENGTH OF THE INTEGRATION INTERVAL), AND
C     WE ONLY DESIRE AN ACCURACY OF TOLER, WE MAY RETURN IF THE LN OF
C     THIS UPPER LIMIT IS .LT. TOLER1 = LN(TOLER).
C
      IF(FREXP+ALOG((R2-R1)/(SIGMAH*SIGMAV)) .LT. TOLER1) RETURN
      FRO=EXP(FREXP)/(SIGMAH*SIGMAV)
C
C     SINCE INTEGRATING FROM R1 TO R2 WILL GENERALLY BE QUITE EXPENSIVE
C     DUE TO THE LENGTH OF THE INTERVAL (R1,R2), AND SINCE THE NATURE
C     OF F IS SUCH THAT IT DECAYS EXPONENTIALLY AWAY FROM RO, IT IS
C     WORTH SHORTENING THE INTERVAL (R1,R2) AS MUCH AS POSSIBLE WITHOUT
C     CAUSING AN ERROR IN THE INTEGRATION OF MORE THAN TOLER/2.  THIS
C     PROCESS ALSO ELIMINATES THE POSSIBILITY OF EXPONENTIAL UNDERFLOW
C     OCCURRING WHEN TRYING TO EVALUATE THE INTEGRAND AT LARGE DISTANCES
C     FROM RO.
C
C     USE THE BISECTION TECHNIQUE (WITH A MAXIMUM OF 15 TRIALS) STARTING
C     WITH THE POINTS RX (RX IS FIRST R1 AND THEN R2) AND RO TO FIND A
C     NEW RX SUCH THAT THE ELIMINATED PORTION OF THE INTEGRAL WILL BE
C     BOUNDED BY AN AREA .LT. TOLER/2.
C
C
C     REFINE R1 TO ELIMINATE UNDERFLOW AND INCREASE EFFICIENCY.
C
      RX=R1
      RA=RO
      DISTR=DIST(R1)
      ID=INDEX(MIN1(101.0,(DISTR+VC)/100.0+1.0))
      SIGMAH=AHC*(DISTR+HC)**BHC
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      SIGMAV=AV(ID,CLASS)*(DISTR+VC)**BV(ID,CLASS)
      FR1=0.0
      ER=-0.5*((P(R1)/SIGMAH)**2+(DZ/SIGMAV)**2)
      IF(ER .GT. TOLER3) FR1=EXP(ER)/(SIGMAH*SIGMAV)
      IR=0
  121 R=(RA+R1)/2.0
      IR=IR+1
      DISTR=DIST(R)
      ID=INDEX(MIN1(101.0,(DISTR+VC)/100.0+1.0))
      SIGMAH=AHC*(DISTR+HC)**BHC
      SIGMAV=AV(ID,CLASS)*(DISTR+VC)**BV(ID,CLASS)
      FR=0.0
      ER=-0.5*((P(R)/SIGMAH)**2+(DZ/SIGMAV)**2)
      IF(ER .GT. TOLER3) FR=EXP(ER)/(SIGMAH*SIGMAV)
      ER=(FR1+FR)*(R-RX)/2.0
      IF(ER .LE. TOLER2) R1=R
      IF(ER .GT. TOLER2) RA=R
      IF(IR .GE. 15 .OR. ABS(RA-R1) .LT. 1.0) GO TO 140
      GO TO 121
C
C     COMPUTE F AT THE NEW VALUE OF R1.
C
  140 FR=FR1
      DISTR=DIST(R1)
      ID=INDEX(MIN1(101.0,(DISTR+VC)/100.0+1.0))
      SIGMAH=AHC*(DISTR+HC)**BHC
      SIGMAV=AV(ID,CLASS)*(DISTR+VC)**BV(ID,CLASS)
      FR1=EXP(-0.5*((P(R1)/SIGMAH)**2+(DZ/SIGMAV)**2))/(SIGMAH*SIGMAV)
C
C     REFINE R2 TO ELIMINATE UNDERFLOW AND IMPROVE EFFICIENCY.
C
      RX=R2
      RA=RD
      DISTR=DIST(R2)
      ID=INDEX(MIN1(101.0,(DISTR+VC)/100.0+1.0))
      SIGMAH=AHC*(DISTR+HC)**BHC
      SIGMAV=AV(ID,CLASS)*(DISTR+VC)**BV(ID,CLASS)
      FR2=0.0
      ER=-0.5*((P(R2)/SIGMAH)**2+(DZ/SIGMAV)**2)
      IF(ER .GT. TOLER3) FR2=EXP(ER)/(SIGMAH*SIGMAV)
      IR=0
  151 R=(RA+R2)/2.0
      IR=IR+1
      DISTR=DIST(R)
      ID=INDEX(MIN1(101.0,(DISTR+VC)/100.0+1.0))
      SIGMAH=AHC*(DISTR+HC)**BHC
      SIGMAV=AV(ID,CLASS)*(DISTR+VC)**BV(ID,CLASS)
      FR=0.0
      ER=-0.5*((P(R)/SIGMAH)**2+(DZ/SIGMAV)**2)
      IF(ER .GT. TOLER3) FR=EXP(ER)/(SIGMAH*SIGMAV)
      ER=(FR2+FR)*(RX-R)/2.0
      IF(ER .LE. TOLER2) R2=R
      IF(ER .GT. TOLER2) RA=R
      IF(IR .GE. 15 .OR. ABS(RA-R2) .LT. 1.0) GO TO 160
      GO TO 151
C
C
```

```
      C     COMPUTE F AT THE NEW VALUE OF R2.
      C
       160  FR=FR2
            DISTR=DIST(R2)
            ID=INDEX(MIN1(101.0,(DISTR+VC)/100.0+1.0))
            SIGMAH=AHC*(DISTR+HC)**BHC
            SIGMAV=AV(ID,CLASS)*(DISTR+VC)**BV(ID,CLASS)
            FR1=EXP(-0.5*((P(R2)/SIGMAH)**2+(DZ/SIGMAV)**2))/(SIGMAH*SIGMAV)
      C
            INTGRL=0.5*((RO-R1)*(FRO+FR1)+(R2-RO)*(FR2+FRO))
      C
      C     SINCE THE INTEGRAL IS .LT. THIS VALUE OF INTGRL, WE MAY RETURN IF
      C     INTGRL IS .LT. TOLER.
      C
            IF(INTGRL .LT. TOLER) RETURN
      C
      C     INTEGRATE F(R) FROM RA TO RB.  NOTE THAT F(R) IS INTEGRATED AS THE
      C     SUM OF THE INTEGRAL FROM R1 TO RO AND THE INTEGRAL FROM RO TO R2.
      C
            INTGRL=0.0
            RA=R1
            RB=RO
            FR=FR1
            FIRST=.TRUE.
      C
      C     SET UP VARIABLES FOR COTE#S INTEGRATION (FIRST AND SIXTH ORDERS.)
      C     DO NOT INTEGRATE IF THE UPPER BOUND OF THE INTEGRAL OVER THIS
      C     INTERVAL IS .LT. TOLER2 = TOLER/2.
      C
       170  INTGRX=0.5*(RB-RA)*(FRO+FR)
            IF(INTGRX .LT. TOLER2) GO TO 221
            ZR=ABS(RB-RA)/840.0
            IR=3
            LAST=0.0
            SUM=0.0
            STEP=(RB-RA)/6.0
            STEP3=STEP*3.0
            R=RA-STEP
            DO 180 JR=1,7
            R=R+STEP
            DISTR=DIST(R)
            ID=INDEX(MIN1(101.0,(DISTR+VC)/100.0+1.0))
            SIGMAH=AHC*(DISTR+HC)**BHC
            SIGMAV=AV(ID,CLASS)*(DISTR+VC)**BV(ID,CLASS)
            FR=EXP(-0.5*((P(R)/SIGMAH)**2+(DZ/SIGMAV)**2))/(SIGMAH*SIGMAV)
            LAST=LAST+FR*Z(JR)
            Y(JR)=FR
            IF(JR .EQ. 1 .OR. JR .EQ. 7) FR=FR/2.0
            SUM=SUM+FR
       180  CONTINUE
            LAST=LAST*ZR
            LAST1=SUM*ZR*140.0
      C
      C     REPEAT COTE#S INTEGRATION UNTIL DESIRED ACCURACY.
      C
      C
      C     GENERATE NEXT SET OF COTE#S VARIABLES.
```

```
  190 STEP2=STEP/2.0
      DUMMY=Y(4)
      Y(1)=Y(1)+DUMMY
      Y(7)=Y(7)+DUMMY
      DUMMY=Y(3)
      Y(3)=Y(2)+Y(5)
      Y(5)=Y(6)+DUMMY
      IR=IR+2
      DO 201 KR=1,3
      R=RA+STEP2-STEP*KR
      DUMMY=0.0
      DO 200 JR=KR,IR,3
      R=R+STEP3
      DISTR=DIST(R)
      ID=INDEX(MIN1(101.0,(DISTR+VC)/100.0+1.0))
      SIGMAH=AHC*(DISTR+HC)**BHC
      SIGMAV=AV(ID,CLASS)*(DISTR+VC)**BV(ID,CLASS)
      FR=EXP(-0.5*((P(R)/SIGMAH)**2+(DZ/SIGMAV)**2))/(SIGMAH*SIGMAV)
      DUMMY=DUMMY+FR
      SUM=SUM+FR
  200 CONTINUE
      Y(2*KR)=DUMMY
  201 CONTINUE
      ZR=ZR/2.0
      INTGRX=ZR*(Z(1)*(Y(1)+Y(7))+Z(2)*(Y(2)+Y(6))+Z(3)*(Y(3)+Y(5))+
     -Z(4)*Y(4))
C
C     TEST THE COTE*S SIXTH ORDER INTEGRAL FOR CONVERGENCE.  IF IT FAILS
C     TEST THE FIRST ORDER INTEGRAL. NOTE THAT FOR ASYMPTOTIC INTEGRANDS
C     THE LOWER ORDER COTE*S FORMULAS ARE OFTEN SUPERIOR.
C
      IF(ABS(LAST-INTGRX) .LE. TOLER2) GO TO 221
      COTES1=SUM*ZR*140.0
      IF(ABS(LAST1-COTES1) .LE. TOLER2) GO TO 219
      LAST=INTGRX
      LAST1=COTES1
      STEP=STEP2
      STEP3=STEP*3.0
      GO TO 190
C
  219 INTGRX=COTES1
  221 INTGRL=INTGRL+INTGRX
      IF(.NOT.FIRST) RETURN
  222 FIRST=.FALSE.
      RA=RO
      RB=R2
      FR=FR2
      GO TO 170
      END
```

44000B CM STORAGE USED 8.664 SECONDS

```
      REAL FUNCTION ERF(Z)
C
C     ERF(Z) RETURNS THE VALUE OF THE ERROR FUNCTION OF Z. THE ALGORITHM
C     IS DUE TO H. ABRAMSON OF NEWYORK UNIVERSITY AND IS OF THE
C     CHEBYCHEV POLYNOMIAL TYPE.
C
C
      INTEGER I,J
C
      REAL AAZERO,AZERO,BBZERO,BZERO,COEFF,X,Y,Z
C
      REAL A(26),AA(17),B(28),BB(19)
C
      DATA AZERO     / 3.8873036552229         /
      DATA A(1)      /-1.3816314200198         /
      DATA A(2)      / .64731640485458         /
      DATA A(3)      /-.30593102442204         /
      DATA A(4)      /.138679747202030         /
      DATA A(5)      /-.0592474565912590       /
      DATA A(6)      / .236917518249282E-01    /
      DATA A(7)      /-.884736263524O5E-02     /
      DATA A(8)      / .306566171136O9E-02     /
      DATA A(9)      /-.100638635123798E-02    /
      DATA A(10)     /.30754632884308E-03      /
      DATA A(11)     /-.882619837553363E-04    /
      DATA A(12)     / .238450961660726E-04    /
      DATA A(13)     /-.607910028505833E-05    /
      DATA A(14)     / .146597217338083E-05    /
      DATA A(15)     /-.0335159934272O6E-05    /
      DATA A(16)     / .0072805795442332E-05   /
      DATA A(17)     /-.0015057911766668E-05   /
      DATA A(18)     / .0002970947420555E-05   /
      DATA A(19)     /-.0000560212739838E-05   /
      DATA A(20)     / .0000101131623900E-05   /
      DATA A(21)     /-.1750650465E-10         /
      DATA A(22)     /.0291038139 E-10         /
      DATA A(23)     /-.0046532645E-10         /
      DATA A(24)     / .0007164815E-10         /
      DATA A(25)     /-.0001063749E-10         /
      DATA A(26)     / .0000152467E-10         /
      DATA B(27)     / .0                      /
      DATA B(28)     / .0                      /
      DATA AAZERO    / 1.97070527225754        /
      DATA AA(1)     /-.143397402717750E-01    /
      DATA AA(2)     / .297361692202262E-03    /
      DATA AA(3)     /-.980351604336624E-05    /
      DATA AA(4)     / .043313342034728E-05    /
      DATA AA(5)     /-.002362150026241E-05    /
      DATA AA(6)     / .000151549676581E-05    /
      DATA AA(7)     /-.000011084939856E-05    /
      DATA AA(8)     / .0904259014E-10         /
      DATA AA(9)     /-.0080947054E-10         /
      DATA AA(10)    / .0007853856E-10         /
      DATA AA(11)    /-.0000817918E-10         /
      DATA AA(12)    / .90715E-15              /
      DATA AA(13)    /-.10646E-15              /
      DATA AA(14)    / .01315E-15              /
```

```
      DATA AA(15)  /-.00170E-15          /
      DATA AA(16)  / .00023E-15          /
      DATA AA(17)  /-.00003E-15          /
      DATA BB(18)  / .0                  /
      DATA BB(19)  / .0                  /
C
C
      Y=ABS(Z)
      IF(Y .GT. 16.) GO TO 4
      IF(Y.GT.4.0)GO TO 2
      X=Y/4.
      COEFF=4.*X*X-2.
      DO 1 I=1,26
      J=27-I
      B(J)=COEFF*B(J+1)-B(J+2)+A(J)
    1 CONTINUE
      BZERO=COEFF*B(1)-B(2)+AZERO
      ERF=SIGN(X/2*(BZERO-B(2)),Z)
      RETURN
    2 X=4./Y
      COEFF=4.*X*X-2.
      DO 3 I=1,17
      J=18-I
      BB(J)=COEFF*BB(J+1)-BB(J+2)+AA(J)
    3 CONTINUE
      BBZERO=COEFF*BB(1)-BB(2)+AAZERO
      ERF=SIGN(1.-(BBZERO-BB(2))/(2.*Y*EXP(Y*Y))*.564189583547776,Z)
      RETURN
    4 ERF=SIGN(1.,Z)
      RETURN
      END

 41000B CM STORAGE USED        .421 SECONDS
```

```
                                INPUT DATA LISTING

THE RECEPTOR, DX, DY, DZ =    15.,     0.,     2.
ROADWAY 1, X1, Y1, X2, Y2 =   -50.,  2000.,    50., -2000.
ROADWAY 2, X1, Y1, X2, Y2 =   -54.,  2000.,    46., -2000.
ROADWAY 3, X1, Y1, X2, Y2 =   -58.,  2000.,    42., -2000.
ROADWAY 4, X1, Y1, X2, Y2 =   -74.,  2000.,    26., -2000.
ROADWAY 5, X1, Y1, X2, Y2 =   -78.,  2000.,    22., -2000.
ROADWAY 6, X1, Y1, X2, Y2 =   -82.,  2000.,    18., -2000.

TP  1
   CLASS 4, STATIN(1 TO 6) =    601    -1.68541     1.02802     9.45589    -1.92770    17.66351
   CLASS 5, STATIN(1 TO 6) =    319     -.50868     -.10188     1.13178      .21923     1.89802
   B/S CONDITION  1      .143  1.92  676.  676.  676.  676.  676.  676.
   B/S CONDITION  2      .143  1.34  473.  473.  473.  473.  473.  473.
   B/S CONDITION  3      .143  1.26  445.  445.  445.  445.  445.  445.
   B/S CONDITION  4      .143  1.44  507.  507.  507.  507.  507.  507.
   B/S CONDITION  5      .143  1.81  637.  637.  637.  637.  637.  637.
   B/S CONDITION  6      .143  1.70  597.  597.  597.  597.  597.  597.
   B/S CONDITION  7      .143  1.57  552.  552.  552.  552.  552.  552.

TP  2
   CLASS 4, STATIN(1 TO 6) =    608    -1.60613     1.04630     8.91752    -1.02915    16.33521
   CLASS 5, STATIN(1 TO 6) =    312     -.54561     -.09263     1.07813      .17771     1.87593
   B/S CONDITION  1      .143  2.88  592.  592.  592.  592.  592.  592.
   B/S CONDITION  2      .143  2.02  414.  414.  414.  414.  414.  414.
   B/S CONDITION  3      .143  1.90  390.  390.  390.  390.  390.  390.
   B/S CONDITION  4      .143  2.16  444.  444.  444.  444.  444.  444.
   B/S CONDITION  5      .143  2.71  557.  557.  557.  557.  557.  557.
```

B/S CONDITION 6	.143	2.54	523.	523.	523.	523.	523.	523.
B/S CONDITION 7	.143	2.35	483.	483.	483.	483.	483.	483.

TP 3

CLASS 4, STATIN(1 TO 6) =	600	-1.57178	1.14070	9.49712	-1.55316	16.21417		
CLASS 5, STATIN(1 TO 6) =	320	-.58350	-.05941	1.12962	.14081	1.67696		
B/S CONDITION 1	.143	3.36	507.	507.	507.	507.	507.	507.
B/S CONDITION 2	.143	2.35	355.	355.	355.	355.	355.	355.
B/S CONDITION 3	.143	2.21	334.	334.	334.	334.	334.	334.
B/S CONDITION 4	.143	2.52	380.	380.	380.	380.	380.	380.
B/S CONDITION 5	.143	3.16	478.	478.	478.	478.	478.	478.
B/S CONDITION 6	.143	2.97	448.	448.	448.	448.	448.	448.
B/S CONDITION 7	.143	2.74	414.	414.	414.	414.	414.	414.

TP 4

CLASS 4, STATIN(1 TO 6) =	589	-1.51857	1.16304	8.63453	-1.06051	16.06932		
CLASS 5, STATIN(1 TO 6) =	331	-.49420	-.17248	1.20556	.34075	1.62419		
B/S CONDITION 1	.143	2.68	423.	423.	423.	423.	423.	423.
B/S CONDITION 2	.143	2.02	296.	296.	296.	296.	296.	296.
B/S CONDITION 3	.143	1.90	278.	278.	278.	278.	278.	278.
B/S CONDITION 4	.143	2.16	317.	317.	317.	317.	317.	317.
B/S CONDITION 5	.143	2.71	398.	398.	398.	398.	398.	398.
B/S CONDITION 6	.143	2.54	373.	373.	373.	373.	373.	373.
B/S CONDITION 7	.143	2.35	345.	345.	345.	345.	345.	345.

TP 5

CLASS 4, STATIN(1 TO 6) =	592	-1.57718	1.12880	8.56545	-.65451	15.57766		
CLASS 5, STATIN(1 TO 6) =	328	-.49875	-.11061	1.06776	.29919	1.91607		
B/S CONDITION 1	.143	2.68	592.	592.	592.	592.	592.	592.
B/S CONDITION 2	.143	2.02	414.	414.	414.	414.	414.	414.

```
B/S CONDITION  3      .143  1.90  390.  390.  390.  390.  390.  390.
B/S CONDITION  4      .143  2.16  444.  444.  444.  444.  444.  444.
B/S CONDITION  5      .143  2.71  557.  557.  557.  557.  557.  557.
B/S CONDITION  6      .143  2.54  523.  523.  523.  523.  523.  523.
B/S CONDITION  7      .143  2.35  483.  483.  483.  483.  483.  483.

TP  6
CLASS 4, STATIN(1 TO 6) =   602    -1.60181    1.16299    8.59392   -1.09444   15.29264
CLASS 5, STATIN(1 TO 6) =   318     -.56714    -.19497    1.24690     .38666    1.74974
B/S CONDITION  1      .143  2.88 1690. 1690. 1690. 1690. 1690. 1690.
B/S CONDITION  2      .143  2.02 1183. 1183. 1183. 1183. 1183. 1183.
B/S CONDITION  3      .143  1.90 1113. 1113. 1113. 1113. 1113. 1113.
B/S CONDITION  4      .143  2.16 1268. 1268. 1268. 1268. 1268. 1268.
B/S CONDITION  5      .143  2.71 1592. 1592. 1592. 1592. 1592. 1592.
B/S CONDITION  6      .143  2.54 1493. 1493. 1493. 1493. 1493. 1493.
B/S CONDITION  7      .143  2.35 1381. 1381. 1381. 1381. 1381. 1381.

TP  7
CLASS 4, STATIN(1 TO 6) =   596    -1.60594    1.16087    8.90845   -1.20862   15.64198
CLASS 5, STATIN(1 TO 6) =   324     -.56395    -.12201    1.27728     .29087    1.74829
B/S CONDITION  1      .143  3.84 5410. 5410. 5410. 5410. 5410. 5410.
B/S CONDITION  2      .143  2.69 3787. 3787. 3787. 3787. 3787. 3787.
B/S CONDITION  3      .143  2.53 3561. 3561. 3561. 3561. 3561. 3561.
B/S CONDITION  4      .143  2.88 4057. 4057. 4057. 4057. 4057. 4057.
B/S CONDITION  5      .143  3.62 5094. 5094. 5094. 5094. 5094. 5094.
B/S CONDITION  6      .143  3.39 4778. 4778. 4778. 4778. 4778. 4778.
B/S CONDITION  7      .143  3.14 4418. 4418. 4418. 4418. 4418. 4418.

TP  8
CLASS 4, STATIN(1 TO 6) =   628    -1.51911    1.14014    8.75491   -1.21427   15.10953
```

CLASS 5, STATIN(1 TO 6) = 292 -.59442 -.14911 .97799 .19266 1.68788

B/S CONDITION 1 .143 4.60 6677. 6677. 6677. 6677. 6677. 6677.

B/S CONDITION 2 .143 3.36 4674. 4674. 4674. 4674. 4674. 4674.

B/S CONDITION 3 .143 3.16 4396. 4396. 4396. 4396. 4396. 4396.

B/S CONDITION 4 .143 3.60 5008. 5008. 5008. 5008. 5008. 5008.

B/S CONDITION 5 .143 4.52 6288. 6288. 6288. 6288. 6288. 6288.

B/S CONDITION 6 .143 4.24 5898. 5898. 5898. 5898. 5898. 5898.

B/S CONDITION 7 .143 3.92 5453. 5453. 5453. 5453. 5453. 5453.

TP 9

CLASS 2, STATIN(1 TO 6) = 94 -.48787 -.26777 .90676 .19071 1.35811

CLASS 3, STATIN(1 TO 6) = 150 -.91513 .02413 5.36034 -.22571 8.43020

CLASS 4, STATIN(1 TO 6) = 512 -1.76779 1.27492 9.92040 -2.13235 17.49392

CLASS 5, STATIN(1 TO 6) = 164 -.50988 -.11604 1.31097 .12500 1.87381

B/S CONDITION 1 .143 5.76 6086. 6086. 6086. 6086. 6086. 6086.

B/S CONDITION 2 .143 4.03 4260. 4260. 4260. 4260. 4260. 4260.

B/S CONDITION 3 .143 3.79 4006. 4006. 4006. 4006. 4006. 4006.

B/S CONDITION 4 .143 4.32 4564. 4564. 4564. 4564. 4564. 4564.

B/S CONDITION 5 .143 5.42 5731. 5731. 5731. 5731. 5731. 5731.

B/S CONDITION 6 .143 5.09 5376. 5376. 5376. 5376. 5376. 5376.

B/S CONDITION 7 .143 4.70 4970. 4970. 4970. 4970. 4970. 4970.

TP 10

CLASS 2, STATIN(1 TO 6) = 194 -.23103 -.52649 .97842 .24961 1.91934

CLASS 3, STATIN(1 TO 6) = 506 -1.02555 .25251 5.60600 -.55725 10.57447

CLASS 4, STATIN(1 TO 6) = 220 -3.34218 3.02123 17.56827 -2.43734 27.27729

B/S CONDITION 1 .143 4.80 4818. 4818. 4818. 4818. 4818. 4818.

B/S CONDITION 2 .143 3.36 3373. 3373. 3373. 3373. 3373. 3373.

B/S CONDITION 3 .143 3.16 3172. 3172. 3172. 3172. 3172. 3172.

B/S CONDITION 4 .143 3.60 3613. 3613. 3613. 3613. 3613. 3613.

```
B/S CONDITION  5       .143  4.52 4537. 4537. 4537. 4537. 4537. 4537.
B/S CONDITION  6       .143  4.24 4256. 4256. 4256. 4256. 4256. 4256.
B/S CONDITION  7       .143  3.92 3935. 3935. 3935. 3935. 3935. 3935.

TP 11
CLASS 2, STATIN(1 TO 6) =   166     .08120    -.44295     .83061     .14959    2.49305
CLASS 3, STATIN(1 TO 6) =   466   -1.03579    -.17260    6.15707    -.82376   11.27349
CLASS 4, STATIN(1 TO 6) =   288   -3.54792    3.27385   17.78715   -2.24430   27.62977
B/S CONDITION  1       .143  3.84 3973. 3973. 3973. 3973. 3973. 3973.
B/S CONDITION  2       .143  2.69 2781. 2781. 2781. 2781. 2781. 2781.
B/S CONDITION  3       .143  2.53 2615. 2615. 2615. 2615. 2615. 2615.
B/S CONDITION  4       .143  2.68 2979. 2979. 2979. 2979. 2979. 2979.
B/S CONDITION  5       .143  3.62 3741. 3741. 3741. 3741. 3741. 3741.
B/S CONDITION  6       .143  3.39 3509. 3509. 3509. 3509. 3509. 3509.
B/S CONDITION  7       .143  3.14 3244. 3244. 3244. 3244. 3244. 3244.

TP 12
CLASS 2, STATIN(1 TO 6) =   144     .35139    -.36806    1.18800     .08255    2.15956
CLASS 3, STATIN(1 TO 6) =   463    -.91495    -.34279    6.25016   -1.12558   12.17379
CLASS 4, STATIN(1 TO 6) =   313   -4.08898    2.83617   15.67151   -3.40942   30.27324
B/S CONDITION  1       .143  2.88 3973. 3973. 3973. 3973. 3973. 3973.
B/S CONDITION  2       .143  2.02 2781. 2781. 2781. 2781. 2781. 2781.
B/S CONDITION  3       .143  1.90 2615. 2615. 2615. 2615. 2615. 2615.
B/S CONDITION  4       .143  2.16 2979. 2979. 2979. 2979. 2979. 2979.
B/S CONDITION  5       .143  2.71 3741. 3741. 3741. 3741. 3741. 3741.
B/S CONDITION  6       .143  2.54 3509. 3509. 3509. 3509. 3509. 3509.
B/S CONDITION  7       .143  2.35 3244. 3244. 3244. 3244. 3244. 3244.

TP 13
CLASS 2, STATIN(1 TO 6) =   126     .11397    -.27357    1.59349    -.31901    2.52416
```

```
CLASS 3, STATIN(1 TO 6) =    443     -.88093     -.51242     6.09195    -1.21419    11.86817
CLASS 4, STATIN(1 TO 6) =    351    -4.16427     2.47696    16.01762    -3.49115    29.92637
B/S CONDITION  1      .143  2.40 3888. 3888. 3888. 3888. 3888. 3888.
B/S CONDITION  2      .143  1.68 2722. 2722. 2722. 2722. 2722. 2722.
B/S CONDITION  3      .143  1.56 2560. 2560. 2560. 2560. 2560. 2560.
B/S CONDITION  4      .143  1.80 2916. 2916. 2916. 2916. 2916. 2916.
B/S CONDITION  5      .143  2.26 3661. 3661. 3661. 3661. 3661. 3661.
B/S CONDITION  6      .143  2.12 3435. 3435. 3435. 3435. 3435. 3435.
B/S CONDITION  7      .143  1.96 3175. 3175. 3175. 3175. 3175. 3175.

TP 14
CLASS 2, STATIN(1 TO 6) =    119      .34908     -.26244      .99797      .00054     2.51431
CLASS 3, STATIN(1 TO 6) =    468    -1.12902     -.34947     6.91530    -2.10349    12.07549
CLASS 4, STATIN(1 TO 6) =    333    -4.27598     2.08727    16.65050    -4.68722    33.91771
B/S CONDITION  1      .143  1.92 4226. 4226. 4226. 4226. 4226. 4226.
B/S CONDITION  2      .143  1.34 2958. 2958. 2958. 2958. 2958. 2958.
B/S CONDITION  3      .143  1.26 2782. 2782. 2782. 2782. 2782. 2782.
B/S CONDITION  4      .143  1.44 3170. 3170. 3170. 3170. 3170. 3170.
B/S CONDITION  5      .143  1.61 3980. 3980. 3980. 3980. 3980. 3980.
B/S CONDITION  6      .143  1.70 3733. 3733. 3733. 3733. 3733. 3733.
B/S CONDITION  7      .143  1.57 3451. 3451. 3451. 3451. 3451. 3451.

TP 15
CLASS 2, STATIN(1 TO 6) =    125      .29440     -.35864     1.36116     -.00607     2.01676
CLASS 3, STATIN(1 TO 6) =    470    -1.24340     -.30557     6.77340    -2.21857    12.29479
CLASS 4, STATIN(1 TO 6) =    325    -4.08982     2.31363    16.61250    -4.35616    30.86760
B/S CONDITION  1      .143  2.40 4226. 4226. 4226. 4226. 4226. 4226.
B/S CONDITION  2      .143  1.68 2958. 2958. 2958. 2958. 2958. 2958.
B/S CONDITION  3      .143  1.56 2782. 2782. 2782. 2782. 2782. 2782.
B/S CONDITION  4      .143  1.60 3170. 3170. 3170. 3170. 3170. 3170.
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B/S CONDITION 5      .143 2.26 3980. 3980. 3980. 3980. 3980. 3980.
B/S CONDITION 6      .143 2.12 3733. 3733. 3733. 3733. 3733. 3733.
B/S CONDITION 7      .143 1.96 3451. 3451. 3451. 3451. 3451. 3451.

TP 16
CLASS 2, STATIN(1 TO 6) =   166     .02755    -.21934    1.42393    -.00282    1.88943
CLASS 3, STATIN(1 TO 6) =   498   -1.24147    -.25992    6.62576   -2.10039   11.55C09
CLASS 4, STATIN(1 TO 6) =   316   -3.62750    2.21560   16.00064   -5.31647   31.47524
B/S CONDITION 1      .143 2.88 5748. 5748. 5748. 5748. 5748. 5748.
B/S CONDITION 2      .143 2.02 4023. 4023. 4023. 4023. 4023. 4023.
B/S CONDITION 3      .143 1.90 3784. 3784. 3784. 3784. 3784. 3784.
B/S CONDITION 4      .143 2.16 4311. 4311. 4311. 4311. 4311. 4311.
B/S CONDITION 5      .143 2.71 5412. 5412. 5412. 5412. 5412. 5412.
B/S CONDITION 6      .143 2.54 5077. 5077. 5077. 5077. 5077. 5077.
B/S CONDITION 7      .143 2.35 4694. 4694. 4694. 4694. 4694. 4694.

TP 17
CLASS 2, STATIN(1 TO 6) =    30     .05267    -.27367    1.02978     .00218    1.31366
CLASS 3, STATIN(1 TO 6) =   159   -1.05447    -.02497    6.07479   -2.00448   10.85469
CLASS 4, STATIN(1 TO 6) =   614   -2.33577    1.04886   12.83448   -5.15783   21.98268
CLASS 5, STATIN(1 TO 6) =   117    -.35675    -.34897    1.46774    -.27621    2.72806
B/S CONDITION 1      .143 3.36 6424. 6424. 6424. 6424. 6424. 6424.
B/S CONDITION 2      .143 2.35 4497. 4497. 4497. 4497. 4497. 4497.
B/S CONDITION 3      .143 2.21 4229. 4229. 4229. 4229. 4229. 4229.
B/S CONDITION 4      .143 2.52 4818. 4818. 4818. 4818. 4818. 4818.
B/S CONDITION 5      .143 3.16 6049. 6049. 6049. 6049. 6049. 6049.
B/S CONDITION 6      .143 2.97 5674. 5674. 5674. 5674. 5674. 5674.
B/S CONDITION 7      .143 2.74 5246. 5246. 5246. 5246. 5246. 5246.

TP 18
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CLASS 4, STATIN(1 TO 6) =	702	-1.54490	.99503	11.30662	-4.02117	18.15382		
CLASS 5, STATIN(1 TO 6) =	217	-.49373	-.39539	1.50079	-.30684	2.06521		
B/S CONDITION 1	.143	3.64	6677.	6677.	6677.	6677.	6677.	6677.
B/S CONDITION 2	.143	2.69	4674.	4674.	4674.	4674.	4674.	4674.
B/S CONDITION 3	.143	2.53	4396.	4396.	4396.	4396.	4396.	4396.
B/S CONDITION 4	.143	2.68	5006.	5006.	5006.	5006.	5006.	5006.
B/S CONDITION 5	.143	3.62	6288.	6288.	6288.	6288.	6288.	6288.
B/S CONDITION 6	.143	3.39	5896.	5896.	5896.	5898.	5896.	5698.
B/S CONDITION 7	.143	3.14	5453.	5453.	5453.	5453.	5453.	5453.

TP 19

CLASS 4, STATIN(1 TO 6) =	678	-1.39505	.94760	11.26978	-3.37778	17.13650		
CLASS 5, STATIN(1 TO 6) =	242	-.40880	-.29618	1.64228	-.27403	2.49923		
B/S CONDITION 1	.143	4.32	4733.	4733.	4733.	4733.	4733.	4733.
B/S CONDITION 2	.143	3.02	3313.	3313.	3313.	3313.	3313.	3313.
B/S CONDITION 3	.143	2.64	3116.	3116.	3116.	3116.	3116.	3116.
B/S CONDITION 4	.143	3.24	3550.	3550.	3550.	3550.	3550.	3550.
B/S CONDITION 5	.143	4.07	4457.	4457.	4457.	4457.	4457.	4457.
B/S CONDITION 6	.143	3.62	4181.	4181.	4181.	4181.	4181.	4181.
B/S CONDITION 7	.143	3.53	3866.	3866.	3866.	3866.	3866.	3866.

TP 20

CLASS 4, STATIN(1 TO 6) =	662	-1.47063	.78953	10.78315	-3.29360	17.23590		
CLASS 5, STATIN(1 TO 6) =	258	-.24306	-.34539	1.71568	-.08915	2.21698		
B/S CONDITION 1	.143	3.36	4733.	4733.	4733.	4733.	4733.	4733.
B/S CONDITION 2	.143	2.35	3313.	3313.	3313.	3313.	3313.	3313.
B/S CONDITION 3	.143	2.21	3116.	3116.	3116.	3116.	3116.	3116.
B/S CONDITION 4	.143	2.52	3550.	3550.	3550.	3550.	3550.	3550.
B/S CONDITION 5	.143	3.16	4457.	4457.	4457.	4457.	4457.	4457.
B/S CONDITION 6	.143	2.97	4181.	4181.	4181.	4181.	4181.	4181.

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   B/S CONDITION  7      .143  2.74 3866. 3866. 3866. 3866. 3866. 3866.

 TP 21

   CLASS 4, STATIN(1 TO 6) =    655     -1.56153       .92614     10.44831     -2.73626     17.94710
   CLASS 5, STATIN(1 TO 6) =    264      -.41992      -.35447      1.48475      -.04116      1.77558
   B/S CONDITION  1      .143  1.92 3381. 3381. 3381. 3381. 3381. 3381.
   B/S CONDITION  2      .143  1.34 2367. 2367. 2367. 2367. 2367. 2367.
   B/S CONDITION  3      .143  1.26 2226. 2226. 2226. 2226. 2226. 2226.
   B/S CONDITION  4      .143  1.44 2536. 2536. 2536. 2536. 2536. 2536.
   B/S CONDITION  5      .143  1.81 3184. 3184. 3184. 3184. 3184. 3184.
   B/S CONDITION  6      .143  1.70 2987. 2987. 2987. 2987. 2987. 2987.
   B/S CONDITION  7      .143  1.57 2761. 2761. 2761. 2761. 2761. 2761.

 TP 22
   CLASS 4, STATIN(1 TO 6) =    634     -1.63882      1.08136     10.07673     -2.20567     16.73855
   CLASS 5, STATIN(1 TO 6) =    286      -.41958      -.39308      1.10405       .02513      1.92972
   B/S CONDITION  1      .143  1.92 2536. 2536. 2536. 2536. 2536. 2536.
   B/S CONDITION  2      .143  1.34 1775. 1775. 1775. 1775. 1775. 1775.
   B/S CONDITION  3      .143  1.26 1669. 1669. 1669. 1669. 1669. 1669.
   B/S CONDITION  4      .143  1.44 1902. 1902. 1902. 1902. 1902. 1902.
   B/S CONDITION  5      .143  1.81 2388. 2388. 2388. 2388. 2388. 2388.
   B/S CONDITION  6      .143  1.70 2240. 2240. 2240. 2240. 2240. 2240.
   B/S CONDITION  7      .143  1.57 2071. 2071. 2071. 2071. 2071. 2071.

 TP 23
   CLASS 4, STATIN(1 TO 6) =    629     -1.62014      1.07639      9.76819     -1.99274     16.71808
   CLASS 5, STATIN(1 TO 6) =    291      -.42718      -.31605      1.23217       .11760      1.95111
   B/S CONDITION  1      .143  2.40 1690. 1690. 1690. 1690. 1690. 1690.
   B/S CONDITION  2      .143  1.68 1183. 1183. 1183. 1183. 1183. 1183.
   B/S CONDITION  3      .143  1.58 1113. 1113. 1113. 1113. 1113. 1113.
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B/S CONDITION 4	.143	1.60	1266.	1266.	1268.	1268.	1268.	1268.
B/S CONDITION 5	.143	2.26	1592.	1592.	1592.	1592.	1592.	1592.
B/S CONDITION 6	.143	2.12	1493.	1493.	1493.	1493.	1493.	1493.
B/S CONDITION 7	.143	1.96	1381.	1381.	1381.	1381.	1381.	1381.
TP 24								
CLASS 4, STATIN(1 TO 6) =	604	-1.74728	1.12942	9.82399	-1.78525	16.90720		
CLASS 5, STATIN(1 TO 6) =	316	-.36820	-.26804	1.36445	.25727	2.02111		
B/S CONDITION 1	.143	1.92	845.	845.	845.	845.	845.	845.
B/S CONDITION 2	.143	1.34	592.	592.	592.	592.	592.	592.
B/S CONDITION 3	.143	1.26	556.	556.	556.	556.	556.	556.
B/S CONDITION 4	.143	1.44	634.	634.	634.	634.	634.	634.
B/S CONDITION 5	.143	1.61	796.	796.	796.	796.	796.	796.
B/S CONDITION 6	.143	1.70	747.	747.	747.	747.	747.	747.
B/S CONDITION 7	.143	1.57	690.	690.	690.	690.	690.	690.
TP 25								
CLASS 4, STATIN(1 TO 6) =	669	-1.07628	.65045	13.22726	-1.92132	16.51152		
CLASS 5, STATIN(1 TO 6) =	222	-.63694	-.32090	1.75255	.05595	2.25167		
B/S CONDITION 1	.143	2.16	761.	761.	761.	761.	761.	761.
B/S CONDITION 2	.143	1.51	533.	533.	533.	533.	533.	533.
B/S CONDITION 3	.143	1.42	501.	501.	501.	501.	501.	501.
B/S CONDITION 4	.143	1.62	571.	571.	571.	571.	571.	571.
B/S CONDITION 5	.143	2.03	716.	716.	716.	716.	716.	716.
B/S CONDITION 6	.143	1.91	672.	672.	672.	672.	672.	672.
B/S CONDITION 7	.143	1.76	621.	621.	621.	621.	621.	621.
TP 26								
CLASS 4, STATIN(1 TO 6) =	658	-1.16187	.68172	13.36755	-1.76039	16.58081		
CLASS 5, STATIN(1 TO 6) =	234	-.54299	-.27577	1.50473	.05182	2.68472		

B/S CONDITION 1	.143	3.24	666.	666.	666.	666.	666.	666.
B/S CONDITION 2	.143	2.27	466.	466.	466.	466.	466.	466.
B/S CONDITION 3	.143	2.13	438.	438.	438.	438.	438.	438.
B/S CONDITION 4	.143	2.43	499.	499.	499.	499.	499.	499.
B/S CONDITION 5	.143	3.05	627.	627.	627.	627.	627.	627.
B/S CONDITION 6	.143	2.66	588.	588.	588.	588.	588.	588.
B/S CONDITION 7	.143	2.65	544.	544.	544.	544.	544.	544.

TP 27

CLASS 4, STATIN(1 TO 6) =	661	-1.15027	.85272	12.82191	-1.36046	16.30372		
CLASS 5, STATIN(1 TO 6) =	232	-.50578	-.26060	1.74669	.36330	2.13471		
B/S CONDITION 1	.143	3.78	571.	571.	571.	571.	571.	571.
B/S CONDITION 2	.143	2.65	399.	399.	399.	399.	399.	399.
B/S CONDITION 3	.143	2.49	376.	376.	376.	376.	376.	376.
B/S CONDITION 4	.143	2.84	428.	428.	428.	428.	428.	428.
B/S CONDITION 5	.143	2.49	376.	376.	376.	376.	376.	376.
B/S CONDITION 6	.143	2.84	428.	428.	428.	428.	428.	428.
B/S CONDITION 7	.143	3.56	537.	537.	537.	537.	537.	537.

TP 28

CLASS 4, STATIN(1 TO 6) =	634	-1.15393	1.13150	13.02368	-1.52383	16.93918		
CLASS 5, STATIN(1 TO 6) =	257	-.49926	-.21381	1.52207	.18874	2.20233		
B/S CONDITION 1	.143	3.34	504.	504.	504.	504.	504.	504.
B/S CONDITION 2	.143	3.09	466.	466.	466.	466.	466.	466.
B/S CONDITION 3	.143	3.24	475.	475.	475.	475.	475.	475.
B/S CONDITION 4	.143	2.27	333.	333.	333.	333.	333.	333.
B/S CONDITION 5	.143	2.13	313.	313.	313.	313.	313.	313.
B/S CONDITION 6	.143	2.43	357.	357.	357.	357.	357.	357.
B/S CONDITION 7	.143	3.05	448.	448.	448.	448.	448.	448.

TP 29

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CLASS 4, STATIN(1 TO 6) =    657     -1.04070    1.08572    12.96584    -1.15134    16.84933
CLASS 5, STATIN(1 TO 6) =    236      -.61809    -.29076     1.46312      .23006     2.03809
B/S CONDITION  1      .143  2.86  420.  420.  420.  420.  420.  420.
B/S CONDITION  2      .143  2.65  388.  388.  388.  388.  388.  388.
B/S CONDITION  3      .143  3.24  666.  666.  666.  666.  666.  666.
B/S CONDITION  4      .143  2.27  466.  466.  466.  466.  466.  466.
B/S CONDITION  5      .143  2.13  438.  438.  438.  438.  438.  438.
B/S CONDITION  6      .143  2.43  499.  499.  499.  499.  499.  499.
B/S CONDITION  7      .143  3.05  627.  627.  627.  627.  627.  627.

TP 30
CLASS 4, STATIN(1 TO 6) =    639      -.93933    1.31756    13.28420    -1.11384    15.73613
CLASS 5, STATIN(1 TO 6) =    252      -.55052    -.26111     1.55947      .13832     2.36337
B/S CONDITION  1      .143  2.86  588.  588.  588.  588.  588.  588.
B/S CONDITION  2      .143  2.65  544.  544.  544.  544.  544.  544.
B/S CONDITION  3      .143  3.24 1902. 1902. 1902. 1902. 1902. 1902.
B/S CONDITION  4      .143  2.27 1331. 1331. 1331. 1331. 1331. 1331.
B/S CONDITION  5      .143  2.13 1252. 1252. 1252. 1252. 1252. 1252.
B/S CONDITION  6      .143  2.43 1426. 1426. 1426. 1426. 1426. 1426.
B/S CONDITION  7      .143  3.65 1791. 1791. 1791. 1791. 1791. 1791.

TP 31
CLASS 4, STATIN(1 TO 6) =    656      -.95904    1.21601    13.95619     -.62875    16.12360
CLASS 5, STATIN(1 TO 6) =    236      -.55894    -.22267     1.44342      .30946     1.82310
B/S CONDITION  1      .143  2.86 1680. 1680. 1680. 1680. 1680. 1680.
B/S CONDITION  2      .143  2.65 1553. 1553. 1553. 1553. 1553. 1553.
B/S CONDITION  3      .143  4.32 6086. 6086. 6086. 6086. 6086. 6086.
B/S CONDITION  4      .143  3.02 4260. 4260. 4260. 4260. 4260. 4260.
B/S CONDITION  5      .143  2.84 4006. 4006. 4006. 4006. 4006. 4006.
B/S CONDITION  6      .143  3.24 4564. 4564. 4564. 4564. 4564. 4564.
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B/S CONDITION  7     .143  4.07 5731. 5731. 5731. 5731. 5731. 5731.

TP 32
CLASS 1, STATIN(1 TO 6) =     2     .36500     .36500    4.23405     4.22405     4.23405
CLASS 2, STATIN(1 TO 6) =    98    -.28143    -.44704    2.11957      .44822     2.68282
CLASS 3, STATIN(1 TO 6) =   139    -.77050     .10935    8.23827     1.38389    14.10153
CLASS 4, STATIN(1 TO 6) =   516   -1.30236    1.66145   14.79259    -1.23821    17.03728
CLASS 5, STATIN(1 TO 6) =   135    -.32289    -.18985    1.38201      .48120     1.87745
B/S CONDITION  1     .143  3.62 5376. 5376. 5376. 5376. 5376. 5376.
B/S CONDITION  2     .143  3.23 4970. 4970. 4970. 4970. 4970. 4970.
B/S CONDITION  3     .143  5.40 7512. 7512. 7512. 7512. 7512. 7512.
B/S CONDITION  4     .143  3.78 5258. 5258. 5258. 5258. 5258. 5258.
B/S CONDITION  5     .143  3.56 4945. 4945. 4945. 4945. 4945. 4945.
B/S CONDITION  6     .143  4.05 5634. 5634. 5634. 5634. 5634. 5634.
B/S CONDITION  7     .143  5.09 7074. 7074. 7074. 7074. 7074. 7074.

TP 33
CLASS 1, STATIN(1 TO 6) =    16    -.07813    -.54937    1.40874     -.69401     3.76513
CLASS 2, STATIN(1 TO 6) =   143     .03720    -.37538    3.05314      .57341     3.76814
CLASS 3, STATIN(1 TO 6) =   305    -.62590     .57784    9.90750      .47148    13.99643
CLASS 4, STATIN(1 TO 6) =   368   -1.74685    1.96375   18.92257    -1.71147    21.22541
CLASS 5, STATIN(1 TO 6) =    61    -.44885    -.62869    1.24884      .07738     1.73768
B/S CONDITION  1     .143  4.77 6636. 6636. 6636. 6636. 6636. 6636.
B/S CONDITION  2     .143  4.41 6135. 6135. 6135. 6135. 6135. 6135.
B/S CONDITION  3     .143  6.48 6846. 6846. 6846. 6846. 6846. 6846.
B/S CONDITION  4     .143  4.54 4793. 4793. 4793. 4793. 4793. 4793.
B/S CONDITION  5     .143  4.27 4507. 4507. 4507. 4507. 4507. 4507.
B/S CONDITION  6     .143  4.66 5135. 5135. 5135. 5135. 5135. 5135.
B/S CONDITION  7     .143  6.10 6447. 6447. 6447. 6447. 6447. 6447.

TP 34
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CLASS 1, STATIN(1 TO 6) =	22	-.02182	-.45455	2.43895	-.00607	3.49903		
CLASS 2, STATIN(1 TO 6) =	165	.26432	-.53389	2.96346	.24077	4.84444		
CLASS 3, STATIN(1 TO 6) =	455	-.73749	.58389	10.42403	-.52801	15.16475		
CLASS 4, STATIN(1 TO 6) =	230	-3.44730	2.96435	25.31691	-1.53859	26.94720		
B/S CONDITION 1	.143	5.72	6048.	6048.	6048.	6048.	6048.	6048.
B/S CONDITION 2	.143	5.29	5591.	5591.	5591.	5591.	5591.	5591.
B/S CONDITION 3	.143	5.40	5420.	5420.	5420.	5420.	5420.	5420.
B/S CONDITION 4	.143	3.78	3794.	3794.	3794.	3794.	3794.	3794.
B/S CONDITION 5	.143	3.56	3568.	3568.	3568.	3568.	3568.	3568.
B/S CONDITION 6	.143	4.65	4065.	4065.	4065.	4065.	4065.	4065.
B/S CONDITION 7	.143	5.09	5104.	5104.	5104.	5104.	5104.	5104.

TP 35

CLASS 1, STATIN(1 TO 6) =	29	.88931	-.85552	2.21570	.18318	3.44990		
CLASS 2, STATIN(1 TO 6) =	174	.20920	-.18420	3.70959	-.84618	6.54698		
CLASS 3, STATIN(1 TO 6) =	454	-.70802	.48626	12.21087	-2.14882	17.62326		
CLASS 4, STATIN(1 TO 6) =	234	-3.83577	2.69291	26.47639	-2.47034	31.04779		
B/S CONDITION 1	.143	4.77	4788.	4788.	4788.	4788.	4788.	4788.
B/S CONDITION 2	.143	4.41	4426.	4426.	4426.	4426.	4426.	4426.
B/S CONDITION 3	.143	4.32	4469.	4469.	4469.	4469.	4469.	4469.
B/S CONDITION 4	.143	3.02	3128.	3128.	3128.	3128.	3128.	3128.
B/S CONDITION 5	.143	2.64	2942.	2942.	2942.	2942.	2942.	2942.
B/S CONDITION 6	.143	3.24	3352.	3352.	3352.	3352.	3352.	3352.
B/S CONDITION 7	.143	4.07	4209.	4209.	4209.	4209.	4209.	4209.

TP 36

CLASS 1, STATIN(1 TO 6) =	32	-.03594	-.23313	2.59350	-.41777	3.92127
CLASS 2, STATIN(1 TO 6) =	158	.34184	-.13867	4.59544	-.02593	5.48248
CLASS 3, STATIN(1 TO 6) =	455	-1.28389	.45048	13.07811	-2.57104	18.68619
CLASS 4, STATIN(1 TO 6) =	248	-3.96177	2.32363	26.61194	-3.01963	30.26284

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B/S CONDITION  1     .143  3.82 3948. 3948. 3948. 3948. 3948. 3948.
B/S CONDITION  2     .143  3.53 3650. 3650. 3650. 3650. 3650. 3650.
B/S CONDITION  3     .143  3.24 4469. 4469. 4469. 4469. 4469. 4469.
B/S CONDITION  4     .143  2.27 3128. 3128. 3128. 3128. 3128. 3128.
B/S CONDITION  5     .143  2.13 2942. 2942. 2942. 2942. 2942. 2942.
B/S CONDITION  6     .143  2.43 3352. 3352. 3352. 3352. 3352. 3352.
B/S CONDITION  7     .143  3.05 4209. 4209. 4209. 4209. 4209. 4209.

TP 37
CLASS 1, STATIN(1 TO 6) =    30     .75367     .03367     2.21348    -.24224     3.09953
CLASS 2, STATIN(1 TO 6) =   165     .09424    -.21909     4.59090    -.84385     6.46555
CLASS 3, STATIN(1 TO 6) =   441   -1.08218     .16896    13.97094   -3.25622    18.48553
CLASS 4, STATIN(1 TO 6) =   257   -4.50475    2.05837    23.08510   -3.29570    34.91664
B/S CONDITION  1     .143  2.86 3948. 3948. 3948. 3948. 3948. 3948.
B/S CONDITION  2     .143  2.65 3650. 3650. 3650. 3650. 3650. 3650.
B/S CONDITION  3     .143  2.70 4374. 4374. 4374. 4374. 4374. 4374.
B/S CONDITION  4     .143  1.69 3062. 3062. 3062. 3062. 3062. 3062.
B/S CONDITION  5     .143  1.78 2880. 2880. 2880. 2880. 2880. 2880.
B/S CONDITION  6     .143  2.03 3281. 3281. 3281. 3281. 3281. 3281.
B/S CONDITION  7     .143  2.54 4119. 4119. 4119. 4119. 4119. 4119.

TP 38
CLASS 1, STATIN(1 TO 6) =    25     .70320    -.75480     2.69909    -.00327     2.99011
CLASS 2, STATIN(1 TO 6) =   143    -.09573    -.22646     5.01647    -.56136     4.69066
CLASS 3, STATIN(1 TO 6) =   442    -.91930     .32661    13.20482   -2.47874    20.48983
CLASS 4, STATIN(1 TO 6) =   263   -4.37120    1.37548    23.81951   -4.06979    35.93066
B/S CONDITION  1     .143  2.39 3864. 3864. 3864. 3864. 3864. 3864.
B/S CONDITION  2     .143  2.21 3572. 3572. 3572. 3572. 3572. 3572.
B/S CONDITION  3     .143  2.16 4755. 4755. 4755. 4755. 4755. 4755.
B/S CONDITION  4     .143  1.51 3328. 3328. 3328. 3328. 3328. 3328.
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B/S CONDITION  5      .143  1.42 3130. 3130. 3130. 3130. 3130. 3130.
B/S CONDITION  6      .143  1.62 3566. 3566. 3566. 3566. 3566. 3566.
B/S CONDITION  7      .143  2.03 4477. 4477. 4477. 4477. 4477. 4477.

TP 39
CLASS 1, STATIN(1 TO 6) =    23      .98565      .83043     3.01923    -.71618     1.80563
CLASS 2, STATIN(1 TO 6) =   131      .30336     -.33412     3.35654    -.92849     5.50074
CLASS 3, STATIN(1 TO 6) =   434    -1.00823      .09671    12.95265   -3.08673    18.44417
CLASS 4, STATIN(1 TO 6) =   305    -4.21220     1.31984    23.88656   -5.27167    37.58985
B/S CONDITION  1      .143  1.91 4200. 4200. 4200. 4200. 4200. 4200.
B/S CONDITION  2      .143  1.76 3883. 3883. 3883. 3883. 3883. 3883.
B/S CONDITION  3      .143  2.70 4755. 4755. 4755. 4755. 4755. 4755.
B/S CONDITION  4      .143  1.69 3328. 3328. 3328. 3328. 3328. 3328.
B/S CONDITION  5      .143  1.78 3130. 3130. 3130. 3130. 3130. 3130.
B/S CONDITION  6      .143  2.03 3566. 3566. 3566. 3566. 3566. 3566.
B/S CONDITION  7      .143  2.54 4477. 4477. 4477. 4477. 4477. 4477.

TP 40
CLASS 1, STATIN(1 TO 6) =    16      .09188     -.34125     2.85096     .16000     3.32096
CLASS 2, STATIN(1 TO 6) =   116      .07716     -.36069     3.15181    -.00415     4.32806
CLASS 3, STATIN(1 TO 6) =   425     -.89358      .17840    11.56795   -3.23553    16.74127
CLASS 4, STATIN(1 TO 6) =   335    -4.18758     1.37767    24.90705   -4.39218    34.50002
B/S CONDITION  1      .143  2.39 4200. 4200. 4200. 4200. 4200. 4200.
B/S CONDITION  2      .143  2.21 3883. 3883. 3883. 3883. 3883. 3883.
B/S CONDITION  3      .143  3.24 6466. 6466. 6466. 6466. 6466. 6466.
B/S CONDITION  4      .143  2.27 4526. 4526. 4526. 4526. 4526. 4526.
B/S CONDITION  5      .143  2.13 4257. 4257. 4257. 4257. 4257. 4257.
B/S CONDITION  6      .143  2.43 4850. 4850. 4850. 4850. 4850. 4850.
B/S CONDITION  7      .143  3.05 6089. 6089. 6089. 6089. 6089. 6089.

TP 41
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CLASS 1, STATIN(1 TO 6) =     7     -.52571      .10429     3.69960    -1.44505     2.54343
CLASS 2, STATIN(1 TO 6) =    92      .08022     -.13717     3.50031     -.53863     3.77857
CLASS 3, STATIN(1 TO 6) =   438     -.72219      .10146    10.64400    -2.11263    14.68064
CLASS 4, STATIN(1 TO 6) =   355    -3.54713     1.73346    25.64099    -6.61350    34.68848
B/S CONDITION  1      .143  2.86 5712. 5712. 5712. 5712. 5712. 5712.
B/S CONDITION  2      .143  2.65 5281. 5281. 5281. 5281. 5281. 5281.
B/S CONDITION  3      .143  3.78 7227. 7227. 7227. 7227. 7227. 7227.
B/S CONDITION  4      .143  2.65 5059. 5059. 5059. 5059. 5059. 5059.
B/S CONDITION  5      .143  2.49 4758. 4758. 4758. 4758. 4758. 4758.
B/S CONDITION  6      .143  2.84 5420. 5420. 5420. 5420. 5420. 5420.
B/S CONDITION  7      .143  3.56 6805. 6805. 6805. 6805. 6805. 6805.

TP 42
CLASS 2, STATIN(1 TO 6) =    55      .15655     -.56909     2.77709     -.39998     3.24747
CLASS 3, STATIN(1 TO 6) =   292     -.60712      .07740    10.67920    -1.98069    12.90557
CLASS 4, STATIN(1 TO 6) =   523    -2.23671     1.19709    24.74218    -6.62163    25.72875
CLASS 5, STATIN(1 TO 6) =    23      .01391     -.88957     1.47852     -.04647     1.58630
B/S CONDITION  1      .143  3.34 6384. 6384. 6384. 6384. 6384. 6384.
B/S CONDITION  2      .143  3.09 5902. 5902. 5902. 5902. 5902. 5902.
B/S CONDITION  3      .143  4.32 7512. 7512. 7512. 7512. 7512. 7512.
B/S CONDITION  4      .143  3.02 5258. 5258. 5258. 5258. 5258. 5258.
B/S CONDITION  5      .143  2.64 4945. 4945. 4945. 4945. 4945. 4945.
B/S CONDITION  6      .143  3.24 5634. 5634. 5634. 5634. 5634. 5634.
B/S CONDITION  7      .143  4.07 7074. 7074. 7074. 7074. 7074. 7074.

TP 43
CLASS 4, STATIN(1 TO 6) =   804    -1.05757      .73856    17.64595    -4.54776    19.92377
CLASS 5, STATIN(1 TO 6) =    88     -.35807      .05000     1.87008     -.70893     2.93337
B/S CONDITION  1      .143  3.82 6636. 6636. 6636. 6636. 6636. 6636.
B/S CONDITION  2      .143  3.53 6135. 6135. 6135. 6135. 6135. 6135.
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B/S CONDITION  3      .143  4.66 5325. 5325. 5325. 5325. 5325. 5325.
B/S CONDITION  4      .143  3.40 3728. 3728. 3728. 3728. 3728. 3728.
B/S CONDITION  5      .143  3.20 3506. 3506. 3506. 3506. 3506. 3506.
B/S CONDITION  6      .143  3.65 3994. 3994. 3994. 3994. 3994. 3994.
B/S CONDITION  7      .143  4.58 5014. 5014. 5014. 5014. 5014. 5014.

TP 44
CLASS 4, STATIN(1 TO 6) =   760      -.91118       .71379     16.39306     -4.45931     18.20996
CLASS 5, STATIN(1 TO 6) =   112      -.46277       .00437      2.22100      -.57669      2.38713
B/S CONDITION  1      .143  4.29 4704. 4704. 4704. 4704. 4704. 4704.
B/S CONDITION  2      .143  3.97 4349. 4349. 4349. 4349. 4349. 4349.
B/S CONDITION  3      .143  3.78 5325. 5325. 5325. 5325. 5325. 5325.
B/S CONDITION  4      .143  2.65 3728. 3728. 3728. 3728. 3728. 3728.
B/S CONDITION  5      .143  2.49 3506. 3506. 3506. 3506. 3506. 3506.
B/S CONDITION  6      .143  2.84 3994. 3994. 3994. 3994. 3994. 3994.
B/S CONDITION  7      .143  3.56 5014. 5014. 5014. 5014. 5014. 5014.

TP 45
CLASS 4, STATIN(1 TO 6) =   737      -.99548       .73178     14.70496     -2.97496     18.23450
CLASS 5, STATIN(1 TO 6) =   155      -.34516      -.36548      2.22254      -.46548      2.64126
B/S CONDITION  1      .143  3.34 4704. 4704. 4704. 4704. 4704. 4704.
B/S CONDITION  2      .143  3.09 4349. 4349. 4349. 4349. 4349. 4349.
B/S CONDITION  3      .143  2.16 3804. 3804. 3804. 3804. 3804. 3804.
B/S CONDITION  4      .143  1.51 2663. 2663. 2663. 2663. 2663. 2663.
B/S CONDITION  5      .143  1.42 2504. 2504. 2504. 2504. 2504. 2504.
B/S CONDITION  6      .143  1.62 2853. 2853. 2853. 2853. 2853. 2853.
B/S CONDITION  7      .143  2.03 3582. 3582. 3582. 3582. 3582. 3582.

TP 46
CLASS 4, STATIN(1 TO 6) =   717      -.94856       .73282     14.28413     -2.78447     18.40618
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CLASS 5, STATIN(1 TO 6) =	176	-.48409	-.45392	1.85046	-.09468	2.60644		
B/S CONDITION 1	.143	1.91	3360.	3360.	3360.	3360.	3360.	3360.
B/S CONDITION 2	.143	1.76	3106.	3106.	3106.	3106.	3106.	3106.
B/S CONDITION 3	.143	2.16	2853.	2853.	2853.	2853.	2853.	2853.
B/S CONDITION 4	.143	1.51	1997.	1997.	1997.	1997.	1997.	1997.
B/S CONDITION 5	.143	1.42	1878.	1878.	1878.	1878.	1878.	1878.
B/S CONDITION 6	.143	1.62	2140.	2140.	2140.	2140.	2140.	2140.
B/S CONDITION 7	.143	2.03	2686.	2686.	2686.	2686.	2686.	2686.

TP 47

CLASS 4, STATIN(1 TO 6) =	700	-1.09676	.61051	13.46809	-2.71452	18.31672		
CLASS 5, STATIN(1 TO 6) =	192	-.57672	-.35010	1.74401	-.00879	2.54298		
B/S CONDITION 1	.143	1.91	2520.	2520.	2520.	2520.	2520.	2520.
B/S CONDITION 2	.143	1.76	2330.	2330.	2330.	2330.	2330.	2330.
B/S CONDITION 3	.143	2.70	1902.	1902.	1902.	1902.	1902.	1902.
B/S CONDITION 4	.143	1.89	1331.	1331.	1331.	1331.	1331.	1331.
B/S CONDITION 5	.143	1.78	1252.	1252.	1252.	1252.	1252.	1252.
B/S CONDITION 6	.143	2.03	1426.	1426.	1426.	1426.	1426.	1426.
B/S CONDITION 7	.143	2.54	1791.	1791.	1791.	1791.	1791.	1791.

TP 48

CLASS 4, STATIN(1 TO 6) =	767	-1.08762	.56413	12.69361	-2.49078	17.09770		
CLASS 5, STATIN(1 TO 6) =	185	-.61005	-.37757	1.24651	.19296	2.72093		
B/S CONDITION 1	.143	2.39	1680.	1680.	1680.	1680.	1680.	1680.
B/S CONDITION 2	.143	2.21	1553.	1553.	1553.	1553.	1553.	1553.
B/S CONDITION 3	.143	2.16	951.	951.	951.	951.	951.	951.
B/S CONDITION 4	.143	1.51	666.	666.	666.	666.	666.	666.
B/S CONDITION 5	.143	1.42	626.	626.	626.	626.	626.	626.
B/S CONDITION 6	.143	1.62	713.	713.	713.	713.	713.	713.
B/S CONDITION 7	.143	2.03	895.	895.	895.	895.	895.	895.

TP 49

CLASS 4, STATIN(1 TO 6) =	599	-.49576	-1.05205	6.86172	.69127	14.61503		
CLASS 5, STATIN(1 TO 6) =	321	-.59477	-.63053	1.36539	-.15309	2.35793		
B/S CONDITION 1	.143	1.91	840.	840.	840.	840.	840.	840.
B/S CONDITION 2	.143	1.76	777.	777.	777.	777.	777.	777.
B/S CONDITION 3	.143	2.88	1014.	1014.	1014.	1014.	1014.	1014.
B/S CONDITION 4	.143	2.02	710.	710.	710.	710.	710.	710.
B/S CONDITION 5	.143	1.90	668.	668.	668.	668.	668.	668.
B/S CONDITION 6	.143	2.16	761.	761.	761.	761.	761.	761.
B/S CONDITION 7	.143	2.71	955.	955.	955.	955.	955.	955.

TP 50

CLASS 4, STATIN(1 TO 6) =	582	-.56146	-.80345	6.60769	.67390	14.26775		
CLASS 5, STATIN(1 TO 6) =	338	-.59056	-.73663	1.29068	.15066	2.09749		
B/S CONDITION 1	.143	2.54	896.	896.	896.	896.	896.	896.
B/S CONDITION 2	.143	2.35	828.	828.	828.	828.	828.	828.
B/S CONDITION 3	.143	4.32	888.	888.	888.	888.	888.	888.
B/S CONDITION 4	.143	3.02	621.	621.	621.	621.	621.	621.
B/S CONDITION 5	.143	2.64	584.	584.	584.	584.	584.	584.
B/S CONDITION 6	.143	3.24	666.	666.	666.	666.	666.	666.
B/S CONDITION 7	.143	4.07	836.	836.	836.	836.	836.	836.

TP 51

CLASS 4, STATIN(1 TO 6) =	577	-.59307	-.66256	7.61931	1.22544	14.21985		
CLASS 5, STATIN(1 TO 6) =	343	-.67948	-.53948	1.09510	.15535	2.31241		
B/S CONDITION 1	.143	3.82	784.	784.	784.	784.	784.	784.
B/S CONDITION 2	.143	3.53	725.	725.	725.	725.	725.	725.
B/S CONDITION 3	.143	5.04	761.	761.	761.	761.	761.	761.
B/S CONDITION 4	.143	3.53	533.	533.	533.	533.	533.	533.

B/S CONDITION 5	.143	3.32	501.	501.	501.	501.	501.	501.
B/S CONDITION 6	.143	3.76	571.	571.	571.	571.	571.	571.
B/S CONDITION 7	.143	4.75	716.	716.	716.	716.	716.	716.

TP 52

CLASS 4, STATIN(1 TO 6) =	548	-.42781	-.33113	7.04329	1.52319	14.02439
CLASS 5, STATIN(1 TO 6) =	372	-.74290	-.42409	.97606	.08955	2.13772

B/S CONDITION 1	.143	4.45	672.	672.	672.	672.	672.	672.
B/S CONDITION 2	.143	4.12	621.	621.	621.	621.	621.	621.
B/S CONDITION 3	.143	4.32	634.	634.	634.	634.	634.	634.
B/S CONDITION 4	.143	3.02	444.	444.	444.	444.	444.	444.
B/S CONDITION 5	.143	2.84	417.	417.	417.	417.	417.	417.
B/S CONDITION 6	.143	3.24	475.	475.	475.	475.	475.	475.
B/S CONDITION 7	.143	4.07	597.	597.	597.	597.	597.	597.

TP 53

CLASS 4, STATIN(1 TO 6) =	520	-.38273	.00979	7.56859	1.87915	14.00769
CLASS 5, STATIN(1 TO 6) =	400	-.73987	-.36477	1.00084	.13983	2.01124

B/S CONDITION 1	.143	3.82	560.	560.	560.	560.	560.	560.
B/S CONDITION 2	.143	3.53	518.	518.	518.	518.	518.	518.
B/S CONDITION 3	.143	4.32	888.	888.	888.	888.	888.	888.
B/S CONDITION 4	.143	3.62	621.	621.	621.	621.	621.	621.
B/S CONDITION 5	.143	2.84	584.	584.	584.	584.	584.	584.
B/S CONDITION 6	.143	3.24	666.	666.	666.	666.	666.	666.
B/S CONDITION 7	.143	4.07	836.	836.	836.	836.	836.	836.

TP 54

CLASS 4, STATIN(1 TO 6) =	540	-.34237	.07537	7.28519	1.92847	13.75205
CLASS 5, STATIN(1 TO 6) =	380	-.68100	-.29105	.99860	.18000	2.12695

B/S CONDITION 1	.143	3.82	784.	784.	784.	784.	784.	784.

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B/S CONDITION  2      .143  3.53  725.  725.  725.  725.  725.  725.
B/S CONDITION  3      .143  4.32 2536. 2536. 2536. 2536. 2536. 2536.
B/S CONDITION  4      .143  3.02 1775. 1775. 1775. 1775. 1775. 1775.
B/S CONDITION  5      .143  2.64 1669. 1669. 1669. 1669. 1669. 1669.
B/S CONDITION  6      .143  3.24 1902. 1902. 1902. 1902. 1902. 1902.
B/S CONDITION  7      .143  4.07 2388. 2388. 2388. 2388. 2388. 2388.

TP 55
CLASS 4, STATIN(1 TO 6) =    557     -.42111      .15684     6.23337     1.81075    13.19527
CLASS 5, STATIN(1 TO 6) =    363     -.65609     -.16667     1.17925      .17698     2.00717
B/S CONDITION  1      .143  3.82 2240. 2240. 2240. 2240. 2240. 2240.
B/S CONDITION  2      .143  3.53 2071. 2071. 2071. 2071. 2071. 2071.
B/S CONDITION  3      .143  5.76 8114. 8114. 8114. 8114. 8114. 8114.
B/S CONDITION  4      .143  4.03 5680. 5680. 5680. 5680. 5680. 5680.
B/S CONDITION  5      .143  3.79 5342. 5342. 5342. 5342. 5342. 5342.
B/S CONDITION  6      .143  4.32 6086. 6086. 6086. 6086. 6086. 6086.
B/S CONDITION  7      .143  5.42 7641. 7641. 7641. 7641. 7641. 7641.

TP 56
CLASS 2, STATIN(1 TO 6) =    147     -.72238     -.14299     1.59460      .22726     2.25184
CLASS 3, STATIN(1 TO 6) =    133     -.57316      .44962     8.10654     1.92250    12.12532
CLASS 4, STATIN(1 TO 6) =    423     -.33707      .31007     7.16984     2.36286    15.23811
CLASS 5, STATIN(1 TO 6) =    217     -.47793      .08456     1.09478      .25490     2.11457
B/S CONDITION  1      .143  5.09 7168. 7168. 7168. 7168. 7168. 7168.
B/S CONDITION  2      .143  4.70 6627. 6627. 6627. 6627. 6627. 6627.
B/S CONDITION  3      .143  7.2010016.10016.10016.10016.10016.10016.
B/S CONDITION  4      .143  5.04 7011. 7011. 7011. 7011. 7011. 7011.
B/S CONDITION  5      .143  4.74 6594. 6594. 6594. 6594. 6594. 6594.
B/S CONDITION  6      .143  5.40 7512. 7512. 7512. 7512. 7512. 7512.
B/S CONDITION  7      .143  6.78 9432. 9432. 9432. 9432. 9432. 9432.
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TP 57

CLASS 1, STATIN(1 TO 6) =	88	-.36795	-.26602	1.19892	.34926	3.39101
CLASS 2, STATIN(1 TO 6) =	394	-.44566	-.03505	2.42853	.01216	4.95085
CLASS 3, STATIN(1 TO 6) =	389	-.44884	.35560	8.76578	2.14474	16.29497
CLASS 4, STATIN(1 TO 6) =	49	.34633	1.71265	29.26642	6.49142	39.27642

B/S CONDITION 1 .143 6.36 8848. 8848. 8848. 8848. 8848. 8848.
B/S CONDITION 2 .143 5.88 8180. 8180. 8180. 8180. 8180. 8180.
B/S CONDITION 3 .143 8.64 9129. 9129. 9129. 9129. 9129. 9129.
B/S CONDITION 4 .143 6.05 6390. 6390. 6390. 6390. 6390. 6390.
B/S CONDITION 5 .143 5.69 6010. 6010. 6010. 6010. 6010. 6010.
B/S CONDITION 6 .143 6.48 6846. 6846. 6846. 6846. 6846. 6846.
B/S CONDITION 7 .143 6.14 8596. 8596. 8596. 8596. 8596. 8596.

TP 58

CLASS 1, STATIN(1 TO 6) =	151	-.08828	-.29377	1.73215	-.04496	3.46078
CLASS 2, STATIN(1 TO 6) =	343	-.35679	.02609	4.49699	.22245	7.16039
CLASS 3, STATIN(1 TO 6) =	389	-.66969	.65093	11.15962	.96983	17.58733
CLASS 4, STATIN(1 TO 6) =	37	-.30297	2.36865	27.13222	5.49464	37.19966

B/S CONDITION 1 .143 7.63 8064. 8064. 8064. 8064. 8064. 8064.
B/S CONDITION 2 .143 7.06 7455. 7455. 7455. 7455. 7455. 7455.
B/S CONDITION 3 .143 7.20 7227. 7227. 7227. 7227. 7227. 7227.
B/S CONDITION 4 .143 5.04 5059. 5059. 5059. 5059. 5059. 5059.
B/S CONDITION 5 .143 4.74 4758. 4758. 4758. 4758. 4758. 4758.
B/S CONDITION 6 .143 5.40 5420. 5420. 5420. 5420. 5420. 5420.
B/S CONDITION 7 .143 6.78 6805. 6805. 6805. 6805. 6805. 6805.

TP 59

CLASS 1, STATIN(1 TO 6) =	137	.31912	.10190	2.32192	-.24060	3.93203
CLASS 2, STATIN(1 TO 6) =	345	-.02287	-.13484	4.69536	-.40005	8.42964

CLASS 3, STATIN(1 TO 6) = 394 -1.04234 .31234 11.71694 -1.06373 18.32541
CLASS 4, STATIN(1 TO 6) = 44 -.33455 2.24591 32.12233 2.63457 34.11343
B/S CONDITION 1 .143 6.36 6384. 6384. 6384. 6384. 6384. 6384.
B/S CONDITION 2 .143 5.88 5902. 5902. 5902. 5902. 5902. 5902.
B/S CONDITION 3 .143 5.76 5959. 5959. 5959. 5959. 5959. 5959.
B/S CONDITION 4 .143 4.03 4171. 4171. 4171. 4171. 4171. 4171.
B/S CONDITION 5 .143 3.79 3923. 3923. 3923. 3923. 3923. 3923.
B/S CONDITION 6 .143 4.32 4469. 4469. 4469. 4469. 4469. 4469.
B/S CONDITION 7 .143 5.42 5611. 5611. 5611. 5611. 5611. 5611.

TP 60

CLASS 1, STATIN(1 TO 6) = 115 .45157 .10487 2.79812 -.02224 3.07771
CLASS 2, STATIN(1 TO 6) = 327 -.01193 -.12382 5.23389 -.68363 8.59053
CLASS 3, STATIN(1 TO 6) = 419 -.85029 .02959 12.36597 -2.13367 18.98398
CLASS 4, STATIN(1 TO 6) = 58 -1.38000 1.85776 30.35896 3.30352 33.44492
B/S CONDITION 1 .143 5.09 5264. 5264. 5264. 5264. 5264. 5264.
B/S CONDITION 2 .143 4.70 4867. 4867. 4867. 4867. 4867. 4867.
B/S CONDITION 3 .143 4.32 5959. 5959. 5959. 5959. 5959. 5959.
B/S CONDITION 4 .143 3.02 4171. 4171. 4171. 4171. 4171. 4171.
B/S CONDITION 5 .143 2.84 3923. 3923. 3923. 3923. 3923. 3923.
B/S CONDITION 6 .143 3.24 4469. 4469. 4469. 4469. 4469. 4469.
B/S CONDITION 7 .143 4.07 5611. 5611. 5611. 5611. 5611. 5611.

TP 61

CLASS 1, STATIN(1 TO 6) = 113 .33133 -.31726 2.63257 -.49408 3.08830
CLASS 2, STATIN(1 TO 6) = 325 .00403 -.23058 5.23302 -.53521 8.92838
CLASS 3, STATIN(1 TO 6) = 420 -1.19300 -.07548 12.70238 -3.38959 19.65319
CLASS 4, STATIN(1 TO 6) = 62 -1.30339 .25016 31.43742 2.27260 35.56889
B/S CONDITION 1 .143 3.62 5264. 5264. 5264. 5264. 5264. 5264.
B/S CONDITION 2 .143 3.53 4867. 4867. 4867. 4867. 4867. 4867.

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B/S CONDITION  3     .143  3.60 5832. 5832. 5832. 5832. 5832. 5832.
B/S CONDITION  4     .143  2.52 4083. 4083. 4083. 4083. 4083. 4083.
B/S CONDITION  5     .143  2.37 3840. 3840. 3840. 3840. 3840. 3840.
B/S CONDITION  6     .143  2.70 4374. 4374. 4374. 4374. 4374. 4374.
B/S CONDITION  7     .143  3.39 5492. 5492. 5492. 5492. 5492. 5492.

TP 62
CLASS 1, STATIN(1 TO 6) =   85     .15718    -.46965    2.12063    -.38314    3.39633
CLASS 2, STATIN(1 TO 6) =  314    -.42863    -.20755    5.86473   -1.01845    7.92070
CLASS 3, STATIN(1 TO 6) =  450   -1.15902    -.40256   12.66610   -2.91883   20.17472
CLASS 4, STATIN(1 TO 6) =   71   -1.84169     .86028   23.66511     .92548   39.46178
B/S CONDITION  1     .143  3.18 5152. 5152. 5152. 5152. 5152. 5152.
B/S CONDITION  2     .143  2.94 4763. 4763. 4763. 4763. 4763. 4763.
B/S CONDITION  3     .143  2.88 6339. 6339. 6339. 6339. 6339. 6339.
B/S CONDITION  4     .143  2.02 4438. 4438. 4438. 4438. 4438. 4438.
B/S CONDITION  5     .143  1.90 4173. 4173. 4173. 4173. 4173. 4173.
B/S CONDITION  6     .143  2.16 4755. 4755. 4755. 4755. 4755. 4755.
B/S CONDITION  7     .143  2.71 5970. 5970. 5970. 5970. 5970. 5970.

TP 63
CLASS 1, STATIN(1 TO 6) =   85     .19729    -.56482    2.98763    -.00323    2.92049
CLASS 2, STATIN(1 TO 6) =  278    -.45669    -.29158    5.91832   -1.23479    8.58722
CLASS 3, STATIN(1 TO 6) =  479   -1.39599    -.63977   13.47799   -4.37624   19.34068
CLASS 4, STATIN(1 TO 6) =   78    -.38885    -.07590   25.73843   -4.65936   43.80448
B/S CONDITION  1     .143  2.54 5600. 5600. 5600. 5600. 5600. 5600.
B/S CONDITION  2     .143  2.35 5177. 5177. 5177. 5177. 5177. 5177.
B/S CONDITION  3     .143  3.60 6339. 6339. 6339. 6339. 6339. 6339.
B/S CONDITION  4     .143  2.52 4438. 4438. 4438. 4438. 4438. 4438.
B/S CONDITION  5     .143  2.37 4173. 4173. 4173. 4173. 4173. 4173.
B/S CONDITION  6     .143  2.70 4755. 4755. 4755. 4755. 4755. 4755.
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B/S CONDITION  7      .143  3.39 5970. 5970. 5970. 5970. 5970. 5970.

TP 64

CLASS 1, STATIN(1 TO 6) =    94     -.41606     -.34394     2.65089     -.42284      3.32870
CLASS 2, STATIN(1 TO 6) =   268     -.47201     -.47646     6.36885    -1.51051      8.64478
CLASS 3, STATIN(1 TO 6) =   475    -1.26556     -.68621    12.33159    -3.65592     20.05893
CLASS 4, STATIN(1 TO 6) =    63    -1.52928     -.10337    25.97319    -1.24461     46.72904
B/S CONDITION  1      .143  3.18 5600. 5600. 5600. 5600. 5600. 5600.
B/S CONDITION  2      .143  2.94 5177. 5177. 5177. 5177. 5177. 5177.
B/S CONDITION  3      .143  4.32 8622. 8622. 8622. 8622. 8622. 8622.
B/S CONDITION  4      .143  3.02 6035. 6035. 6035. 6035. 6035. 6035.
B/S CONDITION  5      .143  2.84 5676. 5676. 5676. 5676. 5676. 5676.
B/S CONDITION  6      .143  3.24 6466. 6466. 6466. 6466. 6466. 6466.
B/S CONDITION  7      .143  4.07 8119. 8119. 8119. 8119. 8119. 8119.

TP 65

CLASS 1, STATIN(1 TO 6) =    85     -.10353     -.62624     2.62027     -.32542      3.35683
CLASS 2, STATIN(1 TO 6) =   262     -.67412     -.43744     5.56829    -1.92268      8.65498
CLASS 3, STATIN(1 TO 6) =   489    -1.12202     -.61900    12.88694    -2.95284     20.31827
CLASS 4, STATIN(1 TO 6) =    84    -1.93131     -.90274    27.06686    -1.03460     44.51400
B/S CONDITION  1      .143  3.82 7616. 7616. 7616. 7616. 7616. 7616.
B/S CONDITION  2      .143  3.53 7041. 7041. 7041. 7041. 7041. 7041.
B/S CONDITION  3      .143  5.04 9636. 9636. 9636. 9636. 9636. 9636.
B/S CONDITION  4      .143  3.53 6745. 6745. 6745. 6745. 6745. 6745.
B/S CONDITION  5      .143  3.32 6344. 6344. 6344. 6344. 6344. 6344.
B/S CONDITION  6      .143  3.78 7227. 7227. 7227. 7227. 7227. 7227.
B/S CONDITION  7      .143  4.75 9074. 9074. 9074. 9074. 9074. 9074.

TP 66

CLASS 1, STATIN(1 TO 6) =    83     -.45325     -.06747     2.80211     -.37704      3.62442
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CLASS 2, STATIN(1 TO 6) =	242	-.66537	-.55236	6.09995	-1.68717	8.96991		
CLASS 3, STATIN(1 TO 6) =	500	-1.00628	-.72868	11.91743	-2.57461	20.20502		
CLASS 4, STATIN(1 TO 6) =	95	-.95537	-1.43242	30.77305	-4.44796	38.88090		
B/S CONDITION 1	.143	4.45	8512.	8512.	8512.	8512.	8512.	8512.
B/S CONDITION 2	.143	4.12	7869.	7869.	7869.	7869.	7869.	7869.
B/S CONDITION 3	.143	5.76	10016.	10016.	10016.	10016.	10016.	10016.
B/S CONDITION 4	.143	4.03	7011.	7011.	7011.	7011.	7011.	7011.
B/S CONDITION 5	.143	3.79	6594.	6594.	6594.	6594.	6594.	6594.
B/S CONDITION 6	.143	4.32	7512.	7512.	7512.	7512.	7512.	7512.
B/S CONDITION 7	.143	5.42	9432.	9432.	9432.	9432.	9432.	9432.

TP 67

CLASS 1, STATIN(1 TO 6) =	17	-.29941	.56882	3.44067	.34657	3.11020		
CLASS 2, STATIN(1 TO 6) =	205	-.59971	-.29522	4.57502	-.88203	5.82093		
CLASS 3, STATIN(1 TO 6) =	597	-.64854	-.86965	10.68476	-2.25265	16.77955		
CLASS 4, STATIN(1 TO 6) =	161	-1.04297	-.62772	24.65132	-4.58415	42.21967		
B/S CONDITION 1	.143	5.09	8848.	8848.	8848.	8848.	8848.	8848.
B/S CONDITION 2	.143	4.70	8180.	8180.	8180.	8180.	8180.	8180.
B/S CONDITION 3	.143	6.48	7100.	7100.	7100.	7100.	7100.	7100.
B/S CONDITION 4	.143	4.54	4970.	4970.	4970.	4970.	4970.	4970.
B/S CONDITION 5	.143	4.27	4674.	4674.	4674.	4674.	4674.	4674.
B/S CONDITION 6	.143	4.86	5325.	5325.	5325.	5325.	5325.	5325.
B/S CONDITION 7	.143	6.10	6686.	6686.	6686.	6686.	6686.	6686.

TP 68

CLASS 2, STATIN(1 TO 6) =	147	-.80061	-.32415	2.69480	-.31339	2.64723		
CLASS 3, STATIN(1 TO 6) =	616	-.46498	-1.14250	8.61584	-2.26874	13.27917		
CLASS 4, STATIN(1 TO 6) =	157	.12471	-.44369	24.61562	-2.11064	33.41601		
B/S CONDITION 1	.143	5.72	6272.	6272.	6272.	6272.	6272.	6272.
B/S CONDITION 2	.143	5.29	5798.	5798.	5798.	5798.	5798.	5798.

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B/S CONDITION 3     .143 5.64 7100. 7100. 7100. 7100. 7100. 7100.
B/S CONDITION 4     .143 3.53 4970. 4970. 4970. 4970. 4970. 4970.
B/S CONDITION 5     .143 3.32 4674. 4674. 4674. 4674. 4674. 4674.
B/S CONDITION 6     .143 3.78 5325. 5325. 5325. 5325. 5325. 5325.
B/S CONDITION 7     .143 4.75 6686. 6686. 6686. 6686. 6686. 6686.

TP 69
CLASS 4, STATIN(1 TO 6) =   766    -.12535   -1.08568   9.12055   -1.13712   14.74900
CLASS 5, STATIN(1 TO 6) =   154    -.81455    -.37494   1.98752    -.50277    2.66305
B/S CONDITION 1     .143 4.45 6272. 6272. 6272. 6272. 6272. 6272.
B/S CONDITION 2     .143 4.12 5798. 5798. 5798. 5798. 5798. 5798.
B/S CONDITION 3     .143 2.88 5071. 5071. 5071. 5071. 5071. 5071.
B/S CONDITION 4     .143 2.02 3550. 3550. 3550. 3550. 3550. 3550.
B/S CONDITION 5     .143 1.90 3339. 3339. 3339. 3339. 3339. 3339.
B/S CONDITION 6     .143 2.16 3804. 3804. 3804. 3804. 3804. 3804.
B/S CONDITION 7     .143 2.71 4776. 4776. 4776. 4776. 4776. 4776.

TP 70
CLASS 4, STATIN(1 TO 6) =   711    -.07489   -1.22499   8.29287    -.36168   13.65858
CLASS 5, STATIN(1 TO 6) =   209    -.66498    -.74081   2.08641    -.49756    2.41848
B/S CONDITION 1     .143 2.54 4480. 4480. 4480. 4480. 4480. 4480.
B/S CONDITION 2     .143 2.35 4142. 4142. 4142. 4142. 4142. 4142.
B/S CONDITION 3     .143 2.88 3804. 3804. 3804. 3804. 3804. 3804.
B/S CONDITION 4     .143 2.02 2663. 2663. 2663. 2663. 2663. 2663.
B/S CONDITION 5     .143 1.90 2504. 2504. 2504. 2504. 2504. 2504.
B/S CONDITION 6     .143 2.16 2853. 2853. 2853. 2853. 2853. 2853.
B/S CONDITION 7     .143 2.71 3582. 3582. 3582. 3582. 3582. 3582.

TP 71
CLASS 4, STATIN(1 TO 6) =   654    -.34910   -1.30599   7.77543    -.68759   14.18000
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CLASS 5, STATIN(1 TO 6) =	266	-.41718	-.86459	1.75249	-.24114	2.42321		
B/S CONDITION 1	.143	2.54	3360.	3360.	3360.	3360.	3360.	3360.
B/S CONDITION 2	.143	2.35	3106.	3106.	3106.	3106.	3106.	3106.
B/S CONDITION 3	.143	3.60	2536.	2536.	2536.	2536.	2536.	2536.
B/S CONDITION 4	.143	2.52	1775.	1775.	1775.	1775.	1775.	1775.
B/S CONDITION 5	.143	2.37	1669.	1669.	1669.	1669.	1669.	1669.
B/S CONDITION 6	.143	2.70	1902.	1902.	1902.	1902.	1902.	1902.
B/S CONDITION 7	.143	3.39	2388.	2388.	2388.	2388.	2388.	2388.

TP 72

CLASS 4, STATIN(1 TO 6) =	615	-.38914	-1.23413	7.49379	-.05448	14.15955		
CLASS 5, STATIN(1 TO 6) =	305	-.66292	-.75482	1.43087	-.09301	2.37689		
B/S CONDITION 1	.143	3.18	2240.	2240.	2240.	2240.	2240.	2240.
B/S CONDITION 2	.143	2.94	2071.	2071.	2071.	2071.	2071.	2071.
B/S CONDITION 3	.143	2.88	1268.	1268.	1268.	1268.	1268.	1268.
B/S CONDITION 4	.143	2.02	888.	888.	888.	888.	888.	888.
B/S CONDITION 5	.143	1.90	835.	835.	835.	835.	835.	835.
B/S CONDITION 6	.143	2.16	951.	951.	951.	951.	951.	951.
B/S CONDITION 7	.143	2.71	1194.	1194.	1194.	1194.	1194.	1194.

TP 73

CLASS 4, STATIN(1 TO 6) =	533	-.35957	-.18869	6.92166	.87571	15.51588		
CLASS 5, STATIN(1 TO 6) =	387	-.60085	-.29041	1.17493	.12252	2.14979		
B/S CONDITION 1	.143	2.54	1120.	1120.	1120.	1120.	1120.	1120.
B/S CONDITION 2	.143	2.35	1035.	1035.	1035.	1035.	1035.	1035.
B/S CONDITION 3	.143	2.64	930.	930.	930.	930.	930.	930.
B/S CONDITION 4	.143	1.85	651.	651.	651.	651.	651.	651.
B/S CONDITION 5	.143	1.74	612.	612.	612.	612.	612.	612.
B/S CONDITION 6	.143	1.98	697.	697.	697.	697.	697.	697.
B/S CONDITION 7	.143	2.49	876.	876.	876.	876.	876.	876.

TP 74

CLASS 4, STATIN(1 TO 6) =	514	-.37514	.01963	7.34561	1.44110	15.60732		
CLASS 5, STATIN(1 TO 6) =	406	-.58069	-.27756	1.17274	.20926	2.25988		
B/S CONDITION 1	.143	2.33	821.	821.	821.	821.	821.	821.
B/S CONDITION 2	.143	2.16	759.	759.	759.	759.	759.	759.
B/S CONDITION 3	.143	3.96	814.	814.	814.	814.	814.	814.
B/S CONDITION 4	.143	2.77	569.	569.	569.	569.	569.	569.
B/S CONDITION 5	.143	2.61	536.	536.	536.	536.	536.	536.
B/S CONDITION 6	.143	2.97	610.	610.	610.	610.	610.	610.
B/S CONDITION 7	.143	3.73	766.	766.	766.	766.	766.	766.

TP 75

CLASS 4, STATIN(1 TO 6) =	522	-.29885	.35011	6.85868	1.52581	15.54717		
CLASS 5, STATIN(1 TO 6) =	398	-.73023	-.29116	1.04587	.25812	2.11468		
B/S CONDITION 1	.143	3.50	719.	719.	719.	719.	719.	719.
B/S CONDITION 2	.143	3.23	664.	664.	664.	664.	664.	664.
B/S CONDITION 3	.143	4.62	697.	697.	697.	697.	697.	697.
B/S CONDITION 4	.143	3.23	488.	488.	488.	488.	488.	488.
B/S CONDITION 5	.143	3.04	459.	459.	459.	459.	459.	459.
B/S CONDITION 6	.143	3.47	523.	523.	523.	523.	523.	523.
B/S CONDITION 7	.143	4.35	657.	657.	657.	657.	657.	657.

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TP 76

CLASS 4, STATIN(1 TO 6) =	491	-.35128	.80157	7.40053	1.92324	15.31635		
CLASS 5, STATIN(1 TO 6) =	429	-.60457	-.29636	1.01426	.27580	2.13361		
B/S CONDITION 1	.143	4.08	616.	616.	616.	616.	616.	616.
B/S CONDITION 2	.143	3.77	569.	569.	569.	569.	569.	569.
B/S CONDITION 3	.143	3.96	581.	581.	581.	581.	581.	581.
B/S CONDITION 4	.143	2.77	407.	407.	407.	407.	407.	407.

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      B/S CONDITION  5      .143  2.61  383.  383.  383.  383.  383.  383.
      B/S CONDITION  6      .143  2.97  436.  436.  436.  436.  436.  436.
      B/S CONDITION  7      .143  3.73  547.  547.  547.  547.  547.  547.

  TP 77
      CLASS 4, STATIN(1 TO 6) =    500      -.26712      .95712      6.86932     1.93337     13.63829
      CLASS 5, STATIN(1 TO 6) =    420      -.64024     -.20726      1.00576      .29082      2.25168
      B/S CONDITION  1      .143  3.50  513.  513.  513.  513.  513.  513.
      B/S CONDITION  2      .143  3.23  475.  475.  475.  475.  475.  475.
      B/S CONDITION  3      .143  3.96  814.  814.  814.  814.  814.  814.
      B/S CONDITION  4      .143  2.77  569.  569.  569.  569.  569.  569.
      B/S CONDITION  5      .143  2.61  536.  536.  536.  536.  536.  536.
      B/S CONDITION  6      .143  2.97  610.  610.  610.  610.  610.  610.
      B/S CONDITION  7      .143  3.73  766.  766.  766.  766.  766.  766.

  TP 78
      CLASS 4, STATIN(1 TO 6) =    482      -.32241      1.21830     6.74953     1.88243     13.73273
      CLASS 5, STATIN(1 TO 6) =    438      -.66276     -.01680      1.03284      .29110      2.27828
      B/S CONDITION  1      .143  3.50  719.  719.  719.  719.  719.  719.
      B/S CONDITION  2      .143  3.23  664.  664.  664.  664.  664.  664.
      B/S CONDITION  3      .143  3.96 2324. 2324. 2324. 2324. 2324. 2324.
      B/S CONDITION  4      .143  2.77 1627. 1627. 1627. 1627. 1627. 1627.
      B/S CONDITION  5      .143  2.61 1530. 1530. 1530. 1530. 1530. 1530.
      B/S CONDITION  6      .143  2.97 1743. 1743. 1743. 1743. 1743. 1743.
      B/S CONDITION  7      .143  3.73 2189. 2189. 2189. 2189. 2189. 2189.

  TP 79
      CLASS 4, STATIN(1 TO 6) =    499      -.26533      1.30218     7.09695     1.38997     12.90291
      CLASS 5, STATIN(1 TO 6) =    421      -.66686      .04732      1.05218      .35308      2.28399
      B/S CONDITION  1      .143  3.50 2053. 2053. 2053. 2053. 2053. 2053.
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B/S CONDITION  2     .143  3.23 1898. 1898. 1898. 1898. 1898. 1898.
B/S CONDITION  3     .143  5.28 7438. 7438. 7438. 7438. 7438. 7438.
B/S CONDITION  4     .143  3.70 5207. 5207. 5207. 5207. 5207. 5207.
B/S CONDITION  5     .143  3.48 4897. 4897. 4897. 4897. 4897. 4897.
B/S CONDITION  6     .143  3.96 5579. 5579. 5579. 5579. 5579. 5579.
B/S CONDITION  7     .143  4.97 7004. 7004. 7004. 7004. 7004. 7004.

TP 80
CLASS 4, STATIN(1 TO 6) =   547    -.22982    1.13165    6.35390    1.40831   13.53286
CLASS 5, STATIN(1 TO 6) =   373    -.62898     .03032     .93746     .32964    2.01759
B/S CONDITION  1     .143  4.66 6570. 6570. 6570. 6570. 6570. 6570.
B/S CONDITION  2     .143  4.31 6074. 6074. 6074. 6074. 6074. 6074.
B/S CONDITION  3     .143  6.60 9181. 9181. 9181. 9181. 9181. 9181.
B/S CONDITION  4     .143  4.62 6427. 6427. 6427. 6427. 6427. 6427.
B/S CONDITION  5     .143  4.35 6044. 6044. 6044. 6044. 6044. 6044.
B/S CONDITION  6     .143  4.95 6886. 6886. 6886. 6886. 6886. 6886.
B/S CONDITION  7     .143  6.22 8646. 8646. 8646. 8646. 8646. 8646.

TP 81
CLASS 1, STATIN(1 TO 6) =    21   -1.18190     .61667    1.16689    -.02001    3.18334
CLASS 2, STATIN(1 TO 6) =   284    -.55655     .03183    1.63481     .45027    3.12741
CLASS 3, STATIN(1 TO 6) =   260     .00704     .78592    6.56966    2.42622   11.75767
CLASS 4, STATIN(1 TO 6) =   232    -.56569    2.26897    9.53413    1.57098   16.76213
CLASS 5, STATIN(1 TO 6) =   123    -.54203     .01520     .81411     .39470    2.10851
B/S CONDITION  1     .143  5.83 8110. 8110. 8110. 8110. 8110. 8110.
B/S CONDITION  2     .143  5.39 7498. 7498. 7498. 7498. 7498. 7498.
B/S CONDITION  3     .143  7.92 8368. 8368. 8368. 8368. 8368. 8368.
B/S CONDITION  4     .143  5.54 5858. 5858. 5858. 5858. 5858. 5858.
B/S CONDITION  5     .143  5.21 5509. 5509. 5509. 5509. 5509. 5509.
B/S CONDITION  6     .143  5.94 6276. 6276. 6276. 6276. 6276. 6276.
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    B/S CONDITION  7     .143  7.46 7880. 7880. 7880. 7880. 7880. 7880.

  TP 82
    CLASS 1, STATIN(1 TO 6) =    48      -.41417      .14187     1.25945     .24024     3.74228
    CLASS 2, STATIN(1 TO 6) =   355      -.26952     -.03837     2.12869     .34181     3.73101
    CLASS 3, STATIN(1 TO 6) =   417      -.25201      .85820     7.76278    2.05762    13.51037
    CLASS 4, STATIN(1 TO 6) =   100       .22280     3.82780    19.00630    2.83300    28.27442
    B/S CONDITION  1     .143  7.60 7392. 7392. 7392. 7392. 7392. 7392.
    B/S CONDITION  2     .143  6.47 6834. 6834. 6834. 6834. 6834. 6834.
    B/S CONDITION  3     .143  6.60 6625. 6625. 6625. 6625. 6625. 6625.
    B/S CONDITION  4     .143  4.62 4637. 4637. 4637. 4637. 4637. 4637.
    B/S CONDITION  5     .143  4.35 4361. 4361. 4361. 4361. 4361. 4361.
    B/S CONDITION  6     .143  4.95 4968. 4968. 4968. 4968. 4968. 4968.
    B/S CONDITION  7     .143  6.22 6238. 6238. 6238. 6238. 6238. 6238.

  TP 83
    CLASS 1, STATIN(1 TO 6) =    92       .08891     -.24957     1.71398    -.03961     3.89195
    CLASS 2, STATIN(1 TO 6) =   305       .09525     -.03593     3.35905     .17127     5.64646
    CLASS 3, STATIN(1 TO 6) =   432      -.23028      .80109     9.40897    1.14705    15.18948
    CLASS 4, STATIN(1 TO 6) =    91      -.31231     4.06549    23.08102    -.75899    31.46718
    B/S CONDITION  1     .143  5.83 5852. 5852. 5852. 5852. 5852. 5852.
    B/S CONDITION  2     .143  5.39 5410. 5410. 5410. 5410. 5410. 5410.
    B/S CONDITION  3     .143  5.28 5462. 5462. 5462. 5462. 5462. 5462.
    B/S CONDITION  4     .143  3.70 3824. 3824. 3824. 3824. 3824. 3824.
    B/S CONDITION  5     .143  3.48 3596. 3596. 3596. 3596. 3596. 3596.
    B/S CONDITION  6     .143  3.96 4097. 4097. 4097. 4097. 4097. 4097.
    B/S CONDITION  7     .143  4.97 5144. 5144. 5144. 5144. 5144. 5144.

  TP 84
    CLASS 1, STATIN(1 TO 6) =    97       .41959      .00804     2.32957     .31785     3.79283
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CLASS 2, STATIN(1 TO 6) =   299     .24217     .00177    3.40931    -.50142    7.27546
CLASS 3, STATIN(1 TO 6) =   423    -.11095     .29617    9.48704     .68340   17.30694
CLASS 4, STATIN(1 TO 6) =   101   -1.29911    3.15337   25.99046    5.99615   32.90304
B/S CONDITION  1     .143  4.66 4825. 4825. 4825. 4825. 4825. 4825.
B/S CONDITION  2     .143  4.31 4461. 4461. 4461. 4461. 4461. 4461.
B/S CONDITION  3     .143  3.96 5462. 5462. 5462. 5462. 5462. 5462.
B/S CONDITION  4     .143  2.77 3824. 3824. 3824. 3824. 3824. 3824.
B/S CONDITION  5     .143  2.61 3596. 3596. 3596. 3596. 3596. 3596.
B/S CONDITION  6     .143  2.97 4097. 4097. 4097. 4097. 4097. 4097.
B/S CONDITION  7     .143  3.73 5144. 5144. 5144. 5144. 5144. 5144.

TP 85
CLASS 1, STATIN(1 TO 6) =    94     .41277    -.06043    2.35669     .11261    3.76171
CLASS 2, STATIN(1 TO 6) =   297     .20923     .01980    4.34149    -.57441    7.83272
CLASS 3, STATIN(1 TO 6) =   419    -.24339    -.12141    9.90349    -.79026   17.79493
CLASS 4, STATIN(1 TO 6) =   110    -.95082    2.75855   25.39039     .26544   35.43439
B/S CONDITION  1     .143  3.50 4825. 4825. 4825. 4825. 4825. 4825.
B/S CONDITION  2     .143  3.23 4461. 4461. 4461. 4461. 4461. 4461.
B/S CONDITION  3     .143  3.30 5346. 5346. 5346. 5346. 5346. 5346.
B/S CONDITION  4     .143  2.31 3742. 3742. 3742. 3742. 3742. 3742.
B/S CONDITION  5     .143  2.17 3520. 3520. 3520. 3520. 3520. 3520.
B/S CONDITION  6     .143  2.48 4010. 4010. 4010. 4010. 4010. 4010.
B/S CONDITION  7     .143  3.11 5034. 5034. 5034. 5034. 5034. 5034.

TP 86
CLASS 1, STATIN(1 TO 6) =   103     .00175     .02340    2.54857    -.20493    3.47035
CLASS 2, STATIN(1 TO 6) =   275     .24222    -.45200    4.08755    -.59005    7.92026
CLASS 3, STATIN(1 TO 6) =   436    -.47544    -.08874   11.31561   -1.52916   18.63173
CLASS 4, STATIN(1 TO 6) =   106    -.75887    2.09575   25.67845     .43272   42.45664
B/S CONDITION  1     .143  2.92 4722. 4722. 4722. 4722. 4722. 4722.
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   B/S CONDITION  2      .143  2.70 4366. 4366. 4366. 4366. 4366. 4366.
   B/S CONDITION  3      .143  2.64 5811. 5811. 5811. 5811. 5811. 5811.
   B/S CONDITION  4      .143  1.85 4068. 4068. 4068. 4068. 4068. 4068.
   B/S CONDITION  5      .143  1.74 3826. 3826. 3826. 3826. 3826. 3826.
   B/S CONDITION  6      .143  1.98 4358. 4358. 4358. 4358. 4358. 4358.
   B/S CONDITION  7      .143  2.49 5472. 5472. 5472. 5472. 5472. 5472.

 TP 87
   CLASS 1, STATIN(1 TO 6) =   81      .13988    -.02988    2.72225    -.16375    3.72275
   CLASS 2, STATIN(1 TO 6) =  279      .20591    -.28896    4.53105    -.78234    7.92632
   CLASS 3, STATIN(1 TO 6) =  449    -.63441    -.22962   10.34021    -.46098   18.47963
   CLASS 4, STATIN(1 TO 6) =  111   -1.34874    1.22928   24.63897   -1.72754   42.37972
   B/S CONDITION  1      .143  2.33 5133. 5133. 5133. 5133. 5133. 5133.
   B/S CONDITION  2      .143  2.16 4746. 4746. 4746. 4746. 4746. 4746.
   B/S CONDITION  3      .143  3.30 5811. 5811. 5811. 5811. 5811. 5811.
   B/S CONDITION  4      .143  2.31 4068. 4068. 4068. 4068. 4068. 4068.
   B/S CONDITION  5      .143  2.17 3826. 3826. 3826. 3826. 3826. 3826.
   B/S CONDITION  6      .143  2.48 4358. 4358. 4358. 4358. 4358. 4358.
   B/S CONDITION  7      .143  3.11 5472. 5472. 5472. 5472. 5472. 5472.

 TP 88
   CLASS 1, STATIN(1 TO 6) =   72    -.20778    -.13208    2.73919     .08716    3.66997
   CLASS 2, STATIN(1 TO 6) =  271    -.06723    -.37598    4.57664    -.63130    7.45828
   CLASS 3, STATIN(1 TO 6) =  456    -.62686    -.56110   10.18009   -1.45523   17.35999
   CLASS 4, STATIN(1 TO 6) =  121   -1.20868    1.54388   26.97734     .66242   43.28136
   B/S CONDITION  1      .143  2.92 5133. 5133. 5133. 5133. 5133. 5133.
   B/S CONDITION  2      .143  2.70 4746. 4746. 4746. 4746. 4746. 4746.
   B/S CONDITION  3      .143  3.96 7903. 7903. 7903. 7903. 7903. 7903.
   B/S CONDITION  4      .143  2.77 5532. 5532. 5532. 5532. 5532. 5532.
   B/S CONDITION  5      .143  2.61 5203. 5203. 5203. 5203. 5203. 5203.
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B/S CONDITION 6 .143 2.97 5927. 5927. 5927. 5927. 5927. 5927.

B/S CONDITION 7 .143 3.73 7442. 7442. 7442. 7442. 7442. 7442.

TP 89

CLASS 1, STATIN(1 TO 6) = 42 -.35905 -.13714 3.17219 -.45571 3.84002

CLASS 2, STATIN(1 TO 6) = 248 -.10734 -.17347 4.25665 -.73844 7.73116

CLASS 3, STATIN(1 TO 6) = 495 -.55174 -.58691 8.79935 -.38448 16.75901

CLASS 4, STATIN(1 TO 6) = 135 -.98178 1.33844 26.61087 -3.30439 42.05655

B/S CONDITION 1 .143 3.50 6981. 6981. 6981. 6981. 6981. 6981.

B/S CONDITION 2 .143 3.23 6454. 6454. 6454. 6454. 6454. 6454.

B/S CONDITION 3 .143 4.62 8833. 8833. 8833. 8833. 8833. 8833.

B/S CONDITION 4 .143 3.23 6183. 6183. 6183. 6183. 6183. 6183.

B/S CONDITION 5 .143 3.04 5815. 5815. 5815. 5815. 5815. 5815.

B/S CONDITION 6 .143 3.47 6625. 6625. 6625. 6625. 6625. 6625.

B/S CONDITION 7 .143 4.35 8318. 8318. 8318. 8318. 8318. 8318.

TP 90

CLASS 1, STATIN(1 TO 6) = 20 .05900 .39400 2.02474 -.75621 4.79521

CLASS 2, STATIN(1 TO 6) = 217 -.29912 -.37152 3.82323 -.60739 5.49732

CLASS 3, STATIN(1 TO 6) = 536 -.44918 -.68537 8.76704 -.87348 14.20507

CLASS 4, STATIN(1 TO 6) = 147 -.22762 .81605 24.44823 -2.22403 40.04560

B/S CONDITION 1 .143 4.08 7802. 7802. 7802. 7802. 7802. 7802.

B/S CONDITION 2 .143 3.77 7213. 7213. 7213. 7213. 7213. 7213.

B/S CONDITION 3 .143 5.28 9181. 9181. 9181. 9181. 9181. 9181.

B/S CONDITION 4 .143 3.70 6427. 6427. 6427. 6427. 6427. 6427.

B/S CONDITION 5 .143 3.48 6044. 6044. 6044. 6044. 6044. 6044.

B/S CONDITION 6 .143 3.96 6886. 6886. 6886. 6886. 6886. 6886.

B/S CONDITION 7 .143 4.97 8646. 8646. 8646. 8646. 8646. 8646.

TP 91

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CLASS 1, STATIN(1 TO 6) =    7     -.99571    .51657     2.15506    -.40986     5.63081
CLASS 2, STATIN(1 TO 6) =  139     -.30656   -.11266     3.27064    -.29332     4.58298
CLASS 3, STATIN(1 TO 6) =  394     -.01739   -.65685     8.34386   -1.00174    13.01852
CLASS 4, STATIN(1 TO 6) =  324     -.15929    .20247    13.05983   -2.12109    22.72886
CLASS 5, STATIN(1 TO 6) =   56     -.37000   -.88375     2.82410    -.26927     2.15881
B/S CONDITION  1      .143  4.66 8110. 8110. 8110. 8110. 8110. 8110.
B/S CONDITION  2      .143  4.31 7498. 7498. 7498. 7498. 7498. 7498.
B/S CONDITION  3      .143  5.94 6508. 6508. 6508. 6508. 6508. 6508.
B/S CONDITION  4      .143  4.16 4556. 4556. 4556. 4556. 4556. 4556.
B/S CONDITION  5      .143  3.91 4285. 4285. 4285. 4285. 4285. 4285.
B/S CONDITION  6      .143  4.46 4881. 4881. 4881. 4881. 4881. 4881.
B/S CONDITION  7      .143  5.59 6129. 6129. 6129. 6129. 6129. 6129.

TP 92
CLASS 4, STATIN(1 TO 6) =  695      .25675   -.39407     9.83900    -.73978    15.08566
CLASS 5, STATIN(1 TO 6) =  225     -.37920   -.48164     2.14862    -.59062     2.51477
B/S CONDITION  1      .143  5.25 5749. 5749. 5749. 5749. 5749. 5749.
B/S CONDITION  2      .143  4.85 5315. 5315. 5315. 5315. 5315. 5315.
B/S CONDITION  3      .143  4.62 6508. 6508. 6508. 6508. 6508. 6508.
B/S CONDITION  4      .143  3.23 4556. 4556. 4556. 4556. 4556. 4556.
B/S CONDITION  5      .143  3.04 4285. 4285. 4285. 4285. 4285. 4285.
B/S CONDITION  6      .143  3.47 4881. 4881. 4881. 4881. 4881. 4881.
B/S CONDITION  7      .143  4.35 6129. 6129. 6129. 6129. 6129. 6129.

TP 93
CLASS 4, STATIN(1 TO 6) =  626      .31696   -.48105     8.55199    -.43791    14.67232
CLASS 5, STATIN(1 TO 6) =  294     -.38949   -.63027     1.74242    -.16582     2.46857
B/S CONDITION  1      .143  4.08 5749. 5749. 5749. 5749. 5749. 5749.
B/S CONDITION  2      .143  3.77 5315. 5315. 5315. 5315. 5315. 5315.
B/S CONDITION  3      .143  2.64 4649. 4649. 4649. 4649. 4649. 4649.
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B/S CONDITION  4      .143  1.65 3254. 3254. 3254. 3254. 3254. 3254.
B/S CONDITION  5      .143  1.74 3060. 3060. 3060. 3060. 3060. 3060.
B/S CONDITION  6      .143  1.96 3487. 3487. 3487. 3487. 3487. 3487.
B/S CONDITION  7      .143  2.49 4378. 4378. 4378. 4378. 4378. 4378.

TP 94
CLASS 4, STATIN(1 TO 6) =    566      .10148     -.28800     8.34113      .44894    15.36172
CLASS 5, STATIN(1 TO 6) =    333     -.36096     -.67357     1.51025      .06092     2.16639
B/S CONDITION  1      .143  2.33 4106. 4106. 4106. 4106. 4106. 4106.
B/S CONDITION  2      .143  2.16 3797. 3797. 3797. 3797. 3797. 3797.
B/S CONDITION  3      .143  2.64 3487. 3487. 3487. 3487. 3487. 3487.
B/S CONDITION  4      .143  1.65 2441. 2441. 2441. 2441. 2441. 2441.
B/S CONDITION  5      .143  1.74 2295. 2295. 2295. 2295. 2295. 2295.
B/S CONDITION  6      .143  1.98 2615. 2615. 2615. 2615. 2615. 2615.
B/S CONDITION  7      .143  2.49 3283. 3283. 3283. 3283. 3283. 3283.

TP 95
CLASS 4, STATIN(1 TO 6) =    559     -.02038     -.53309     8.58243     1.24015    15.14722
CLASS 5, STATIN(1 TO 6) =    361     -.52778     -.48388     1.28808      .06574     2.21663
B/S CONDITION  1      .143  2.33 3080. 3080. 3080. 3080. 3080. 3080.
B/S CONDITION  2      .143  2.16 2847. 2847. 2847. 2847. 2847. 2847.
B/S CONDITION  3      .143  3.30 2324. 2324. 2324. 2324. 2324. 2324.
B/S CONDITION  4      .143  2.31 1627. 1627. 1627. 1627. 1627. 1627.
B/S CONDITION  5      .143  2.17 1530. 1530. 1530. 1530. 1530. 1530.
B/S CONDITION  6      .143  2.48 1743. 1743. 1743. 1743. 1743. 1743.
B/S CONDITION  7      .143  3.11 2189. 2189. 2189. 2189. 2189. 2189.

TP 96
CLASS 4, STATIN(1 TO 6) =    543     -.29838     -.37492     8.59797     1.28468    15.50311
CLASS 5, STATIN(1 TO 6) =    377     -.50546     -.42708     1.18083      .14525     2.12828
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B/S CONDITION 1	.143	2.92	2053.	2053.	2053.	2053.	2053.	2053.
B/S CONDITION 2	.143	2.70	1898.	1898.	1898.	1898.	1898.	1898.
B/S CONDITION 3	.143	2.64	1162.	1162.	1162.	1162.	1162.	1162.
B/S CONDITION 4	.143	1.85	814.	814.	814.	814.	814.	814.
B/S CONDITION 5	.143	1.74	765.	765.	765.	765.	765.	765.
B/S CONDITION 6	.143	1.98	872.	872.	872.	872.	872.	872.
B/S CONDITION 7	.143	2.49	1094.	1094.	1094.	1094.	1094.	1094.

RESULTS

FOR A STANDARD OF 35.0 PPM

THE AVERAGE NUMBER OF VIOLATIONS PER YEAR IS 1.204 WITH A STANDARD ERROR OF .036

THE MAXIMUM PROBABILITY OF TWO OR MORE VIOLATIONS PER YEAR IS 33.90 O/O WITH A STANDARD ERROR OF 1.31 O/O

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                         >>> COST REPORT FOR PROBC73 <<<

                    06/08/79                          14.48.26

      RESOURCE                 BILLING RATE                 UNITS USED           COST

CENTRAL PROCESSOR           $100.00  /HOUR            171.557 CP SECONDS      $  5.00
PERIPHERAL PROCESSOR          20.00  /HOUR             17.563 PP SECONDS          .10
I/O                           80.00  /HOUR              7.879 IO SECONDS          .18
FIELD LENGTH                   3.00  /KILO-WRD-HOUR  3300.288 KILO-WRD-SECS.     2.75
MAGNETIC TAPES MOUNTED          .50  /TAPE                  1 MAG TAPE(S)         .50
CARDS READ                    .0025/CARD                 1982 CARDS READ         4.96
                                                                              --------
(BASIC COST EXCLUDES LINES PRINTED, CARDS PUNCHED               BASIC COST      13.48
  AND PLOTTER TIME CHARGES)

JOB PRIORITY  4        PRIORITY COST FACTOR  1.00       APPROXIMATE ADJUSTED COST   13.48

      AS OF LAST ACCOUNT UPDATE, ACCOUNT EXPIRES 06/30/79, FUNDS LEFT UNLIMITED

                  +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

                     STARTING MONDAY, JUNE 11, NOS/BE WILL NO LONGER BE AVAILABLE.
                     NOS WILL BE THE OPERATING SYSTEM.

                  +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

 06/08/79    UVA NOS/BE 1.2   LEVEL 454-03/11/78
14.40.31.PROBC73  FROM
14.40.31.PROBC01,428740,T7777,MT1.
14.40.31.LABEL,TAPE4,R,L=STATISTX,T=999,VSN=603,N
14.40.31.RING,D=HY.
14.40.31.( MT 025 ASSIGNED)
14.40.32.MT25 VOLUME SERIAL NUMBER IS  000603
14.40.33. LABEL READ WAS      STATISTX
14.40.33.   EDITION NUMBER    00
14.40.33.   RETENTION CYCLE   999
14.40.33.   CREATION DATE     78331
14.40.33.   REEL NUMBER       0001
14.40.33.SKIPF,TAPE4,2,17,B.
14.40.34.FTN(CL=F)
14.41.00.  44000B   CM STORAGE USED
14.41.00.     11.818 CP SECONDS COMPILATION TIME
14.41.00.LGO.
14.48.25.MT25  BLOCKS READ 000017
14.48.25.     STOP
14.48.25.   158.271 CP SECONDS EXECUTION TIME
14.48.26.     STOP
14.48.27.EJ  END OF JOB, **

PRINT COST $003.26  PROBC73  //// END OF LIST ////  0002967 LINES
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3270